Lei Sun

From rhetoric to practice: enhancing environmental literacy of pupils in China

Faculteit Bètawetenschappen FIsme

From rhetoric to practice:
enhancing environmental literacy of pupils in China

Sun, Lei

From rhetoric to practice: enhancing environmental literacy of pupils in China/
L. Sun – Utrecht: Freudenthal Institute for Science and Mathematics Education,
Faculty of Science, Utrecht University / FIsme Scientific Library (formerly published
as CD-β Scientific Library), no. 81, 2014.

Dissertation Utrecht University. With references. Met een samenvatting in het
Nederlands.
ISBN: 978-90-70786-22-9
Keywords: environmental literacy, rhetoric-practice gap, design research,
environmental education, school curriculum
Cover design: Vormgeving Faculteit Bètawetenschappen
Printed by: Drukkerij Wilco, Amersfoort

From rhetoric to practice: enhancing environmental literacy of pupils in China

Van retoriek naar praktijk: het bevorderen van milieubewustzijn bij leerlingen in China

(met een samenvatting in het Nederlands)

Proefschrift
ter verkrijging van de graad van doctor aan de Universiteit Utrecht
op gezag van de rector magnificus, prof. dr. G.J. van der Zwaan,
ingevolge het besluit van het college voor promoties
in het openbaar te verdedigen
op woensdag 22 januari 2014 des morgens te 10.30 uur
door

Lei Sun

geboren op 14 mei 1975, te Gansu, China P.R.

Promotoren:	Prof.dr. K.T. Boersma
	Prof.dr.ir. C.S.A. van Koppen

Table of contents

Chapter 1 Introduction

1 Motive

Environmental concern has increased tremendously worldwide. With the recognition of an ecological crisis of global significance, there is a growing and urgent need to re-evaluate the relationship between human activities and natural environment. China, confronted with accumulating environmental challenges from a lasting economic growth, has a growing concern for a harmonious coexistence between economy and ecology. It is of great importance for the future of the country and also of the world that the development of China is environmentally sustainable. A prominent issue facing China and other countries is to promote people taking responsibilities to sustain the global environment, together with a continued development of the quality of life. The World Commission on the Environment and Development, in its report *Our common future* (1987), introduced sustainable development as the accepted concept for development aimed at finding a balance between providing the needs of present and future human society and protecting the environment. It is crucial to prepare an environmentally informed and responsible citizenry to achieve the goal of sustainable development. Environmental education provides a basic avenue for capacity-building in environmental reform with the aim for society of acquiring environmental literacy. It will even be more promising when environmental education involves young students who are to take decision making roles in future society. However, the goal of an environmentally literate citizenry will be hard to meet unless we understand the problems, know the obstacles to get there and come up with adequate solutions.

2 Situation

Environmental education in China was initiated in the early 1980s, in the Nine-Year Compulsory Education (NYCE)[1], which includes primary school, grades 1 to 6, and junior middle school, grades 7 to 9. Environmental education in China schools is mostly conducted by integrating it into various existing subjects as a cross-curricular theme. It is the teachers' freedom and responsibility to interpret the integrated environmental education in their disciplinary classes. A number of empirical studies with data collected from surveys and interviews reveal a bottleneck of implementing environmental

1 All the abbreviations are presented in appendix I.

education, that is, teachers often found they lacked confidence in interpreting the integrated environmental education in their classes, as well as a lack of assistance on how to conduct environmental education that works best in their contexts (Bian, 2004; Shu, 2004; Tian, 2004a; Wang et al., 2004; Wasmer, 2005). In February 2003 the Ministry of Education in China issued the '*Syllabus on Environmental Subject for Students in Middle and Primary Schools*' and the '*National Environmental Education Guideline*'. In the syllabus on environmental education, as a cross-disciplinary theme, students are recommended to collectively apply knowledge from various subjects in an innovative curriculum, *integrated practical activity curriculum* (IPAC)[2]. In addition, it is especially encouraged to carry out environmental education as a domain-specific subject in itself and to find the necessary course time in the reformed *school curriculum* and *local curriculum*[3]. The innovative curricula are the outcomes of the seventh and eighth curriculum reforms as part of the decision to progress decentralization and essential-qualities-oriented education (Su Zhi Jiao Yu) (SE2, SE5, SE6)[4]. Environmental education when planned in IPAC, the local and school curriculum, is one of many educational themes, such as health education and safety education. In contrast with the growing support stated in the educational policy discourse, the actual inclusion of environmental education in the school agenda remains marginalized. According to a survey study conducted across 25 provinces in China by Cui and Wang (2006), the course time[5] of IPAC and the school

2 Integrated Practical Activity Curriculum (IPAC) is defined as a compulsory course in 2001 in the eighth curriculum reform in China. The eighth curriculum reform was initiated in 1999 and is still in progress. The Integrated Practical Activity is an innovative curriculum with an essential-qualities-oriented education as its aim. The suggested themes are: inquiry-based learning, community-based learning and social participation, labor skills, and information and communication technology.

3 The decision to implement a school curriculum and a local curriculum was taken in 1999 in the seventh curriculum reform in China. The seventh curriculum reform was from 1992 to 1999. School curriculum and local curriculum are proposed with an intention to give more autonomy in curriculum design to schools located in different provinces. Therefore, the local curriculum leaves freedom for all levels of educational administrations under the central government to decide curricular policies, design materials, and activities with a close relevance to its locality. The school curriculum is open for schools to decide on topics and activities from their particular interest and locality. The establishment of a local curriculum and a school curriculum is further confirmed in the eighth and ninth curriculum reforms.

4 All the documents are listed in appendix II.

5 The course time of IPAC is defined in the "Compulsory Education Curriculum pilot program" (Yi wu jiao yu ke cheng she zhi shi yan fang an) promulgated in 2001 by the Ministry of Education. The course hours of IPAC SBC and the Local curriculum together account for 16%-20% of the total of curriculum hours.

curriculum are often used instead for other major courses, in particular English, Chinese and mathematics. And within the limited courses, the activities are restricted merely to free sports and art crafts making (Cui & Wang, 2006). Considering the current state of environmental education in China, it is appropriate to identify opportunities for advancing substantive environmental education practices in schools and thus for improved learning outcome to meet its goals.

We see it as urgent to deepen our understanding of the implementation problem before we define where to focus the research effort of this study. In searching for explanations about the difficulties environmental education in China experiences, we notice that a similar difficulty is addressed in studies from various contexts (Barrett, 2007; González-Gaudiano, 2007; Gruenewald & Manteaw, 2007; Hackings, Scott, & Barratt, 2007; Lotz-Sisikta & Schudel, 2007; Stevenson, 1987, 2007). The notion of the rhetoric-practice gap is supported by Stevenson and other researchers who provide insightful explanations for the frustrated implementation of environmental education.

3 Rhetoric-practice gap

International debates on environmental education have largely recognized a disconnection between an abundance of plans, guidelines and curricula on the one hand, and on the other hand, their unsatisfactory implementation in schools (Van Koppen, 2007). This indicates that achieving the envisioned goals of environmental education may face resistances. According to Stevenson (1987), the problematic tensions in the frustrated implementation of environmental education in school agenda can be explained by a rhetoric-practice gap between environmental education and general school education. The rhetoric of environmental education implies particular kinds of curricular and pedagogical practices, which are not accepted in general schooling. Since it was first discerned in the 1980s, the rhetoric-practice gap has been an ongoing concern in environmental education research and has been observed by a number of authors in more recent studies elsewhere, according to a review of Gruenewald and Manteaw (2007).

According to Stevenson (1987, 2007), the curricular and pedagogical practices of schooling fundamentally reflect the mainstream or dominant beliefs, values and norms held by those in political power. Therefore, schools convey prevailing norms and contribute to the reproduction and maintenance of the existing structure of society. Schooling thus primarily concerns the transmission of factual knowledge, routine skill, values, and beliefs held by the dominant political and social power. By doing so, schools are helping students to pursuit individual status and economic well-being in society, whereas the goals desired in environmental education are concerned with alleviation of environmental exploitation and avoiding injustice. Harmony between humanity and nature means interdependency and collective responsibility. Environmental education pursues to develop students' ability of noticing and inquiring into environmental problems; to critique and defend their own environmental beliefs and choices; to be prepared to act innovatively according to their choices, critically contribute solution to environmental problems. Since the nature of environmental education necessitates particular kinds of curriculum and pedagogy to achieve is envisions, environmental education contrasts with general schooling extensively in curricular and pedagogical aspects. According to the review of Hacking et al. (2007), Stevenson's contention of the curricular and pedagogical contrasts is respectively identified in goals and curriculum framing, determination of curriculum and pedagogy, function of knowledge, teaching and learning processes, role of students, role of teacher, development of knowledge, and assessment. The rhetoric-practice gap helps to explain the resistances that environmental education received in schools. The perceived contrasts between educational purposes and curricular features need to be examined more critically on their nature and evidence in China.

This study contributes to a contemporary perspective from China to provide evidence for the gap, and to explicate the tension that may be caused by it. We intend to look for not only resistance in China but most importantly, the opportunities in China to advance environmental education in schools. Stevenson (2007) also claimed that reducing the gap is possible, and re-examined the movement of the political discourse that shaped school practices over the past decades. This re-examination may concern new trends or continuities within the discourse of environmental education per se, and the course of general political discourse. We consider the possibility that schooling needs not to be merely assessed as a resistance to environmental education.

Firstly, as Stevenson (2007) noted, in the course of the general political discourse, we would be alert for new spaces that have a potential to improve the inclusion of environmental education. One example is the notion of ecological modernization being recognized in the political discourse in

Germany, the Netherlands, the United Kingdom and China. According to the interpretation of ecological modernization, a harmonious relation of ecology and economy is to be achieved by scientific-technological innovation as a key driving force. The appraisal of ecological modernization indicates a new orientation for environmental education to be possibly adapted and promoted within the schooling system.

Secondly, we should also look for recent shifts in curricular policy and the defined acceptable practices in schools, in order to identify positive spaces for advancing environmental education. We consider that the contest of environmental education discourses and other competing discourses can be examined in its manifestation. Such a manifestation often takes the form of the production of a curriculum (Letschert & Kessels, 2003). Especially for the on-going curriculum reform in China, which continues pursuing essential-qualities-oriented education and encourages comprehensive competences of students, its meaning to environmental education should be closely examined. In this examination, we hope to be explicit about where the tension that creates the rhetoric-practice gap arises and thus to gain some improved insights in opportunities to reduce the tension.

Thirdly, we are aware of the need to have teachers engaged in environmental education curriculum development. The discourse of environmental education as stated in the curricular guidelines should be examined in relation to teachers' practices of the actual inclusion of environmental education into their teaching agenda. As we noticed from our tentative investigations in several schools in China, Qinghai province, for most teachers, environmental education creates a conflict with their current teaching and learning approaches. However, most teachers have little experience and have not been supported in this task. As observed by Lotz-Sisikta and Schudel (2007) and Stevenson (2007), the interpretation at the level of teachers and in their curricular and pedagogical practices is often neglected. It is therefore argued to have a perspective shift from teachers implementing to enrich teachers' learning experience of inquiring environmental problems. What is needed at the school level are not only learning and teaching support materials with tangible stimulus examples, but also an appreciation of teachers' commitment in environmental education. The ultimate purpose of empowering teachers is to acquire a shared understanding of how environmental education can best be taught to students in a particular context in China. How such an understanding can be acquired will be exemplified through a design-based study further introduced in the next section.

4 Design research

In this study, we choose design research as our research approach, because it is considered appropriate for solving practical problems and/or research questions calling for developing an intervention with the purpose of identifying optimal conditions. Design research can be placed within the framework of research approaches as 'narrative research', 'phenomenology', 'grounded theory', 'ethnography', and 'case study research' (Meijer, Prins, Bulte, & Pilot, 2008). The initiation of design research can be understood as a response to disappointment about the effect of conventional research approaches in education science (Walker, 2006). As Plomp (2006) recognized, the insufficient quality of much educational research is argued from the lack of relevance for practices (Reeves, 2006; Van den Akker, Gravemeijer, McKenney, and Nieveen, 2006), and from the over-ambitious claims of much educational research (Van den Akker, 1999; Walker, 2006). As Walker stated, these traditional research approaches only occasionally take into account how students and teachers really respond to specific features of a theory-driven design. Van den Akker argued that considering the complex nature of educational reforms worldwide, rather than claiming ambitious reforms, systematic research on implementation processes in various contexts deserves more efforts.

Design research investigates the design process itself in relation to the effect of the designed products. Designers do research to show that their designs function as theoretical criteria predict in a certain context. The tests of a design in school practice give evaluative suggestions on how a precise configuration in a design needs to be tuned and optimized. Design research is by its nature relevant for educational practices and therefore also for educational policies. In reviewing the state of educational research, we argue in line with Meijer et al. (2008), Plomp (2006) and Reeves (2006) that instead of comparing 'whether method A is better than B in a certain context', and comparing 'why method A is better in context X and why method B is better in context B', design research is more relevant for recognizing opportunities and developing optimal solutions in addressing complex problems for which no or only a few solutions are available. Designing an intervention is essential in design research. Detailed design of a domain-specific lesson unit and a sequence of teaching and learning activities are accompanied by argued expectations of how a sequence or unit is functioning and why (Meijer et al., 2008). The design of the intervention is supported and structured by a theoretical framework, a set of 'design criteria' (Reeves, 2006; Van den Akker, 1999; Van den Akker et al., 2006). The aim is to capture the most appropriate knowledge and to explicate the implicit decisions associated with the domain-specific and context-based design task, and to transform them into guidelines that seem promising to solve the problems. The value of the criteria increases when they are convincingly backed up with empirical evidence about the impact of the criteria, and validated in similar interventions in various contexts (Plomp, 2006). Therefore, a design study yields outcomes for three aspects, the intervention product, the theoretical outputs in the forms of validated design criteria and a context-based domain specific teaching-learning strategy, and professional development of the involved practitioners gained in the engagement of the design study.

5 Environmental literacy

As Roth (1992) argued, we are still relatively vague about what it is we are trying to accomplish with environmental education. The ultimate goal of environmental education is to form an environmentally literate citizenry (Disinger & Roth, 1992; Hungerford, Peyton, & Wilk, 1980; Roth, 1992; UNESCO, 1980). As is acknowledged in literature on the concept of environmental literacy, a universally accepted definition of environmental literacy is still lacking. Roth's initial effort in the late 1960s is identified as the earliest emergence of the notion of environmental literacy (Chu et al., 2007; Clair, 2003; Disinger & Roth, 1992; Hsu & McBeth, 2010; Roth, 1999; Swanepoel, Loubser, & Chacko, 2002). The following definition provided by Roth in 1992 is widely accepted: *environmental literacy involves human discourse about inter-relationships with the environment, and it is considered as our capacity to perceive and interpret the relative health of environmental systems and take appropriate actions to maintain, restore, or improve the health of those systems* (Roth, 1992). The concept of environmental literacy has also been linked with sustainable development. In 1989, UNESCO-UNEP offered the following conceptualization of environmental literacy: a basic functional education for all people, which provides them with the elementary knowledge, skills and motives to cope with environmental needs and contribute to sustainable development. Operationally, environmental literacy is an individual's knowledge about and attitudes towards the environment and environmental issues, skills and motivation to work towards the resolution of environmental problems, and active involvement in working towards the maintenance of dynamic equilibrium between the quality of life and the quality of the environment (Hsu & Roth, 1999; Roth, 1992). In sum, as indicated by Roth (1992), environmental literacy draws upon four strands of learning outcomes: knowledge, skills, affect (sensitivity, attitudes, and values) and behavior (personal investment, responsibility and active involvement). This study has as its goal to attain environmental literacy of pupils in China, encompassing the four strands.

6 Scope and objective

Following our general research concern, two issues are central to this study. One is to know the current state of environmental education in schools in China, for the awareness of a rhetoric-practice gap. The other, after having identified a gap, is to design an educational intervention as a curricular solution of how environmental literacy of students can be best included in school education in China. Selected schools in China will serve as a test bed to design the curriculum unit, implement it, validate it and refine it. Considering the relatively higher pressure of standard tests in lower secondary schools, we focus on environmental education in primary schools. This study is formed by two studies, an explorative study to reveal the probable rhetoric-practice gap, and a design study to develop a curricular solution, a scenario, to narrow the gap if defined, to better attain environmental literacy.

Main Objective

This study has as its goal to attain environmental literacy of pupils in China, more particularly, to investigate how environmental literacy can be best included in the curriculum, in taking into account a possible gap between environmental education and general schooling.

Sub-objectives

1. We intend to show whether there is a gap between environmental education and schooling in China, and what the tensions are that create that gap.

2. We intend to identify curricular solutions to ease the tension of the rhetoric-practice gap. We hope to contribute to a Chinese perspective on how ideal environmental education would optimally be carried out in school practices.

3. We intend to show how, when environmental education exists, students' environmental literacy can be incorporated in the curriculum while optimizing the available space in current schooling.

This study is primarily intended for curriculum designers/developers of environmental education. However, it should be also useful for teachers, administrators, and any other educational professionals who participate in making collective decisions for environmental education curricula. It may also give insights for science communication campaigns that target raising the environmental literacy of children in China today. This study is about sharing and contributing to an exchange of understandings on how an environmental education curriculum may optimally fulfill ambitions by offering a perspective from China.

7 Research questions and chapter outline

General research questions

Is there a rhetoric-practice gap evidenced between environmental education and general schooling in China, and if so, how is it evidenced?

What are the characteristics of a curricular solution that effectively built environmental literacy, taking into account the probable rhetoric-practice gap in China?

Sub-questions and chapters outline

Chapter 1: What are the initiation, value, and focus of this study?

Chapter 2: What is the conceptual framework for defining the rhetoric-practice gap in China?

Chapter 3: What is the research design of the explorative study, the logic of research activities?

Chapter 4: What is the nature of the school education and environmental education in the rhetoric?

Chapter 5: What is the nature of the school education and environmental education evidenced in curriculum products?

Chapter 6: What is the nature of the school education and environmental education performed in actual practices?

Chapter 7:	Who are the involved actors in the possible rhetoric-practice gap?
Chapter 8:	What is the evidence of the rhetoric-practice gap in China?
Chapter 9:	What is the application of environmental education in the current curriculum system? What is the space suitable for a design study in it?
Chapter 10:	What is the research design of the design study, the logic of research activities?
Chapter 11:	What are the criteria for designing the scenario?
Chapter 12:	What is the scenario and how is the scenario as a curricular solution developed?
Chapter 13:	How is the scenario implemented?
Chapter 14:	What has the scenario accomplished as a curricular solution in improving students' environmental literacy?
Chapter 15:	What has the scenario accomplished in providing the intervention product, the teachers' professional development advices, and theoretical outputs?
Chapter 16:	What has the scenario accomplished as a curricular solution in closing the rhetoric-practice gap? And what would be the optimal application of environmental education in meeting the challenges that exist in the current curriculum system in China?

Chapter 2 Theoretical Framework for the Explorative Study

1 Introduction

In China, environmental education remains peripheral in the school agenda (Cui & Wang, 2006; Wang et al., 2004; Wasmer, 2005). Guided by the research concern of how environmental literacy can be best introduced in current school education in China, we first have to confront an implementation problem. The question of building environmental literacy in school education in China cannot be answered separately from an understanding of why environmental education is marginalized and how it can be optimally included in the school agenda. A conceptual framework is required to guide our investigation into the actual state of environmental education in China. The framework is built around the concern of the rhetoric-practice gap in explaining the position of environmental education in the current Chinese educational scheme. The framework is constituted from three perspectives: rhetoric-practice gap, curriculum representations, and curriculum elements. The framework outlines that when included in curriculum system of current schooling, environmental education may have tension or gaps between the vision described in the intended curriculum, the link that converts the vision into materials potentially to be implemented, and the practice actually implemented in schools.

2 Rhetoric-practice gap

2.1 Stevenson's notion of the rhetoric-practice gap

We began in chapter 1 with an introduction of the rhetoric-practice gap as posited by Stevenson and re-conceptualized by other researchers. We referred to it to help explain the problematic gap that frustrates the inclusion of environmental education in the current school agenda. In this study, the notion of the rhetoric-practice gap serves as an explanatory perspective that mostly underpins our vision of the current state of environmental education in China.

Summarized, Stevenson (1987) states that the rhetoric of environmental education implies particular kinds of curricular and pedagogical practices that necessitate the achievement of the stated goals, such as to be responsible for sustaining the environment, or to be critical for environmental problems and choices. Whereas in reality, the practices in schooling are framed by other political discourses that are in line with the prevailing culture and dominant policy e.g. pursuing an agenda of economic modernization, or conveying prevailing social norms. As Stevenson explained, such contradiction resulted in a rhetoric-practice gap. According to Stevenson's contention (1987, 2007) and a review of Hacking et al. (2007), the contrasts between environmental education and conventional schooling can be defined with eight curricular and pedagogical aspects. A detailed list of contradictions has been presented below.

Table 2.1: Curricular and pedagogical contrasts between environmental education and schooling

Curricular & pedagogical aspects	Environmental education	Schooling
1. Goals and curriculum framing	An interdisciplinary approach (holistic) with a focus on real practical problems, content arises when students are involved in specific, authentic environmental problems	A discipline-based approach (fragmented) with emphasis on abstract theoretical problems, content is defined as removed from life experience
2. Determination of curriculum and pedagogy	Problematic, uncertain issues with students' involvement in inquiring and solving, adapting to students' social construct, highly flexible	Predefined to serve predetermined specific ends, and assessed by clearly defined criteria
3. Function of knowledge	Immediate use for sustainable and emancipated quality of life, knowledge is not merely directed toward action, rather to prepare for inquiry and taking action in exerting influence on the environment	Storage for future use and enhancement of individual status and economic well-being, knowledge is for individually use in their later life, e.g. university attendance, job searching
4. Teaching and learning processes	Collaborative process of inquiry into and action on real environmental issues, with students actively engaging in critical or complex thinking about real problems	Individual process in which teacher is leading and students' participation is limited to making response to teacher questions raised largely to recite already defined factual knowledge and well-structured problem
5. Role of students	Active and critical thinker, generator of knowledge	Passive recipients of factual knowledge and already determined, correct solutions
6. Role of teacher	Should be amenable to students' autonomous decisions; teachers are agents and have their own view and ideology about education that shape their curricular and pedagogical decision-making	Dispenser of factual knowledge

Curricular & pedagogical aspects	Environmental education	Schooling
7. Development of knowledge	Complex and contradicting information resources, uncertainty about solution, high relevance of real life world problem, critical thinking and cooperative learning, holistic disciplinary integration	Disciplinary-derived unproblematic truth and factual information, standard-based knowledge, predefined problem with agreed correct solutions
8. Assessment	Process of inquiry, critique and reflection with assistance to develop and defend their own environmental beliefs and choice, and ability to act according to their choice	Student achievement measured by content-area test for passive assimilation and reproduction of factual knowledge, emphasize the mastery of fragmented facts, concepts; the test occur in artificial situations on theoretical materials removed from students present or future life experiences

2.2 Re-conceptualizing the gap

The rhetoric-practice gap helps to explain the resistance that environmental education received in its introduction at schools in the 1980s. The rhetoric-practice gap has been an ongoing concern in environmental education research. This can be evidenced by the continuing frequent citations of Stevenson's statement of twenty years ago and has been observed by a number of authors in their recent studies elsewhere. According to the review by Gruenewald and Manteaw (2007), ever since Stevenson's 1987 essay, several texts were published. More details can be found in the work of Orr (1992, 1994), Bowers (1993, 1997), Fien (1993), Huckle and Sterling (1996), Hart (1997), O'Sullivan (1999), Smith and Williams (1999). These research efforts converged into a comprehensive critique of structural, ideological, pedagogical and curricular practices of the dominant schooling practice that continue to work against the goals of environmental education.

2.3 An extended diagram for the rhetoric-practice gap in China

We have an increasingly clear idea of what is required for environmental education and what is supported in schooling. The summary of the rhetoric-practice gap by Stevenson and others represents a starting point for our exploration. We take the stance of a rhetoric-practice gap in exploring the actual state of environmental education in China. In listing the contrasts, we come to realize the ambiguities in the term 'rhetoric-practice gap'. We stress a critique of the rhetoric-practice gap claim which does not demonstrate explicitly what ‘rhetoric’ and ‘practice’ mean for environmental education and schooling respectively. To use the concepts in our research, it is crucial to critically unravel the notions of ‘rhetoric’ and ‘practice’ in relation to environmental education and schooling, in considering that environmental education can actually be a part of schooling.

As noted by Stevenson (1987), environmental education states in its rhetoric a set of necessary curriculum and pedagogical practices, while the schooling practices are structured according to another prevailing culture and dominant policy. As Stevenson explained, such contradiction resulted in a rhetoric-practice gap. Here the confusion arises: does the rhetoric-practice gap represent the gap between the rhetoric of environmental education and the practice of schooling, or the gap vice versa, or even the gap between the rhetoric and the practice of environmental education itself? With this caution, we come up with a diagram showing an inclusive representation of Stevenson’s term.

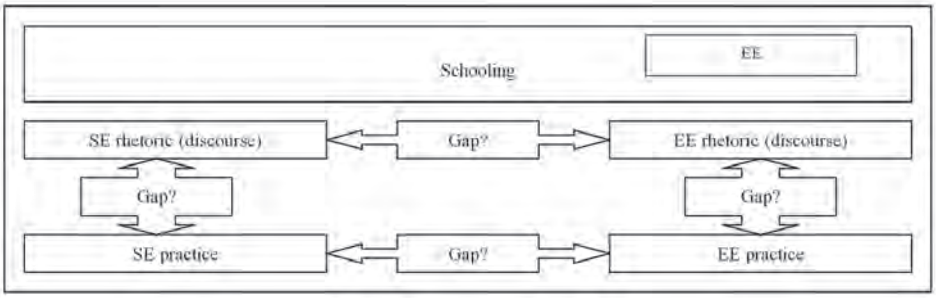


Figure 2.1: An extended diagram for rhetoric-practice gap in comparison of school education (SE) and environmental education (EE)

In figure 2.1 environmental education is presented as a part of schooling. We accept that this is so, because as long as environmental education is conducted as school education, it is a part of that schooling. Opportunities arise from this acceptance. The terms ‘rhetoric’ and ‘practice’ are applied to schooling and its subset environmental education. The opportunities are possible interpretations of the rhetoric-practice gap in speculating on its evidence in China. As the figure shows, several conjectures appear: (1) What is the rhetoric of general schooling? And what is the rhetoric particular to environmental education? How are they related? Is there a gap? (2) What are the practices of schooling in general and environmental education in particular? How are they related? Is there a gap? (3) In schooling in general, how is its rhetoric related with its practice? Is there a gap? (4) And in environmental education particularly, how is its rhetoric related with its practice? Is there a gap? (5) How do the dynamics of rhetoric-practice in schooling and the dynamics of rhetoric-practice in environmental education compare and relate? Is there a gap? We will include these issues in the investigation of the actual state of environmental education in China.

To conclude, we begin with clarifying the two facets of the contrasts defined by Stevenson and supported by others. We then come up with a diagram (as in figure 2.1) showing an inclusive representation based on Stevenson's term. However, we also come to a realization of one critical ambiguity, with which we argue for a need to consider the notions of 'rhetoric' and 'practice' for all possible evidences of the gap in environmental education in China. And the diagram can be extended when we take into account theories on curriculum

3 Curriculum representation

In order to further elaborate the diagram of figure 2.1, we give our first attention to the theory on curriculum representation.

3.1 Curriculum representation

From an analytical perspective, problems occurring in curriculum changes can be explained by a three-level representation including six sub-representations (Goodlad, 1979; Van den Akker 2003). In table 2.2, the representations are established in four notable curricular activities (Van den Akker, 2003). In a curriculum system, gaps may occur among three representations as outlined in table 2.2. The intended curriculum, as expressed in documents or materials, is built as a result of policy making, design and development. The implemented curriculum, as shown in teaching practices, is established in the activity of implementation. Finally, the attained curriculum, as manifested in learners' learning experiences and outcomes, is assessed in the activity of evaluation.

According to Van den Akker (2003), the typology of curriculum representations is useful to sketch curriculum design in a problematic situation, where there are tensions between representations, and frustrations among involved actors. In a similar vein, McKenney, Nieveen, and Van den Akker (2006) have pointed out that harmony between the representations is required to make robust curriculum designs.

Table 2.2: Curriculum representation and curricular activity (Goodlad, 1979; Van den Akker 2003)

Curricular activity	Curriculum representation		
Policy making & design and development	Intended curriculum	Ideal	Vision (rationale or basic philosophy underlying a curriculum)
		Formal/written	Intentions as specified in curriculum documents and/or materials
Implementation	Implemented curriculum	Perceived	Curriculum as interpreted by its users (especially teachers)
		Operational	Actual process of teaching and learning (also: curriculum-in-action)
Evaluation	Attained curriculum	Experiential	Leaning experiences as perceived by learners
		Learned	Resulting learning outcomes of learners

3.2 A tripartite model of curriculum

Following the idea of curriculum representations (Goodlad, 1979; Van den Akker, 2003), it must be noted that the yielded curricular products are implied in the sketch of curriculum representations. From the standpoint of our research, the products are the teaching materials and policy documents. We could discern that the intended curriculum, e.g. visions and intentions, is documented and can be acquired through educational and curricular documents, whereas according to the sketch of curriculum representations, textbooks and other teaching source materials cannot be placed unambiguously as either the intended, the implemented, or the attained curriculum. As we proved in our preliminary field visit in schools in China, textbooks provided a predominant source for classroom teaching, providing identified topics and a mix of teaching methods, exercises and assignment that support teachers. Johansson (2005) also noticed the crucial role of textbooks and proposed to pay particular attention to the appropriateness of textbooks in translating the stated visions into instructions at classroom level. To address this issue, we find further support in the tripartite curriculum model by Valverde, Bianchi, Wolfe, Schmidt, and Houang (2002) (see figure 2.2).

In the tripartite model, a crucial bridging curriculum representation is introduced, i.e. the potentially implemented curriculum. Therefore the potentially implemented curriculum shows the link between the intended curriculum and the implemented curriculum. In the model, textbooks and other teaching resource materials represent the potentially implemented curriculum. Hence, the translation process from the intended to the implemented is made explicit, as the salient role of textbooks and materials becomes distinguishable. The three-level model of curriculum representations is extended to four levels.

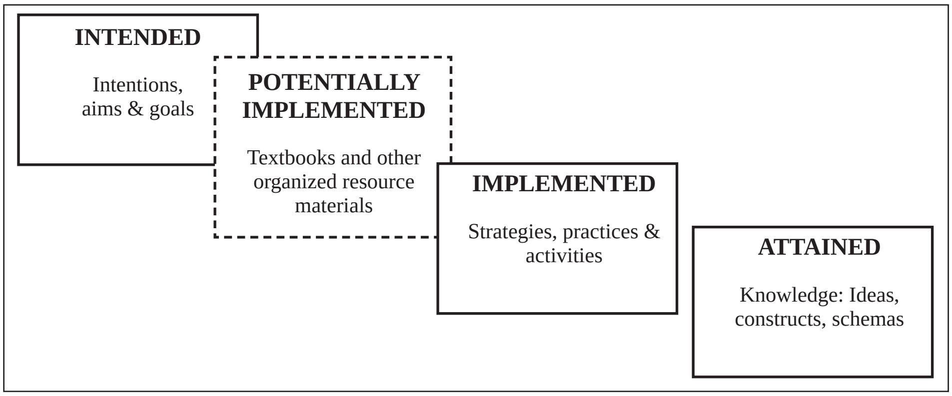


Figure 2.2: The tripartite model of curriculum (Valverde et al., 2002)

In conclusion, typology of the four-level model of curriculum representation is useful to sketch problems occurring within the curriculum, by which the tensions or gaps among the representations can reveal and pinpoint where the rhetoric-practice gap has arisen.

4 An analytical framework of curriculum analysis for the rhetoric-practice gap

4.1 An inclusive perspective of curriculum analysis for the rhetoric-practice gap

Drawing on the typologies discussed above, it is now possible to present an inclusive view on curriculum analysis in investigating the rhetoric-practice gap. The tripartite model added a distinct 'link', by which the translation process from 'rhetoric' to 'practice' becomes visible. Therefore, any possible gaps might occur among the intended, potentially implemented, implemented and attained curricula. Taken together, the contributions from Goodlad, Van den Akker, and Valverde et al. have enabled us to have a clear view on the transferring process from rhetoric to practice, as in table 2.3.

Firstly, the 'rhetoric' is the intended curriculum, presented in policy and curriculum documents, and it is related to the activity of policy making. Secondly, the 'link' is the potentially implemented curriculum, presented in textbooks and other organized materials, and it is related to the activity of design and development. Thirdly, the 'practice' is the implemented curriculum, represented in teaching operations enacted in classes and in teachers' interpretations, and it is related to implementation. Finally, through these processes, goals are possibly attained which comprises the learning experiences from pupils and the resulting learning outcomes measured in the evaluation.

Table 2.3: An inclusive perspective of curriculum analysis for rhetoric-practice gap

Analytical levels	**Rhetoric-practice gap**	**Tripartite curriculum**	**Curriculum representations**	**Curricular activities**	**Products**
	Stevenson (1987, 2007)	Valverde et al. (2002)	Goodlad, (1979); Akker (2003)	Akker (2003)	Valverde et al. (2002)
Rhetoric	Rhetoric	Intended	Ideal & formal/ written	Policy -making	• Policy documents • Curriculum guidelines/ criteria
Link		Potentially implemented	Formal/written	Design and development	• Text books • Teaching materials
Practice	Practice	Implemented	Perceived & operational	Implementation	• School practice • Classroom practice
Literacy		Attained	Experiential & learned	Evaluation	• Constructs

4.2 An analytical framework of the rhetoric-practice gap

The distinctions made above now allows us to present a figure showing the analytical framework for our investigation into the possible rhetoric-practice gap (see figure 2.3). The figure shows that the 'rhetoric' (intended curriculum) is translated by the 'link' (potentially implemented curriculum) into the 'practice' (implemented curriculum). Through this procedure, the curriculum attained is for an enhanced environmental literacy. With this analytical framework, the complexity of the gap from rhetoric to practice is illustrated and shows possible gaps or tensions.

The rhetoric-practice gap can occur in environmental education and in school education. As seen in figure 2.3, seven gaps can possibly occur. However, the figure is only to show a systematic overview of all possible gaps. Given the research goal and the limitations in research time and resources, the rhetoric-practice gap of general school education is not investigated in this study.

Consequently, it is indicated in the figure in dashed lines. We focus on the rhetoric-practice gap in environmental education as it occurs within school

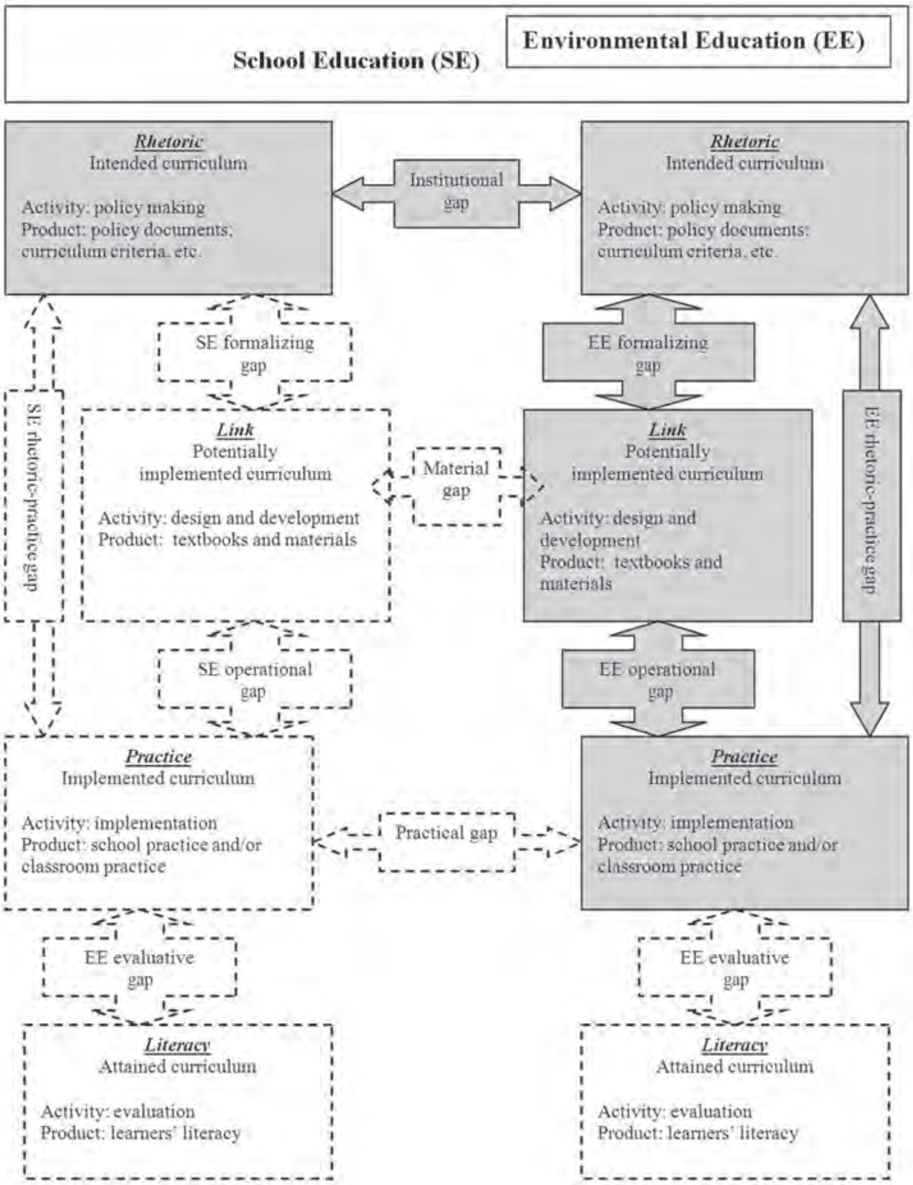


Figure 2.3: An analytical framework of the rhetoric-practice gap (based on Stevenson, 1987; Van den Akker, 2003; and Valverde et al., 2002).

education. As indicated in figure 2.3, this study investigates ‘the rhetorical gap’, ‘the EE formalizing gap’, and ‘the EE operational gap’, emphasized in light gray in the figure.

The analytical framework serves as an outline, and in effect, a shell for the data to enter. To assess the evidence, nature, and extent of the rhetoric-practice gap, we also need to identify actors of the various curricular activities. In elaborating on this analytical framework, we design methods to obtain data for characterizing the curriculum representations and for identifying actors involved in the curricular activities.

5 Curriculum elements

Having outlined our analytical framework, we now need to further develop an instrument to capture the nature of each curriculum representation. The concern of this section is to have theoretical input from the perspective of curriculum components. An instrument of curriculum elements analysis is developed to contribute with clear ideas about how to characterize the intended, potentially implemented, and implemented curricula.

5.1 Defining curriculum and components

Trying to absorb and interpret the vast literature on curriculum theory would cause more confusion than enrichment of our view. To make conceptual clarification obtainable, our main focus is on giving an analytical endeavor responding to curricular implementation challenges in environmental education. With this orientation, it helps to reduce the complexity of curriculum theory by selecting a set of notions and perspectives. Those we chose are insightful in explicating possible curricular aspects to identify, receive and test promising solutions for the advancement of environmental education inclusion into school agenda. The word curriculum has a well-accepted definition by Taba (1962) ‘plan for learning’. This learning plan may be embodied in something concrete to be carried out, such as a course, a program, a guide, textbooks, and teacher plans (Snyder, Bolin, & Zumwalt, 1992). This most obvious interpretation is adequate to begin our clarification of curriculum.

We concur with Van den Akker (2003) that in terms of curriculum design and implementation problems, it is wise to elaborate on curriculum components specifying the planning for student learning. Based on the work of Eash (1991) and Klein (1991), ten components are proposed and presented.

In sum, Van den Akker (2003) states that the rationale component serves as the orientation point and it is the central point of the plan to which the other nine components are linked. Apparently, the components do not exist independently from each other, and should be considered in coherence.

5.2 Coherence among curricular components

According to Van den Akker (2003), the importance of coherence among the correlated ten components is illustrated in a spider web metaphor (see figure 2.4). Presenting the components in such a metaphor emphasizes that any dramatic shift in balance will pull the entire web out of alignment and stretch the system to breaking point when the imbalance is prolonged. The very valuable reminder for curriculum development researchers is that efforts to reform, redesign or implement curricula must pay careful attention to the balance and linkages among the ten components (Mckenney, Nieveen, & Van den Akker, 2006).

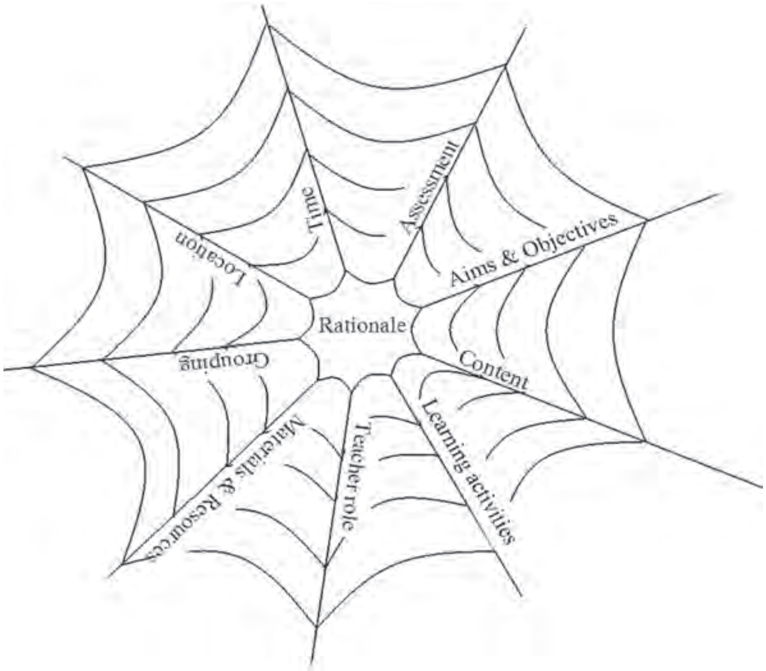


Figure 2.4: Curricular component spider web (Van den Akker, 2003)

5.3 Developing an instrument of curriculum elements analysis

In order to reveal the rhetoric-practice gap of environmental education that is inherent in the current school curriculum system, we need an instrument to help identifying the pattern of the curriculum. In table 2.5, an instrument of seven curriculum elements is presented. We compared Stevenson's eight curricular and pedagogical aspects (1987) (see table 2.1) and Van den Akker's ten curriculum components (2003) (see table 2.4). The purpose is to measure the actual state of environmental education within school from the eight curricular aspects by considering them as curriculum components that are in relation with each other. As shown in table 2.5, the seven curriculum elements, i.e. rationale, content, process, teacher, students, and assessment are generated in combining related curricular aspects and components. And each of the elements, as a coding theme is measured further by one or more sub-codes. For example, the curriculum element rationale is generated in combining Stevenson's items 'curriculum framing' and 'determination of curriculum and pedagogy' and Van den Akker's item 'rationale'. As a coding theme, 'rationale' is measured by four sub-codes, i.e. disciplinarity, focused problem, characteristics of study issue, and conclusion/solution.

Table 2.4: Curriculum components (Van den Akker, 2003)

Rationale: Why are they learning?
Aims and objectives: Toward which goals are they learning?
Content: What are they learning?
Learning activities: How are they learning?
Teacher role: How is the teacher facilitating learning?
Materials and resources: With what are they learning?
Grouping: With whom are they learning?
Location: Where are they learning?
Time: When are they learning?
Assessment: How far has learning progressed?

The value of the seven curriculum elements is twofold. For the explorative study, the curriculum elements serve as coding themes to identify the nature of each curriculum representation. And for the design study, the curriculum elements serve to structure the scenario with the intention of closing the gap for enhanced environmental literacy.

Table 2.5: An instrument for curriculum element analysis (revised from Van den Akker, 2003 and Stevenson, 1987)

Curriculum elements as coding themes	**Curricular and pedagogical aspects** (Stevenson, 1987)	**Curricular components** (Van den Akker, 2003)	**Issues and sub-codes**
1. Rationale	Curriculum framing Determination of curriculum and pedagogy	Rationale: Why are they learning?	● Disciplinarity (interdisciplinary/ discipline-based) ● Focused problem (real, practical specific, authentic/ abstract theoretical problems) ● Characteristics of study issue (problematic, uncertain, flexible / predefined, predetermined, specific ends, clearly defined) ● Conclusion/solution (uncertainty/agreed, correct)
2. Goals	Goals	Aims and objectives: Toward which goals are they learning?	● Function of knowledge (immediate use, sustainable/ future use, individual status, economic well-being)
3. Content	Development of knowledge	Content: What are they learning? Materials and resources: With what are they learning?	● Information (complex, contradicting / unproblematic, factual) ● Relevance (real life problem/removed from life experience) ● Path (critical thinking, cooperative learning, disciplinary integration/ predefined problem, standard base)
4. Process	Teaching and learning processes	Learning activities: How are they learning? Grouping: With whom are they learning? Location: Where are they learning? Time: When are they learning?	● Cooperation (collaborative/ individual) ● Participation (active, critical/response to, factual knowledge) ● Engagement (inquiry into ill-structured problem/ response to well-structured problem)
5. Teacher	Role of teacher	Teacher role: How is the teacher facilitating learning?	● Role of teacher (facilitator, agents/dispenser)

Curriculum elements as coding themes	**Curricular and pedagogical aspects** (Stevenson, 1987)	**Curricular components** (Van den Akker, 2003)	**Issues and sub-codes**
6. Student	Role of students	*Student role: How is the student participating in learning?	• Role of student (active, critical, generator/passive, recipients)
7. Assessment	Assessment	Assessment: How far has learning progressed?	• Assessment (process, own choice, holistic/ content test, factual knowledge, fragmented concepts, artificial situation, theoretical materials)

Note*: 'Student role' is not included in the curricular components defined by Van den Akker. In this study, the curriculum component of 'student role' is extended, based on its interrelationship to the component of 'teacher role'.

The issues and sub-codes mentioned in the table are inspired by Stevenson (1987). Their content will be futher elaborated and underpinned in chapter 11, Scenario Criteria.

Chapter 3 Methodology of the Explorative Study

1 Introduction

Building on the analytical framework, we lay out in this chapter a set of research methods including triangulation to explicitly describe the current state of environmental education in China. Motivated by the goal of revealing gaps or tensions that may change the attained environmental education, five data sets are used in addressing the intended, potentially intended, and implemented curriculum. Specifically, the intended curriculum is examined through document analysis and interviews with designers and policy makers; the potentially implemented curriculum is figured using content analysis of teaching materials; and the implemented curriculum is investigated through class observations and interviews with teachers and school principals.

Firstly, an overall research design is outlined. The five data sets are presented in the analytical framework of the rhetoric-practice gap established in chapter 2, by which the logic of data collection and analysis is explained. Secondly, referring to the theoretical assumptions built from Stevenson (1987) and Hacking et al. (2007), seven curriculum elements are defined, i.e. rationale, goal, content, process, role of students, role of the teacher, and assessment. The seven curriculum elements will serve as coding themes in describing composites of the curriculum representations. Thirdly, the five data sets are introduced with details of the procedures and technical instruments in the analyses.

2 Research design

The explorative study answers the question: what is the evidence for and nature of the rhetoric-practice gap in environmental education in China? To address this question, the research design is structured as indicated in the analytical framework (chapter 2, figure 2.3). With the goal of revealing gaps or tensions in environmental education in mind, we specifically focus on: 1) the formalizing gap between the rhetoric and the link, namely, the gap between the intended and potentially implemented curriculum of environmental education; 2) the operational gap between the link and the practice, namely, the gap between the potentially implemented and implemented curriculum for environmental education; 3) the institutional gap between two rhetoric blocks, namely, the gap between the intended curriculum for general school education and the intended curriculum for environmental education in particular. In figure 3.1, these gaps are highlighted in gray. The figure also presents the data sets for the analyses.

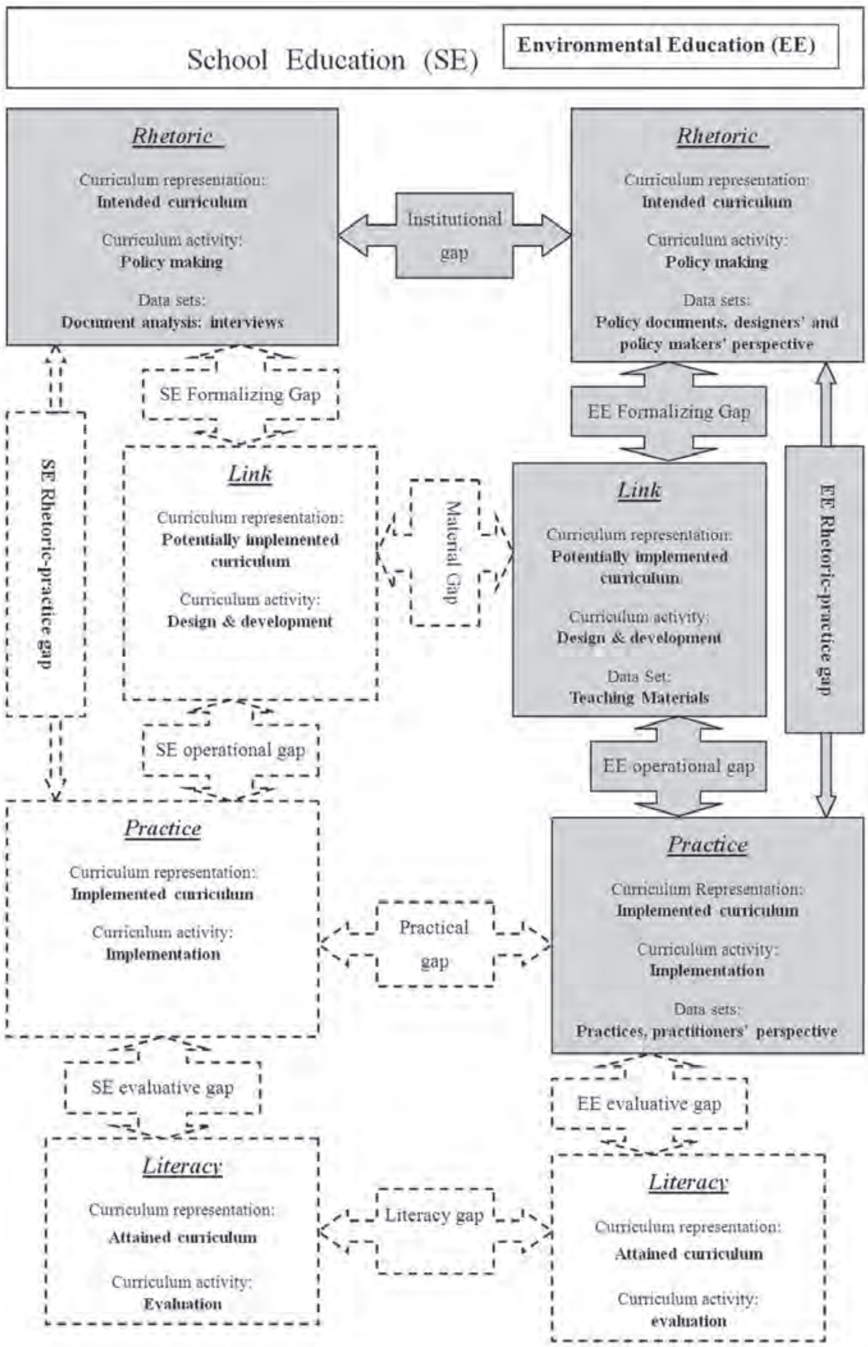


Figure 3.1: Data sets presented in the analytical framework

The institutional gap exists when the intended curriculum for school education is different from the intended curriculum for environmental education. Major actors involved in this gap will be those engaged in educational policy making. The intended curricula as embodied in policy documents are therefore studied through document analysis and interviews with designers and policy makers. The formalizing gap exists when environmental education as described in the intended curriculum is inconsistent with environmental education as presented in the potentially implemented curriculum. Major actors involved in this gap will be those engaged in curriculum design. The potentially implemented curriculum as presented in teaching materials is examined through content analysis. The operational gap exists when environmental education as presented in the potentially implemented curriculum is not fulfilled in the implemented curriculum. Major actors involved in this gap will be those engaged in actual implementation. The implemented curriculum as it exists in schools' actual teaching practices is analyzed using field observations and interviews with teachers and principals.

With this analytical framework, we firstly characterize the intended curriculum (rhetoric) in chapter 4, the potentially implemented curriculum (link) in chapter 5, and the implemented curriculum (practice) in chapter 6. And then, in chapter 7, we identify the actors involved in the four curricular activities, i.e. policy making, design and development, implementation, and evaluation.

3 Instrument of curriculum elements as coding themes

In this section, we use the instrument of seven curriculum elements (see chapter 2, table 2.5) to further clarify the coding themes applied in characterizing curriculum representations.

3.1 Analytical assumptions on curriculum elements

Each curriculum representation is studied for the extent of agreement with the assumptions about curricular features of environmental education and school education. Based on the work of Van den Akker (2003), Stevenson (1987, 2007) and the review by Hacking et al. (2007), we can formulate the following analytical assumptions for the seven curriculum elements. For each of the elements we summarize both for general school education and for environmental education to provide a comparative perspective.

1. Rationale:
    - The curriculum of environmental education takes a holistic, interdisciplinary approach (disciplinarity). The environmental education curriculum has its focus on real, practical, specific environmental problems (focused problem). The curriculum is determined by problematic, uncertain issues with students' involvement in inquiring, solving, and adapting to students' social constructs; therefore it is highly flexible (characteristics of the study issue). The conclusion or the solution for the studied problem is uncertain (solution and conclusion).
    - The curriculum of general school education takes a fragmented, disciplinary-based approach (disciplinarity). The curriculum has its focus on abstract theoretical problems removed from life experience (focused problem). The curriculum is determined by predefined issues to serve predetermined specific ends, and assessed by clearly defined criteria (characteristics of the study issue). The curriculum is composed of standard-based knowledge and predefined problems with agreed correct solutions (solution and conclusion).
2. Goal: The analysis of the curriculum goals is to understand the curriculum of environmental education from its notion of the function of knowledge (function of knowledge).
    - The analytical instrument assumes that in environmental education the function of knowledge is for immediate use for a sustainable and emancipated quality of life. In environmental education, knowledge is not merely directed toward action, but rather to prepare for inquiry and taking action in exerting influence on the environment.
    - The analytical instrument assumes that in general school education, knowledge is stored for students' individual future use, e.g. university attendance, job searching, and enhancement of individual status and economic well-being.
3. Content:
    - The content of environment education is built from complex and contradicting information resources (information source). The content is of high relevance for real life world problem (relevance to students). Content arises when students are involved in

environmental problem inquiry so that knowledge is developed by students rather than directly provided to them as facts (knowledge development path).

- The content of general school education is built from factual information (information source). The content developed is removed from life experience (relevance to students), without students' involvement (knowledge development path).

4. Process:
    - In environmental education, teaching and learning is a collaborative process (cooperation). In the teaching and learning process, students participate actively (participation). The students are engaged in dealing with the environmental problems (engagement).
    - In general school education, teaching and learning is an individual process (cooperation) in which the teacher is leading, and students' participation is limited to making responses to the teacher's questions (participation) that are asked largely to recite already defined factual knowledge and well-structured problems (engagement).
5. Teacher:
    - In environmental education, the teacher should be amenable to students' autonomous decisions. Teachers are agents having their own view and ideology about education which shapes their decisions on curriculum and pedagogy.
    - In general school education, the role of the teacher is considered that of a dispenser of factual knowledge.
6. Student:
    - In environmental education, students should be active and critical thinkers, and the generators of knowledge.
    - In general school education, students are passive recipients of factual knowledge and already determined correct solutions.
7. Assessment:
    - The assessment of environmental education evaluates the process of inquiry, critique, and reflection, and evaluates the extent to which students develop and defend their own environmental beliefs and choices, as well as their ability to act according to their choices.

- The assessment of school education is a content-area test for reproduction of factual knowledge, and emphasizes the mastery of fragmented facts and concepts. And the test often occurs in artificial situations on theoretical materials removed from students' life experiences.

These assumptions serve as points of attention when identifying the curriculum elements. We want to find out if the curriculum representations of environmental education or school education can be characterized as postulated in Stevenson's notion of the rhetoric-practice gap. Then it is possible to further reveal the discrepancy between the curriculum representations.

3.2 Coding themes of curriculum element analysis

Specifically, when characterizing the curriculum representations, the seven curriculum elements are used as coding themes to deductively gather relevant information from the data sets. Each coding theme of a curriculum element is further specified by one or several sub-codes, as has been indicated in the analytical assumptions with reference to chapter 2, table 2.5. In coding, we keep the analytical assumptions presented above in mind as sensitizing notions. We are also reminded to pay attention to the coherence among correlated curriculum elements. The coding will be used with due flexibility. As the curriculum elements are correlated, it can be expected that in classifying data the coding themes will not be entirely exclusive. Moreover, we may also search beyond the listed codes where other useful information is found in the data.

4 Data collection and data analysis

As outlined in the analytical framework (see figure 3.1), detailed data are collected to characterize each curriculum representation by using the instrument of the seven curricular elements (see chapter 2, section 5.3) in reference to the analytical assumptions in the previous section 3.1, and to recognize the actors involved in the four activities, i.e. policy making, design & development, implementation, and evaluation.

4.1 Document analysis

4.1.1 Purpose of document analysis

The document analysis is firstly to characterize the intended curricula by the seven curriculum elements as they are presented in the documents with reference to the analytical assumptions. Findings are then triangulated with policy makers' and designers' perceptions from the interviews. The document analysis is secondly to identify the actors involved in each of the curricular activities as described in the documents, in triangulation with the recognitions from the interviews. Finally, in comparing the two intended curricula, the 'institutional gap' between the two 'rhetorics' will be revealed, together with the actors involved.

4.1.2 Document selection

The selection of documents begins with a literature review on the topics of curriculum reforms and environmental education development in China. The identified landmark documents further refer to other relevant documents, which are either overarching policies or the noteworthy successive versions. The list of landmark documents is additionally approved and complemented by the interviewed environmental educationalists. As a result, two types of documents are selected, the policy documents that provide overarching guidance, and the curricular documents that define specific curriculum design standards. In total, four sets of documents are selected: eight policy documents that shaped the ongoing eighth curriculum reform of general school education (SE1-SE8)[1]; sixteen policy documents that guided the development of environmental education in China (EE1-EE16)[2]; eight curriculum standards that defined the existing curriculum subjects (CSE1-CSE8); and the only two curricular documents for designing the environmental education in China (CEE1-CEE2). (See appendix II: document list)

The relationships among the four sets of the documents are presented in figure 3.2. The policy documents on general education (SE1-SE8) provide an overarching educational perspective, under which the set of new curriculum standards is developed as fruits of the on-going eighth curriculum reform (CSE1-CSE8). These two sets of documents are the documents shaping current general school education and defining the existing curriculum subjects in China. In figure 3.2, the two sets of environmental education documents are indicated in the gray blocks. The policy documents (EE1-EE16) provided the overall perspective on environmental education. The two curricular documents specifically define the curriculum plans in environmental education (CEE1-CEE2). Additionally, since environmental education is a curricular component embedded in all existing school subjects, the environmental education curriculum is also partly defined in the curriculum standards of (CSE1-CSE8).

1 An introduction of the documents is presented in chapter 7, section 2.1.
2 An introduction of the documents is presented in chapter 7, section 3.1.

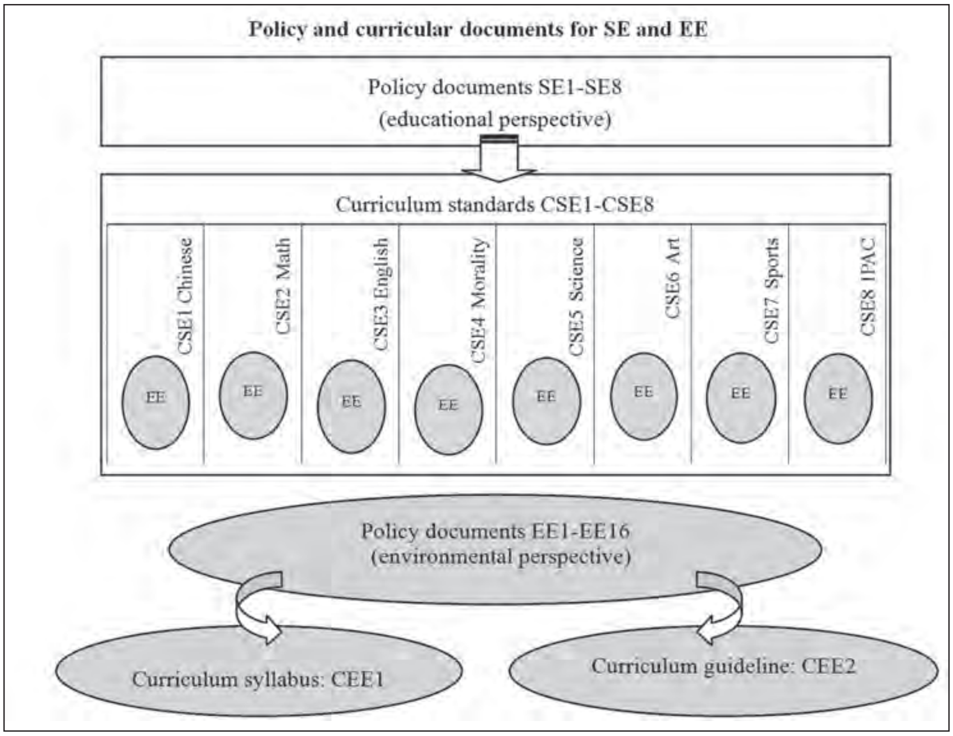


Figure 3.2: An outline of policy documents and curricular documents

4.1.3 Coding procedure of document analysis

In the curriculum element analysis, a coding procedure is applied by using the coding themes of the seven elements. Chunks of text, words, phrases, sentences, or passages that correspond with a theme are identified in the text as units of analysis, and coded. Since a passage may fit more than one theme, multiple coding is possible.

In the curricular actor analysis, instead of using codes, we specifically search in the policy documents of school education for the relevant information that indicates which actors are involved in the curricular activities: 1) In the activity of policy making, we identify the actors responsible for making the intended curriculum in the form of the policy documents, the curriculum standard, syllabus and guidelines. 2) In the activity of design and development, we identify the actors responsible for making the potentially implemented curriculum in the form of textbooks and other materials. Also, here the key designers and policy makers to participate in the interviews can be recognized.

3) In the activity of implementation, we identify the actors responsible for actual teaching practices in schools. 4) In the activity of evaluation, we identify the actors responsible for assessing the learning outcomes.

4.1.4 Data analysis

We conduct curriculum element analysis and curriculum actor analysis for both general school education and environmental education. (See figure 3.3) As shown in figure 3.3, the data of document analysis enter to the two blocks of 'rhetoric'. The nature of the intended curricula is captured by the seven curriculum elements as stated in the policy and curriculum documents where they refer to the analytical assumptions. The analysis is further triangulated with the results of the interviews in which the designers and policy makers are consulted about their perspectives on the curriculum elements and their recognitions of the curriculum actors. When comparing the 'rhetoric' of school education with the 'rhetoric' of environmental education a possible 'institutional gap' will be revealed.

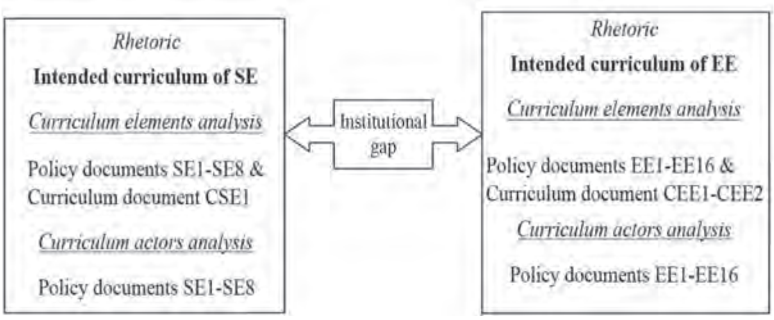


Figure 3.3: Data analysis of policy and curricular documents

Due to the time strain, out of the eight curriculum standards for general school education (CSE1-CSE8), we only analyzed the curriculum standard of the Chinese language (CSE1), with the consideration that the Chinese language classes are chosen to implement our scenario in the design study of the next phase. To define the intended curriculum of school education, we are to analyze curriculum actors as regulated in the policy documents SE1-SE8, and to analyze curriculum elements as stated in the policy documents SE1-SE8 and the curricular document CSE1. To define the intended curriculum of environmental education we analyzed curriculum actors as regulated in the policy documents EE1-EE16, and the curriculum elements as stated in the policy documents EE1-EE16 and in the curricular document CEE1-CEE2.

4.1.5 Data collection

The selected documents are in paper copy or in digital files retrieved from the official website of the Ministry of Education (MoE) of China, and from local educational administrations. All the documents are presented in the official Chinese language version. The key concepts' translation is in reference to official English versions if available, or translated by the author in triangulation with English publications on related topics.

4.2 Interviews with designers and policy makers

4.2.1 Purpose of the interviews

Together with the document analysis, the interviews had as their goal to explore the 'institutional gap'. The interviewed designers and policy makers of environmental education are recognized in the document analysis as key actors in formulating the intended curriculum or in designing potentially implemented curriculum of environmental education in China. The interviews are firstly to find out how the interviewees perceived the intended curriculum of environmental education in terms of the seven curriculum elements, and to triangulate with the description from the document analysis and therefore help to improve accuracy in interpreting the nature of the documents and their applications. The interviews are secondly to triangulate the identification of curricular actors with the recognition from the document analysis, in considering that the interviewees have insiders' knowledge about the background of making the documents.

In addition, being aware of the marginalized introduction of environmental education in China's school agenda, we need to understand the implementation problem in China's current curriculum system. Therefore, as a preparation for the design study of the next study phase, we also collected data on the designers' and policy makers' definition of curriculum levels of environmental education in China, to know the environmental position they take and their views on the reasonable curriculum level to choose to most appropriately introduce our design into the schools. This additional part of the data is presented in chapter 9.

4.2.2 Coding procedure of the interviews

In the curriculum element analysis, as in the document analysis, a coding procedure is applied by using the coding themes of the seven elements. The analytical unit is the 'theme' that may appear in chunks of text, words, phrases, sentences, or passages in the interview transcripts and notes. In the curricular actor analysis, instead of using codes, we specifically search in interview transcripts and notes for the relevant information that indicates actors involved in policy making, design and development, implementation, and evaluation of environmental education. The analysis is further triangulated with results from the document analysis.

4.2.3 Data analysis

In the data analysis of the interviews, we conduct curriculum actor analysis and curriculum element analysis, particularly for environmental education As shown in figure 3.4, the interview data enter into the block of 'rhetoric' of environmental education and add to data of document analysis, therefore the figure is an expanded version of figure 3.3.

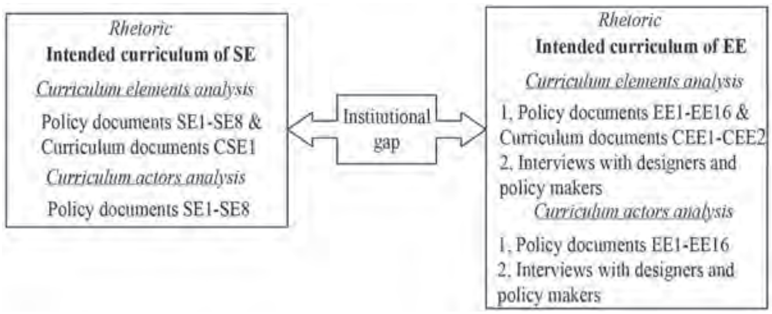


Figure 3.4: Data analysis of interviews with designers and policy makers

4.2.4 Interview design

The interviews are semi-structured, consisting of three sections: 1) introduction of the research, introduction of the interview, and the value of the interviews in the entire research; 2) the interviewees' definition of the curriculum levels of environmental education in China; 3) the interviewees' perspective on curriculum design and implementation, the design principles they prefer, and the tensions and obstacles they perceive in implementation. In total, fifteen questions are designed to cover the most involved aspects (see appendix III). During the interviews, a large amount of time was also devoted to probing crucial points that emerged during the conversation. At the end of the interviews, the interviewees were asked for recommendations of major environmental education textbooks and teaching materials. All the interviewees generously provided their design in the original version, a paper copy or digital version, as well as a list of references of other important curriculum products. From here, we collected the data for the content analysis of teaching materials.

4.2.5 Interviewee selection

The following procedure helped to select designers and policy makers to participate in the interviews. At first, in the literature review on environmental education development in China, the key designers, educationalists and their network were sketched. This information was further triangulated with the results found in the document analysis. Five people were chosen in the first phase. Lastly, from the five interviewees, a snowball sample was extended to another six people. Eleven designers and policy makers were invited for an interview, and nine of them were able to participate. Of the nine interviewees, one is a designer, six have a dual role as designer and researcher, and one has a dual role as designer and policy maker. Administratively, they are from a university, a curriculum institute for environmental education, government, and a NGO. An interviewee list is included in appendix IV, for reasons of confidentiality merely showing their specific roles in environmental education.

4.2.6 Data collection

The interviews with designers and policy makers were conducted in official Chinese, in Beijing and Xining, China, in November of 2008 and May of 2010. Interviews took place in individuals' homes or offices. Each interview was designed to last about one hour. However, many people generously spoke with the author for more than two hours. Before starting the interviews, the interviewees were asked for their permission to make an audio recording. As a result, six of the nine interviews were digitally recorded, and other three interviews were recorded by taking paper notes. The six interviews records were transcribed and the three sets of interview notes were worked up right after the interviews. The interview notes and transcripts were sent back to the interviewees for approval.

4.3 Content analysis of teaching materials

4.3.1 Purpose of content analysis

The content analysis is to characterize the potentially implemented curriculum as presented in the teaching materials of environmental education, such as textbooks and teacher's manuals. The potentially implemented environmental education is analyzed by means of the seven curriculum elements with reference to the analytical assumptions. The results are compared with the intended curriculum found in the document analysis and in the interviews. The comparison will reveal the 'formalizing gap' of environmental education between the 'rhetoric' and the 'practice'.

4.3.2 Teaching material selection

The selection of the teaching materials is based on recommendations of the interviewed designers and experts. For China's schools, environmental education was mainly introduced using two types of teaching materials. The first type is the textbooks of current compulsory subjects, since an environmental education component is integrated in each of the subjects. The second is the learning and teaching materials that consider environmental education as a domain-specific subject, as textbooks and teachers' manuals.

In the integrative mode, environmental education is embedded in the textbooks for all subjects across six grades of primary school. Due to time constrains, we chose only the textbooks of the eight subjects in grade 5 as a sample. The consideration was that in the design study of the next phase, the 5th grade classes are chosen to implement our design scenario, so that we could gain an overview of integrated environmental education across all subjects in the 5th grade. Table 3.1 illustrates the 'horizontal' study sample. For the primary schools participating in the design study, it is compulsory to treat eleven subject courses in the 5th grade: Chinese, English, Mathematics, Morality and Society, Science, Information Technology, Music, Art, Sport, Integrated Practical Activity Curriculum (IPAC) and School-based Curriculum (SBC). All courses, except sports, SBC, and IPAC, have adopted officially validated textbooks. The schools that participated in our design study provided the textbooks of the eight courses in use, and these textbooks are the sample material for the integrative mode of environmental education. In total, 72 lessons that include environmental education are identified. Each lesson may include more than one environmental education related component. For example, one Chinese lesson may include one reading text, and one composition exercise addressing different environmental issues; one music lesson may have three or four songs concerning students' appreciation of nature scenes. In the 72 lessons, 95 information pieces were found that were of relevance to environment education. Each information piece is identified as an independent and complete unit for analysis.

In the domain-specific mode, environmental education is developed into specific textbooks and teachers' manuals. The sample choice is based on the recommendations of the interviewed designers and experts of environmental education. The selected textbooks and the teacher's manuals are considered as major sources because they are either developed by the leading designers, the authorized design institutes, or they are developed in cooperation with local educational bureaus so that they hold high potential for implementation at school level. The sample material of domain-specific environmental education includes all the three sets of textbooks and two sets of teachers' manuals across all six grades of primary school, as shown in table 3.1 for a 'vertical' study sample. For the teaching materials developed in domain-specific mode, the sample was not limited to the 5th grade, but the textbooks for all six grades are included. This was done not only because the population size is feasible for analysis, but more importantly, characterizing textbooks across all six grades would give a complete overview of the potentially implemented environmental education, so that a better comparison can be made with the actual teaching practices as implemented school-wide. In total, 193 lessons are analyzed. Each lesson deals with one particular environmental issue, therefore each lesson makes an independent and complete unit for analysis. A detailed list of the teaching materials is presented in appendix V, with details of editors, versions and publishers.

Table 3.1: Teaching material selection

	Integrative mode (textbooks of existing subjects)								**Domain-specific mode** (textbooks of environmental education)
Grade 1									×
Grade 2									×
Grade 3									×
Grade 4									×
Grade 5	× Chinese	× Math	× English	× Science	× Morality	× Info-Tech	× Music	× Art	×
Grade 6									×

4.3.3 Coding procedure of content analysis

In analyzing the teaching materials, we adopted content analysis as a research method. Content analysis is widely applied in media coverage studies and provides an objective and quantitative measure of recorded information (Berelson, 1952; Krippendorf, 1980). In this study, content analysis of the teaching materials was conducted in several discrete stages, i.e. defining the unit of analysis, constructing the coding categories, training coders, conducting a pilot study, and coding the content according to the established definitions.

The content analysis was conducted to describe the selected teaching materials by the seven curriculum elements in comparison to the analytical assumptions (see section 3.1). The coding categories were constructed deductively from the coding themes and their sub-codes (see section 3.2), and then supplementary categories were added in inductively reading through the teaching materials. Therefore, the coding table consists of a comprehensive set of coding categories that not only represent all essential aspects to measure the curriculum elements as stated in the assumptions, but also include the additional aspects that emerged from the materials. For example, under the coding theme of 'process', twenty coding categories were generated which included all specific ways of engagement, participation, and cooperation found in the teaching materials. In total 56 categories are identified to characterize the teaching materials (see appendix VI).

In coding, we read through the lessons and coded them according to the curriculum elements themes, and code information referring to more specific coding categories. The unit of analysis was each information piece for the integrated mode and each lesson for the domain-specific mode, so that the results and the conclusions are drawn from the 95 pieces of components of grade 5 embedded in the existing compulsory subjects, and the 193 lessons of all six grades in the teaching materials specifically on environmental education.

4.3.4 Data analysis

As show in figure 3.5, the content analysis investigates the 'link', i.e. the potentially implemented environmental education. With content analysis of the teaching materials, the potentially implemented curriculum is described by the seven curriculum elements as present in the selected teaching materials. The results are compared with the 'rhetoric' of environmental education identified in the document analysis and the interviews; therefore the possible 'formalizing gap' will be revealed.

4.3.5 Data collection

The selected teaching materials are in paper copy provided by interviewed designers and the visited schools. All the teaching materials are presented in the official Chinese language. The coding is based on the Chinese version of the coding table, and then the results are summarized in English. The coding is conducted by two coders, the author and a master student studying a major in science communication. The coding table is revised in several rounds, each based on the coding tests on a random small sample of twenty lessons. The coding agreement achieved is 0.76, according to Holsti's (1969) formula of reliability. The coding data are assessed with SPSS.

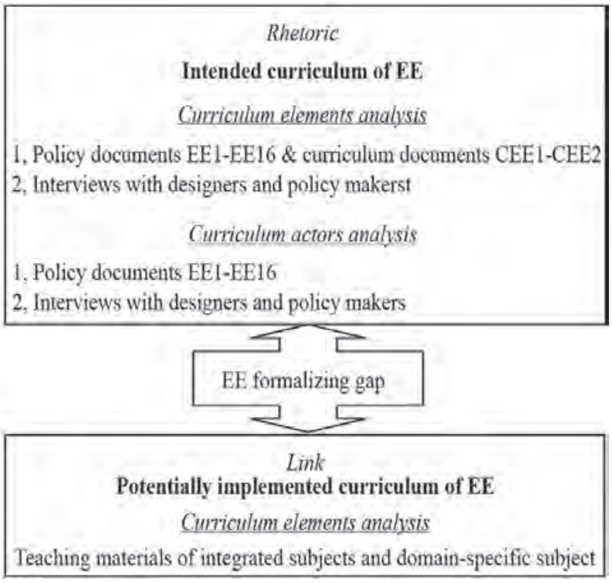


Figure 3.5: Data analysis of teaching materials

4.4 Observations and interviews with teachers and principals

4.4.1 Purpose of observation

The observations of the teaching practice and the interviews are to characterize the implemented curriculum of environmental education as practiced in the visited schools. Environmental education takes the form of extra-curricular activities, and intra-curricular courses that are either integrated into existing subject courses or as a domain-specific subject in separated courses. The implemented environmental education is analyzed by means of the seven curriculum elements with reference to the analytical assumptions, and then compared with the potentially implemented curriculum defined in the content analysis of teaching materials. By this comparison the possible 'operational gap' between the 'link' and the 'practice' will be revealed.

4.4.2 Teaching practice selection and interviewee selection

To become familiar with the current practice of environmental education, we visited five primary schools, two in Xining, and three in Golmud. The schools are recommended by the local educational administrations for performing well in terms of educational quality, and being open to educational innovations. Four of the schools also participated in the design study. In China, the 'practice' of environmental education includes both the intra-curricular implementation and the extra-curricular activities.

The observations of intra-curriculum implementation were conducted in two primary schools, one in Xining, and one in Golmud. In total, seven lessons were observed; the subject and content of each lesson is listed in table 3.2.

Table 3.2: Observed intra-curricular lesson list

Title of the lessons	Subject	Grade	Content
1. Whale	Chinese	5	Learning expository prose on whales, and discussing the problem of whale endangerment.
2. Inspirations from Nature	Chinese	4	Practicing communication skills in discussing two stories in the lesson text 'cleaning the forest' and 'the teachers of humans'. The first story tells about a forest in trouble when all foliage is swept away. The second story listed several bionics examples.
3. Inspirations from Nature	Chinese	4	Ibid
4. Green action	Morality and life	2	Discussing environmental problems that occurred in students' daily life, and proposing action plans.
5. Hello! Nature!	Music	5	Singing a song in choir of which the lyric praises the beauty of nature, and proposing actions to protect the environment in daily life.
6. Home of birds	Fine art	5	Knowing the extinction problems of bird species, and making handicrafts of bird nests by using recycled materials.
7. Trees on campus	Science	4	Visiting and knowing the trees planted in campus

Access to these lessons was decided by three conditions. Firstly, the lessons were the ongoing lessons with integrated environmental education during the author's visiting time period. Secondly, in respect of the schools' curriculum management, these lessons were all recommended by the school principals or the instruction directors. Thirdly, the observations had the permission of the teachers. The data of classroom observation was further enriched by after-lesson interviews with the teachers and conversations with the students. In total, we conducted seven interviews with teachers, and three with students.

We were also able to observe extra-curriculum activities in two schools in Xining and three schools in Golmud. Five types of extra-curricular activities are conducted in the visited schools that are relevant to environmental education: 1) outdoor activities, e.g. spring excursion to city parks; 2) assembly speeches given by young pioneer representation students, teacher representations, school principals, or directors of young pioneer departments; 3) class meetings; 4) competitions organized by educational or environmental administrations e.g. an essay contest on environmental topics; prize-giving competition in art festivals; 5) blackboard newspaper publicizing. In total, during the observations we collected data of sixteen extra-curricular activities (see table 3.3).

Table 3.3: Observed extra-curricular activity list

Activity	Topic	Content	Data collection
Outdoor	Excursion to city park	Picnic and playing games	Interview
Gathering speeches 1	Adopting trees in campus	Put one name card on adopted tree, give water, and protect it from being mistreated	Observation
Gathering speeches 2	Protect garden in campus	Don't trample grass and flowers	Observation
Gathering speeches 3	Keep the campus tidy	Don't litter	Observation
Gathering speeches 4	Environmental protection	Global crisis	Observation
Gathering speeches 5	Water conservation	Don't play with squirt guns	Observation
Gathering speeches 6	Seedlings in campus	Observe seedlings grow	Observation
Class meeting	Keep the classroom tidy	Discuss the problem of keeping tidy the classroom and propose action plans	Interview
Competition 1	Essay contest on environmental protection	Compositing on any issue concerning environment	Interview
Competition 2	Art festival	Develop a program addressing any issue related to environmental protection	Interview
Blackboard 1	World Earth Day	When it is, and why it is	Observation

Activity	Topic	Content	Data collection
Blackboard 2	World Water Day	When it is, and why it is	Observation
Blackboard 3	Protect grassland on campus	Don't trample	Observation
Blackboard 4	Energy saving	Energy crisis, do's and don'ts in saving electricity	Observation
Blackboard 5	Water crisis	Do's and don'ts in conserving water	Observation
Blackboard 6	Solid waste sorting	The importance of sorting	Observation

During the field visit, data were collected not only by observation. For the activities that were not conducted during the visiting period, interviews were applied to find out from the teachers who participated in them. Moreover, interviews with the activity organizers were especially informative. The organizers of the extra-curricular activities are the schools' young pioneer departments (YPD). Especially the director-teachers of the YPD play a key role in design and implementation. School principals have the full responsibility to supervise design and implementation. The class chief teachers are responsible for organizing the class students to work out the activities and report to the school's young pioneer department. In our interviews, four class teachers, two YPD directors, three school principals participated.

4.4.3 Coding procedure of observations and interviews with teachers and principals

To analyze the teaching practices, we conducted observations as our main method. In addition, data were collected from interviews, documents of the exam papers and the drafts of assembly speeches. A coding list was developed based on the coding categories defined for analyzing the teaching materials. The coding categories comprehensively include all possible aspects to measure the curriculum elements; therefore they are used again for analyzing the observations and interviews (see appendix VII).

In coding, we read through the transcripts and noted in the text the descriptions on the curriculum elements, and code information according to more specific coding categories. The unit of analysis is each lesson for intra-curriculum, and each activity for extra-curriculum respectively, so that the results and the conclusions are drawn from the seven lessons with integrated environmental education, and sixteen extra-curricular activities.

4.4.4 Data analysis

As is show in figure 3.6, the data of observations and interviews enter to the block of 'practice' i.e. the implemented environmental education. With the observations and the interviews, the nature of the implemented curriculum is captured in describing the seven curriculum elements as observed in the school practices with a reference to the analytical assumptions. The results are compared with the 'link' of environmental education identified in the content analysis of teaching materials. This comparison may reveal a possible 'operational gap'.

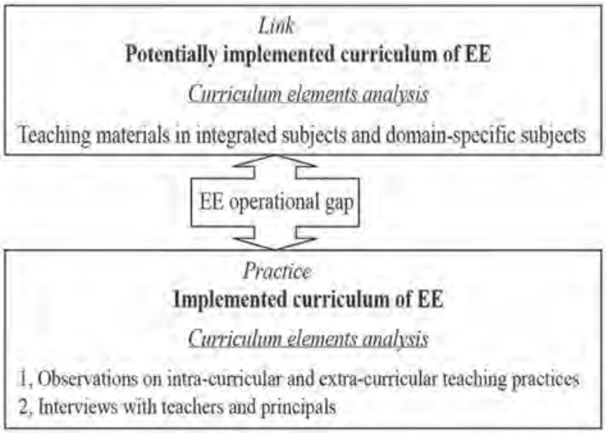


Figure 3.6: Data analysis of teaching practice

4.4.5 Data collection

The observations and interview data were collected in 2007, 2010, and 2011. The observations were conducted in a non-participative way. The after-class interviews with teachers and students took place in the classrooms or in teachers' offices. The interviews with principals were either held in a formal way in their offices or in casual talks on more relaxed occasions. The observed lessons, activities, and the interviews were all in the official Chinese language. The intra-curricular lesson lasted about 40 minutes and the extra-curricular activities lasted from 10 to 40 minutes. The length of the formal and casual interviews varied from a few minutes to about one hour. All the observations were collected in continuous video records, field notes and memos. All formal interviews were kept in audio records, and the casual interviews were extended into notes right after the talks. The record transcription, notes and memos served for the coding analysis. In addition to the observations and interviews, data were also collected in paper documents such as the exam papers and drafts of assembly speeches to support the analysis.

Chapter 4 Intended Curriculum

1 Introduction

In this chapter, we present the results of the analysis of the 'rhetoric', namely, from the documents and the interviews on the intended curriculum of general school education, and the intended curriculum of environmental education. The aim is to reveal the existence and nature of the 'institutional gap', as explained in chapter 3 (see figure 3.13, 3.4). The curriculum representations are characterized by the coding themes of seven curriculum elements, i.e. rationale, goal, content, process, teacher, students, and assessment (see section 5.3, chapter 2), and compared to the analytical assumptions (see section 3.1, chapter 3). To describe the intended curriculum of school education, the curriculum element analysis is conducted on the educational policy documents (SE1-SE8) and one chosen curriculum standard for the Chinese course (CSE1), since in the next phase the design study is tried out in the Chinese language class. The Chinese course is the most important, as it receives most course hours, and is most often taught by a chief teacher of every class. To describe the intended curriculum of environmental education, we analyzed the curriculum elements present in the environmental education policy documents (EE1-EE16), in the two curriculum documents (CEE1-CEE2), and in interpretations of the interviewed policy makers and curriculum designers in environmental education.

2 Intended curriculum of school education

2.1 Rationale

The information concerning the curriculum rationale is coded for disciplinarity, focused problem, characteristics of the study issue, and solution. Based on literature on the rhetoric-practice gap we hypothesized that the curriculum of general school education takes a fragmented, disciplinary-based approach (disciplinarity). The curriculum has its focus on abstract theoretical problems removed from life experience (focused problem). The curriculum is determined by predefined issues to serve predetermined specific ends, and assessed by clearly defined criteria (characteristics of the study issue). The curriculum is composed of standard-based knowledge and predefined problems with agreed correct solutions (solution/conclusion).

In terms of disciplinarity, the current curriculum is developed into disciplinary subjects. In the on-going eighth curriculum reform, the new curriculum standards are discipline-based (SE3). The validation of the teaching materials is also conducted by specific disciplinary groups. Nevertheless, the policy makers are aware of the problems in the conventional discipline-based curriculum, e.g. overload by having too many contents from different subjects, and lack of knowledge transfer among subjects (SE5). Therefore, it is promoted to have integrative courses e.g. 'morality and life', 'morality and society', 'science', 'art' and IPAC (SE5, SE7). Alongside, environment, health, national defense, safety, aesthetic education, production labor work, social practice, safety, mental health education, food safety education, AIDS prevention education, and education against drugs are highly emphasized as integrative educational subjects (SE1, SE2, SE4, SE7, SE8). The curriculum standard of Chinese (CSE1) also advocates learning Chinese with integrative study topics, as it provides students with various perspectives, contents, and methods to open their views with integrated knowledge.

In terms of the focused problem, in the policy documents (SE1-SE8), no information indicates the focused problem in the curriculum. CSE1 emphasizes repeatedly that Chinese language is a very practical course and focused on students' practical competence in the language in everyday life. Such competence is gained mainly by practicing the language, not by acquiring systematic literature knowledge.

In terms of characteristics of the study issue, the policy documents promote students to analyze and solve problems through inquiry and propose to provide space for discussion, for students' creative ideas (SE2, SE4). CSE1 states that Chinese language learning includes identifying and writing characters (comparable to spelling in English learning), reading, composing, oral communication, and integrative study. For each study issue, CSE1 clearly defines criteria for students to meet. The students should be able to use Pinyin, identify about 3500 Chinese characteristics, speak Mandarin, and write in Chinese correctly and fluently; should be able to know how to use dictionaries, and read classical Chinese with the help of dictionaries; should be able to read literature independently in a total length of more than 4 million words; and should be able to express themselves clearly in using everyday vocabularies and expressions, and have basic skills of interpersonal communication.

In terms of solution, the policy documents recommend that the teaching and learning should develop students' competence and guide students to experience and then understand the procedure of finding solutions (SE4, SE5). And according to the curriculum standard of Chinese (CSE1), except for the basic standard-based knowledge and skills, it also considers providing special topics, such as inquiry into environmental problems for students to experience the process of investigation. In the study tasks of reading, composing, speech communication, and integrative study, CSE1 proposes to leave space for the students to make different choices and to extend their competence, rather than acquire passively the pre-defined conclusions or solutions.

In sum, in the policy rhetoric, the assumed features have not yet been fully approved in Chinese school education. Concerning the disciplinarity, integrative courses are established to overcome the weakness of a discipline-based curriculum. Integrative topics are also encouraged in the Chinese course. Environmental education, together with many other educational themes, is required to be integrated into all possible school subjects. However, the new curriculum standard design and the teaching material design are still conducted by discipline-based research groups. Concerning the focused problem, no information was provided by the policy document, but CSE1 clearly emphasized students' practical language competence in daily life. Concerning characteristics of the study issue, though the policy documents supports students to learn by inquiry, to express with creativity, the curriculum standard of Chinese still clearly defines standards to measure students' language competence. Concerning solution, policy documents recommend students to acquire knowledge by experiencing finding solutions. In addition to the necessary basic standard-based knowledge and skills, CSE1 also considers providing special topics, such as environmental problems, for students to experience the process of investigation in finding out their own conclusions or solutions.

2.2 Goal

The analysis of curriculum goals is to understand the purpose of school education and how the curriculum defines the function of knowledge. The analytical instrument assumes that school education conveys prevailing norms, contributes to the reproduction and maintenance of the existing structure of society, and concerns the transmission of factual knowledge, routine skill, values, and beliefs hold by dominant political and social powers; knowledge is a storage for students' individual future use, e.g. university attendance, job searching, and enhancement of individual status and economic well-being.

Foremost, it is clear that the top priority in policy documents is to universalize the nine-year compulsory education all over the country and to eliminate illiteracy among young and middle-aged populations (SE1, SE2, SE4, SE8). The policy documents show that education is one of the bases for national strength and competitiveness (SE1, SE2). Essential-quality-oriented education is one part of the strategy for invigorating China and for China's modernization development (SE2, SE4, SE6, SE8). It is meant to educate and prepare builders and successors of socialism (SE2, SE4). And in the reform of essential-quality-oriented education, the new curriculum standards intend to provide a base for students' life-long learning (SE4, SE5). The new curriculum standards intend to prepare students for sharing social responsibility (SE5). As is emphasized, education should build on the integration of personal value realization with service for the country and the people (SE2, SE5). Moral education has to emphasize patriotism, collectivism, and socialism, as well as social ethics, and revolutionary tradition (SE1). According to CSE1, Chinese language teaching is to build the language literacy for students to study other subjects and for students' life-long learning. The reform of Chinese language teaching is toward the social needs occurring in a developing society; today, society requires citizens to have creativity, an open worldview, and awareness of cooperation, including reading and expression skills, and the competence of collecting and processing information with modern technology.

In sum, compared with the assumption, the policy documents shared a rather similar line and held that school education in China is to provide intellectual support for the country's growth, to found a base for students' life-long learning, and to prepare students for sharing social responsibilities in the country's system. As confirmed in CSE1, the function of Chinese language literacy is to prepare students for life-long development to meet the needs of a modern society. In addition, the top priority task of school education is to universalize nine-year compulsory education across the country and to eliminate illiteracy.

2.3 Content

The curriculum content is defined around three aspects, i.e. information source, relevance to students, and path of knowledge development. The analytical instrument assumes that the content of general education is built from factual information (information source). The content developed is removed from life experience (relevance to students), ignoring students' involvement (path of knowledge development).

In terms of the information source, it is clearly pointed out that the old curriculum paid too much attention to factual content knowledge (SE5). The policy documents propose to develop curriculum content from various resources, such as the local community, nature, museums, science centers, so that the content can be more helpful for the students to construct their own propositions on observations, investigation, operationalizations, and discussions (SE3, SE5). As confirmed in CSE1, the content of the course Chinese should be open and flexible, leaving space for schools and teachers to make different choices, as well as for students to select and extend the content. The content design should pay attention to the connection with emotions, attitudes, knowledge, and competences, therefore to build the language literacy as a whole, instead of merely on factual knowledge.

In terms of relevance to students, it is proposed that the new curriculum standards and the new teaching material design should apply the principle of keeping relevance to students' real life experiences, in order to help develop their own understanding, and to encourage students to build an active attitude of learning (SE3, SE6). As confirmed in CSE1, the content should be related to students' world of experience to raise students' interest and creativity.

In terms of the knowledge development path, it is proposed to avoid the passive learning path and to focus on student-oriented education (SE4, SE5). The students' involvement is the suggested path for knowledge acquisition to increase the relevance of curriculum content to students' life (SE3, SE 5, SE6, SE7). The new curriculum should guide students to take initiatives of learning and to learn actively, and the content should promote students' involvement (SE4, SE5). The curriculum should put more emphasis on students' motivation, emotions and attitudes instead of merely on their basic knowledge and skills (SE4, SE5). The new teaching materials should be based on students' prior knowledge and experiences, and guide them to explore by themselves how knowledge can be generated and developed (SE5). As confirmed in CSE1, the content knowledge and the exercises chosen should be in favor of inquiry study. The content of the Chinese course should consider providing special topics for students to experience the process of investigation and research.

In brief, the policy documents and the Chinese curriculum document all have disproved the assumption. Rather, it is suggested building curriculum content from students' inquiry by utilizing multiple resources, instead of from factual knowledge only. All the documents highly valued relevance to students' life experience in building curriculum content. In the Chinese policy rhetoric, the passive learning path has been abandoned. Students' involvement is the suggested path to acquire knowledge with increased relevance.

2.4 Process

The teaching and learning processes are analyzed by distinguishing three categories, cooperation, participation, and engagement. Our analytical assumption is that in general school education, teaching and learning are individual processes (cooperation) in which the teacher is leading, and students' participation is limited to give responses to the teacher's questions (participation) that are raised largely to recite already defined factual knowledge and well-structured problems (engagement).

The teaching and learning processes were not explicitly addressed in most of the documents. Only three documents (SE2, SE4, SE5) provided clear statements about how to arrange these processes. In terms of cooperation, the approach of cooperative learning is recommended to promote common development of both students and teachers via mutual communication (SE4). As confirmed in CSE1, cooperative learning and dialogues among students and teachers are highly concerned in integrative studies. In terms of participation, teachers should create a favorable educational environment for the students to participate actively instead of giving merely responses to the teacher's questions (SE2, SE5). CSE1 clarifies that *'Chinese language teaching is in a process of equal dialogue between teacher and students'* (CES1, p.15). And in terms of engagement, the approach of inquiry study should be adopted rather than require students to repeat factual knowledge received in well-structured problems (SE2). As confirmed in CSE1, the teaching and learning should show respect for students' individual differences, and students should be encouraged to choose their own study approach. The teaching and learning process should put a high emphasis on developing students' independent learning, instead of learning passively under the teacher's instruction.

In short, the assumed features are disproved in the policy rhetoric. Rather, students' cooperative learning and active participation are highly emphasized. And instead of learning passively under the teacher's instruction, the approach of inquiry study is recommended in the policy documents, and adopted in the curriculum standards of Chinese.

2.5 Teacher

According to our analytical assumptions, the role of the teacher in general school education is considered that of a dispenser of factual knowledge.

In most of the documents the role of teacher was not explicitly defined. However, it is clear that the documents promote a new curriculum in which the student is the master of learning, which implies that the role of the teacher is that of a facilitator, rather than a knowledge dispenser. In teaching and learning processes, the role of the teacher is equal to that of the students, and the teacher should respect the students' personality and give the instruction accordingly (SE2). *'In the teaching and learning process, the teacher should interact actively with the students, and develop together with the students... The teacher should create a favorable educational environment for the students to actively participate, to take study initiatives, and to develop competences of acquiring and applying knowledge'* (SE5, p.2). In the same line, CSE 1 defines the teacher as an organizer and guide in learning activities. The teacher should interpret and apply teaching materials innovatively.

In sum, different from the assumption, the documents define the role of the teacher as organizer and guide in democratic instruction in respect to students' interests and study initiatives.

2.6 Student

It is assumed that in general school education, students are passive recipients of factual knowledge and already determined correct solutions.

However, it has been clearly stated that the reform of basic education is for students to become the master of their own learning (SE3). Students are to be guided to take initiatives to learning, to experience the path of finding knowledge, and then to understand (SE2, SE4). Instead of factual knowledge, the analyzed policy documents give high value to the students' study initiatives, active learning attitude, motivation, creative thinking, independent thinking, and practical competence (SE2, SE4, SE5, SE6, SE8). It is confirmed in CSE1, that students are the maters of their Chinese language learning and their literacy development. CSE1 advocates the inquiry study approach instead of passive learning under the teacher's instruction. For example, in reading exercises, students should be encouraged to feel, and think actively. And the students' feelings, impressions, and understanding should be respected. The students should be encouraged to read from different perspectives.

In sum, the policy rhetoric disproved the assumed role of students. In the curriculum reform, the student is the master of his or her learning. The analyzed policy documents highly value students' study initiative, active learning attitude, motivation, creative thinking, independent thinking, and practical competence, rather than only factual knowledge.

2.7 Assessment

According to our analytical assumption, the assessment of school education is shaped as content-area test for reproduction of factual knowledge, with emphasis on the mastery of fragmented facts, concepts, and the test is often occurs in an artificial context of theoretical learning materials removed from students' life experiences.

The documents investigated foremost disproved the assessment function of selection and making distinction between students. It is proposed to shift to promoting students' development and improving teachers' teaching practices (SE3, SE5). The assessment should be on learning results and also on learning processes (SE4, SE5). The assessment should foster students' development each time from their own prior level, instead of assessing for competition and discrimination among students (SE5). To achieve this, a new assessment approach should be adopted which aims not only at examining students' learning results, but rather at discovering and developing students varied potentials, at understanding the needs occurring in students' development, and at helping students to develop more self-awareness and self-confidence (SE4, SE5). In the assessment reform, primary students' exam results should use grades or stages (SE4). After the exam, the teacher should analyze the students' results according to each student's study condition, and may neither announce the exam results, nor rank the students by their results (SE4, SE5).

In China, the entrance examinations to junior secondary school, to senior secondary school, and to college, and their promotion rates are fundamentally steering the basic education assessment. This issue is of particular concern in the policy documents. Firstly, in order to make the essential-quality-oriented education as realistic as possible, enrollment for junior secondary school will no more be determined by exam selections, but by students' place of residence (SE2, SE5, SE8). In other words, unlike in the past, when students with higher exam scores were to be selected by better quality schools[1], after the reform, the students are required to attend the school located in the administrative division of their home residence address, and no longer take entrance exams for selection. Secondly, the reform on the entrance examination of senior secondary school requires more attention to the topics that are socially practical, relevant to students' life experiences, and focus on students' competence of analyzing and solving problems (SE5). And some courses may even take the form of open book exams (SE5). As for the promotion rate, SE2 stressed, *'the local governments under the provincial level can not set the promotion rate (sheng xue lv) or use the promotion rate as a measurement for a school's performance'* (SE2, p.5). Thirdly, most crucial is the reform of the National College Entrance Examination (NCEE). The reform of NCEE is fundamental for the overall implementation of the essential-quality-oriented education (SE2). In order to give a favorable support for the implementation of the reform in basic education, NCEE should reform the selection of examined subjects, contents, approaches, to put more emphasis on students' integrative competence (SE1, SE2, SE4, SE5, SE8). The reform should speed up a change of NCEE, to change the situation that 'a one-time exam determines one's whole life' (SE2). And ultimately, the students' social background plays a considerable role. In Chinese society, the rules of employment play a leading role, and show the direction to education (SE2). Reforming such social rules of employment is urgently needed for advancing the essential-quality-oriented education (SE2). There is a need to change the traditional definition of talents, and rebuild the concept of talent into one that highly values practical competence instead of educational credentials (SE2).

As confirmed in CSE1, assessment has to improve the curriculum design, the teaching and learning processes, and eventually to improve students' development. Considering that language learning is more about emotional experience and reflection, assessment should not predominantly use quantitative and objective methods. Rather, the assessment should take a holistic approach, and evaluate various aspects of knowledge, competences, learning processes, methods, emotions, attitudes, and values. *'Formative evaluation and summative evaluation are both important, but formative evaluation should be more emphasized.'* (CSE1, p.19) Most interestingly, the Chinese language

1 In China, some primary and secondary schools have a better infrastructure or better qualified teachers than others. It is therefore competitive even for pupils to attend those better or higher quality junior schools, no matter whether these schools are by chance located in the students' community or near to their home residence.

curriculum adopts the method of keeping a student's development in a portfolio, which includes notes of the teacher's observation of the student's performance in general, the teacher's observation of the student's study interests and potentials, the student's self-reflection and summary report, the evaluation notes from other teachers, from classmates, from the parents, etc. *'Qualitative evaluation and quantitative evaluation are both important, but the qualitative evaluation should be more emphasized'* (CSE1, p.19). The school and the teacher should analyze the students' exam results together with their portfolios, define students' improvement as well as their insufficiency, and give further suggestions to their development in the next stage. By assessing a student's general performance, positive evaluation should be used predominantly, for example by encouraging and appraising words. The assessment is multi-agent, and is a combination of the teacher's evaluations, the student's self-evaluations, and the student's interactive evaluations with other students.

In sum, in the policy rhetoric, the assumed features were disproved as deficiencies in conventional assessment of education in the past, such as emphasis on the mastery of fragmented facts, and testing in artificial situations. It is particularly meaningful, but at the same time difficult for school education in China, to shift the purpose of assessment from selection and making distinctions towards improving students' development. To achieve this, several changes and innovations are recommended for the current curriculum reform, such as focus on students' learning processes, on students' development from their prior levels and potentials, and not to rank students by their exam results to avoid competition and discrimination. The enrollment examination system from secondary school to college and the fundamental social background are fundamentally shaping the education assessment. In order to make the essential-quality-oriented education as realistic as possible, several reforms are conducted, such as the residence enrollment to junior secondary school, and giving more emphasis on students' integrative competence in NCEE. The new spirit is also evidenced in CSE1, in which the assessment reform promotes a holistic and democratic approach e.g. by inviting students' self-reflection and keeping up students' development in a portfolio. Nevertheless, the documents express concerns whether the assessment reform can be put in practice, given the cultural traditions in Chinese society in which competitive distinction is still highly favored.

3 Intended curriculum of environmental education

In this section we characterize the intended curriculum of environmental education from three data source, the policy documents of environmental education (EE1-EE16), the Syllabus (CEE1), the Guideline (CEE2), and the interviews. The curriculum is analyzed by the seven elements in referring to our analytical assumptions.

From the sixteen overarching policy documents of environmental education (EE1-EE16), the most prominent finding is that only a very limited amount of information can be found in relevance to environmental education curriculum elements. In EE1, EE4, and EE5, a few sentences were located which gave clarifications on the rational of environmental education. And in EE1, the goal of environmental education is briefly clarified in terms of its function of knowledge. No data are available on the other five curriculum elements, content, process, teacher, student, and assessment.

3.1 Rationale

The information concerning the curriculum rationale is coded by disciplinarity, focused problem, characteristics of the study issue, and solution (see section 5.3, chapter 2). According to the analytical assumptions, the curriculum of environmental education takes a holistic, interdisciplinary approach (disciplinarity). The environmental education curriculum has its focus on real, practical, specific environmental problems (focused problem). And the curriculum is determined by problematic, uncertain issues with students' involvement in inquiring, solving, and adapting to students' social constructs; therefore it is highly flexible (characteristics of the study issue). The conclusion or the solution to the studied problem is uncertain (solution and conclusion).

In terms of disciplinarity, environmental education is proposed to take two modes, in cross-disciplinary integration into existing school subjects, and in extra-curricular activities as a domain-specific subject, in which students integrate knowledge from various disciplinary subjects (SE4, SE5). The Syllabus, CEE1 recommends a multi-disciplinary approach in curriculum design. The guideline, CEE2 clarifies that environmental education is integrative, since its content embraces natural science, social science, and humanities, and its study process requires a holistic understanding from multiple perspectives. Furthermore, all the interviews also agreed that environmental education is disciplinarily integrative. *'Environmental education in itself is related to too many disciplinary subjects. One course can not meet all its educational* *goals. Rather, it should be in complement of every subject, not in overlap of the subjects, or each subject does its own teaching.'*(Interviewee A) In the current primary and secondary curriculum, no discipline-based subject can convey environmental education independently (Interviewee A and B). It requires contributions from all subjects, for example, laws from natural science studies, and humanities subjects are to shape value, and conduct empathic learning (Interviewee G).

In terms of the focused problem, environmental education aims for developing students' practical competences in their life (SE5). CEE2 points out that previously environmental education has put too much attention on knowledge transmission, and it should move towards building a practical competence of solving real and specific problems. As in a recommended example in CEE1, grade 4-6 students should observe the surroundings of the school campus, and draw a map of it; collect information about waste sorting to decide a detailed waste sorting plan. And from the interviews, the introduced worked-out examples all deal with specific environmental problems that are relevant to students' life, and require them to be practically involved in solving the problem (Interviewee A, B, H).

In terms of characteristics of study issue, EE5 clarifies that environmental education should involve the students in study issues that are realistic for them to develop their own knowledge. CEE1 and CEE2 affirm that building students' problem solving competence is prominent in environmental education. For example, it suggests that grade 4-6 students inquire into environmental problems in their communities, for their cause, effect, and solutions. All the interviewees support that the environmental education curriculum should focus on problematic environmental issues which require students' inquiry and dealing with uncertainty. It is proposed to design the environmental curriculum mainly in the form of participative activities that invite students to learn by doing, learn by experiencing, and to investigate, to produce, and express their thoughts (Interviewee H).

In terms of solution, EE5 suggests that the students should be encouraged to develop solutions by inquiry into environmental problems, and draw their own conclusions based on their investigations. To reach their own conclusions and solutions, CEE1 and CEE2 recommends students to observe, investigate, use scientific research methods (e.g. make charts, draw maps, statistical calculations), interview stakeholders, consult experts, and present political proposals to their community. The interviewees also confirmed that environmental education should leave it open for the students to reach their conclusions or find their solutions by inquiry and practice. In the recommended worked-out examples, students were engaged into real problems for which no pre-defined solution is available (Interviewee A, B, C, D, E).

In summary, the analytical assumptions are well reflected in statements of the documents and perceptions of the interviewed environmental educationalists. It is confirmed that environmental education is integrative with regard to disciplines. As emphasized in the interviews, no discipline-based subject can convey environmental education individually and it requires the contribution from all subjects from natural science, social sciences, and humanities. Concerning focused problems, the attention in the documents has shifted from knowledge transmission to building the practical competence of solving real and specific problems in their daily life. This idea is supported and applied by the interviewed curriculum designers. Concerning the characteristics of the study issue, the documents and interviews propose to focus on problematic environmental issues which require students' inquiry with uncertainty to develop their own knowledge. Concerning solution and conclusion, the findings affirm a preference to leave these open for the students to reach their conclusions and find solutions by inquiry.

3.2 Goal

The analysis of curriculum goals is to understand the purpose of environmental education and how the curriculum defines the function of knowledge, as explained in chapter 2, section 5.3. The analytical instrument assumes that in environmental education the function of knowledge is for immediate use for a sustainable and emancipated quality of life. In environmental education, knowledge is not merely directed to action, rather to inquiry and taking action in exerting influence on the environment.

In terms of purpose of environmental education, the *'China's Agenda 21'* (EE1) states that environmental education contributes to build ultimately a group of far-sighted leaders and decision-makers, a contingent of highly-skilled workers in various fields, and a large labor force. As some of the interviewees pointed out, environmental education as one compulsory component of students' full development helps students adapt to their future life in modern society (Interviewee C, E). And CEE2 indicates that the overall purpose of environmental education is *'to encourage students to actively participate into decisions and actions toward sustainable development, and to grow to be practically capable and socially responsible citizens'* (CEE2, p.11).

In terms of function of knowledge, both CEE1 and CEE2 affirm that environmental education is to achieve sustainable development immediately from daily life style changes. It is to form up proper moral values about the environment, practical competence, healthy living habits favorable to the environment, and awareness of engaging in sustainable development related decisions and actions. As stated in CEE1, it is *'to develop among students environmentally friendly emotions, attitudes, and values; and to guide the students to choose a lifestyle favorable to the environment'* (CEE1, p.2). As confirmed in the interviews, ultimately, environmental education has to develop students' healthy habits in their daily life to make environmentally friendly choices (Interviewee A, D). It has to raise the students' interest in solvable problems in their real life, to concern of environmental issues within their capability scope, to help students to make judgments and to guide them in knowing how to actively improve the environment from adjusting their daily life style (Interviewee C, G). Another emphasized goal is that environmental education is to prepare the students to apply the notion of sustainable development when they grow to be future decision makers. (Interviewee D, G) *'For the primary and secondary school students of today, what we are working on is to continuously change the notion, continuously 'greenize', so that the children of today, when they grow to be future leaders, policy makers, entrepreneurs, can apply the notion of sustainable development in their decisions. This is what we, environmental educationalists, are expecting'* (Interviewee D).

In summary, in the policy rhetoric and the perceptions of environmentalists in China, the purpose of environmental education does not challenge the existing structure of society as long as sustainable development is inherent, but contributes to cultivate students into fully developed talents for the future society. As confirmed in the documents and interviews, the function of knowledge is to achieve sustainable development immediately from daily life style changes. In developing students' environmentally friendly emotions, attitudes, moral values, practical competences, and healthy living habits, they will be able to investigate solvable environmental problems within their scope, and to know how to improve the environment.

3.3 Content

According to the assumption, the content of environment education is built from complex and contradicting information resources (information source). Content is of high relevance to real life world problems (relevance to students). Content arises when students are involved in environmental problem inquiry so that knowledge is actively developed by students rather than provided to them as facts (knowledge development path).

In terms of information sources, CEE1 and CEE2 propose a list of learning activities developed from complex and contradicting information sources. For example, the suggested discussion with an open title *'If I were…'* gives students an opportunity to perceive different people's point of view by taking their positions. One other example is the students' investigation about contrasting life styles between the past (in their parents' childhood) and today (the students' life of today). As confirmed by the interviewed designers, the content should be built from rich and complex information resources from the locality of residence, and the community (Interviewee B, C, E).

Regarding the relevance of contents to the students' life, both CEE1 and CEE2 emphasize that the content selection should be making reasonable connections to the students' life experiences. For example, the content design requires the students *'to realize that people's daily living requires space, natural resources and energy; to be aware of daily living influence on the natural environment; to know and practice behavioral norms of environmental protection.* […] *to know the connection between people's living with the changes of the natural environment of the community; to analyze direct or indirect influence of one's own, as well as other people's behavior on the environment, and differentiate environmentally friendly behaviors from the unfriendly.'* (CEE1, p.1, 2) As affirmed in the interviews, every study topic of environmental education should be related to real life conditions of the area, for the students to recognize that the issue is related to their daily life (Interviewee C, D, F).

In term of the path of knowledge development, according to CEE1, and CEE2, all the recommended learning activities require student involvement. Students may use observation, e.g. watching and listening, may join in discussions, engage in art making, or perform investigations, collect data, and take actions. As supported in the interviews, the content should be elaborated in the participative activities, for the students to learn by doing and experiencing (Interviewee H). The content selection should raise students' interests of inquiring into solvable problems within the scope of their competences, to understand what environmental risks and hazards are related to their own life world (Interviewee E, G).

In summary, the assumptions are well reflected in the statements of the documents and the interviews. The curriculum content is recommended to build from complex sources for students to encounter different perspectives. Content selection should be making reasonable connections to the students' life experiences for them to recognize that the issue is related to their daily life. The recommended content design requires students inquiring into solvable problems within the scope of their competences to gain knowledge of environmental problems.

3.4 Process

According to the assumptions, in environmental education, teaching and learning are collaborative processes (cooperation). In teaching and learning processes, students are actively participating (participation). The students are engaged in dealing with environmental problems (engagement).

As defined in CEE1 and CEE2, student initiative is highly valued in the teaching and learning process. In teaching and learning processes the students' participation is emphasized, e.g. by playing games, doing experiments, observations. Cooperative learning is one of the adopted approaches for the students to authentically contribute to environmental problem solving. As stated in CEE1, the students should *'be able to actively, equally, and fairly to cooperate with others, respect different views and opinions, and respect cultural diversity, and be able to understand the importance of group collaboration in solving environmental problems'* (CEE1, p.5, 7). And in cooperation, students share and collect information, exchange their life experiences and thoughts about environmental problems. Teaching and learning processes also should stimulate the students to engage into finding problems, problem inquiry, problem solving, and particularly to take actions, and to start from solvable problems around them, e.g. in school campus, in their community, and at home. According to the interviews, in the worked-out examples recommended as ideal cases of environmental education, the teaching and learning activities all take the approach of inquiry and enable the students to participate to learn by experiencing and in cooperation.

In summary, the assumptions are fairly confirmed in the documents and the interviews. Students' cooperative learning is suggested for sharing information, exchanging ideas, and encountering different perspectives. In all the recommended ideal cases of environmental education, students are invited to participate in various activities, and engaged into finding problems, problem inquiry, problem solving, and particularly in taking actions, starting from solvable problems within their daily life.

3.5 Teacher

As to the assumptions, in environmental education, teachers should be amenable to students' autonomous decisions. Teachers are agents having their own views and ideology about education which shape their decisions on curriculum and pedagogy.

CEE1 and CEE2 clarifies that teachers have freedom to make flexible choices of the teaching and learning approaches and methods to best match with the teaching content, and meet with the teaching goals and needs of their students. It is suggested that teachers must change their traditional view on the student's role, the teacher's role, and the relationship between teacher and student. Implementing environmental education is considered as opportunity to stimulate a democratic atmosphere in school education, in which students are developing with wellness, and to be what they are.

As confirmed in the interviews, the teachers were encouraged to play a role as agents in developing community-based curricula and school-based curricula, with the idea to make a close connection to the real conditions of the schools or the locality. *'In encouraging the development of local and school curriculum of environmental education, there is an important change, namely, the change of the teacher's role. Teachers are not more merely teaching according to books, but may grow to be curriculum developers. The change of the teacher's role requires an improvement of teachers' professional development'* (Interviewee E). Moreover, the teachers are recommended to develop student-based curricula to not only use their freedom in defining the curricula, but also to respect the freedom of students in reforming their curricula. '*Teachers can develop curricula, and we propose that they develop student-based curricula. The teacher should not strictly dispense his/her plan, but should allow changes that occur during class'* (Interviewee H).

In summary, the assumptions are well affirmed in the documents and the interviews. Teachers are requested to develop an interactive relationship with students, to respect their study initiatives in forming curricula. Teachers may make flexible choices of pedagogy, and can even develop their own curricula to be better connected to students' needs, and the real conditions of the schools or the local community.

3.6 Student

According to the assumptions, in environmental education, students should be active and critical thinkers, and the generators of knowledge.

In CEE2, inquiry study and action research are the adopted study approaches for the students to take initiation in exploring real problems in their daily life. It is also emphasized that the students should try to identify environmental problems within 'the most accustomed', that is, they should think critically about what is taken for granted in daily living, and in conventional industrial approaches, e.g. how we treat household waste, and how we discharge waste water. As supported by the interviewed designers, the students take an active role in constructing knowledge (Interviewee A, B, D, E, G, H). For example, in the recommended ideal practices, with the approach of inquiry, the students independently and critically develop knowledge of cultural geography in their explorations about the landscape in their communities, the knowledge of the principle of reduce-reuse-recycle in their investigations into the life cycle of textbooks, or the energy flow of the campus.

In summary, the assumptions are approved in the documents and the interviews. Students are encouraged to critically construct knowledge from inquiry into environmental problems. Inquiry study and action research are adopted approaches to support students' active involvement.

3.7 Assessment

Our analytical instrument assumes, the assessment of environmental education evaluates the process of inquiry, critique, and reflection, evaluates the extent to which students develop and defend their own environmental beliefs and choices, as well as their ability to act according to their choices.

As CEE1 stated, instead of the end-of-pipe evaluation, '*in teaching and learning processes, assessment should focus on students' environmental attitudes, skills, and behaviors, and their performances in participating in the learning activities*' (CEE1, p.3). In defining assessment, CEE2 emphasizes students' learning processes and the development of the competences experiencing, inquiring, indentifying, analyzing, and solving environmental problems. Therefore, CEE2 proposes to adopt predominantly qualitative methods, to associate with quantitative methods, and to adopt predominantly formative evaluation, to associate with summative evaluation. In other words, the evaluation is about the actual performance of the teacher and students during teaching and learning processes. The recommend evaluation methods or tools include paper pencil test, behavioral observation, portfolio, study notes, reflections, etc. In addition, CEE2 also recommends a democratic principle for assessment. The assessment is multi-agent, namely, all stakeholders can be evaluators, students, teacher, school, local communities, environmental protection departments, and NGOs.

As pointed out in the interviews, the assessment as proposed in the ongoing curriculum reform is also suitable for environmental education. *'From the new curriculum system, the most prominent change in assessment is the shift toward process evaluation. In the past, it used to be by final result. The current process evaluation is by means of making notes and development, portfolio, etc'* (Interviewee H). Two assessment theories are currently adopted in China i.e. the developmental theory and the student-centered theory (Interviewee C). The developmental assessment theory has its focus on the developmental processes of students and proposes to evaluate during these processes. The student-centered assessment theory adopts the principle that the evaluation is about the actual performance in achieving the learning goals set by the students. The focus is on students' competence of knowledge application. As evidenced in the recommended successful study cases, the assessment takes a qualitative form, by collecting students' and teachers' feedback in interviews, in questionnaires, or in after class discussion, and by developing a portfolio of students' refection on their learning experiences (Interviewee B, D).

For extra-curricular activities, the evaluation is mainly shaped by the commendation in the *'Green School'* campaign which emphasizes results rather than process, for example, whether the students won any prize in environment protection related competitions, whether the school developed an outline of the infused environmental education in the relevant subjects, whether the school conducted any integrative study activities. And in the actual evaluation, more attention is on campus infrastructure management (Interviewee F).

In summary, the assumptions are confirmed by the documents and the interviews when environmental education is evaluated in its integration into existing subjects. In line with the assessment defined in the current curriculum reform, students' competence development in participative learning processes is of the main concern. At the mean time, in the evaluation of extra-curricular activities, an end-of-pipe approach is still applied which focuses on outcomes and campus infrastructure management.

4 Summary and preview

In this chapter, by analyzing the curriculum elements, we characterized the intended curricula of school education and environmental education respectively. In referring to the analytical assumptions, it is now possible to prove whether and to what extent the contradictions between school education and environmental education postulated by Stevenson (1987) (see table 2.1, chapter 2) are evidenced in China. In a triangulation of data from the policy documents, the curricular documents, and the interviews, we investigated two 'rhetoric' blocks. The possible institutional gap will be revealed in comparing the difference between the two 'rhetoric' blocks. Namely, the institutional gap exists when intended curriculum of school education is different from the intended curriculum of environmental education. With the acknowledgement of involved actors in policy making to account for the gap as presented in chapter 7, we will be able to conclude about the institutional gap in chapter 8.

Chapter 5 Potentially Implemented Curriculum

1 Introduction

In this chapter, we analyze the 'link' between the 'rhetoric' (intended curriculum) and the 'practice' (the implemented curriculum) of environmental education. From the content analysis of the teaching materials, we characterize the potentially implemented curriculum of environmental education, as operationalized in the coding table in chapter 3 (appendix VI). Along with the results on the intended curriculum, the aim is to reveal the existence and nature of the 'formalizing gap', as explained by figure 3.5 in chapter 3. The teaching materials are analyzed through coding the themes of seven curriculum elements, rationale, goal, content, process, teacher, students, and assessment (see chapter 2, section 5.3) in comparing to the analytical assumptions (see chapter 3, section 3.1). The content analysis of the teaching materials is conducted with the selected teaching materials from the two modes of environmental education, as multi-disciplinary integration and as a domain-specific subject. In the textbooks of current compulsory subjects, we analyze the embedded environmental education components. 95 information pieces are found relevant to environment education. Each information piece is considered as an independent and complete unit for analysis. In the domain-specific textbooks and the teacher's manuals, 193 lessons are analyzed. Each lesson deals with a particular environmental issue, and therefore each lesson makes an independent and complete unit for analysis. The results for both modes are presented, i.e. for environmental education in multi-disciplinary integration and for environmental education as a domain-specific subject, and then summarized by making a comparison.

2 Rationale

In the assumption, the environmental education curriculum takes a holistic, interdisciplinary approach (disciplinarity). The environmental education curriculum has its focus on real, practical, specific environmental problems (focused problem). And the curriculum is determined by problematic, uncertain issues since it relies on students' involvement in inquiring, solving, and adapting it to students' social constructs; therefore it is highly flexible (characteristics of the study issue). The conclusion of or the solution to the studied problem is uncertain (solution and conclusion).

Under the four sub-codes (disciplinarity, focused problem, characteristics of the study issue, solution and conclusion), seven categories are developed to understand the rationale, in viewing how the disciplinarity is considered; what the related school subjects are; whether the curriculum concerns a problematic environmental issue; whether it is focused on a real, practical, and specific problem; and whether the solution or conclusion is assumed to be uncertain.

2.1 Multi-disciplinary integration

In terms of disciplinarity, except in the English textbook, environmental education components are found in all other school subjects. Environmental education is most frequently embedded in Music lessons (28.1% of the lessons). Chinese is the second subject in which environmental education is often integrated (20.8%). The results showed that in the textbooks of grade 5, the environmental education components are embedded in school subjects from natural science (e.g. science), to humanities (e.g. Chinese, music), and social sciences (e.g. morality) (see table 5.1).

Table 5.1: Integrations in school subjects (multi-disciplinary integration)

Subjects	music	Chinese	Infotech	science	moral	math	fine art	English	Total
Frequency	27	20	13	11	10	8	6	0	100
Percent	27%	20%	13%	11%	10%	8%	6%	0%	100%

In terms of characteristics of study issue, the analysis showed that only a limited proportion of the information pieces concerned problematic environmental issues (25.3%).

In terms of focused problem, the data revealed that slightly more than half of the studied information pieces meet the criteria of being real, practical, and specific at the same time (54.7%).

In terms of solutions and conclusion, the data showed that the majority of the information pieces predefined true or correct conclusions/solutions, 88.4% against 11.6% that leave conclusions or solutions open and uncertain for the students to explore.

In summary, after examining the rationale defined in the integrated textbooks, we found that environmental issues were included in most of the school subjects, natural science, humanities, and social science. Only a limited proportion of the information pieces concerned the problematic character of environmental issues (25.3%). A little more than half of the information pieces presented issues that were real, practical, and specific (52.6%). And the conclusions or the solutions of only a small number of information pieces were uncertain, (11.6%).

2.2 Domain-specific subject

In terms of disciplinarity, in the domain-specific lessons we investigated whether the content knowledge is also related to subjects other than environment. The results show that the analyzed lessons are related to all the existing school subjects. Science is the most frequently related subject (41.5%), followed by morality (39.4%), as show in table 5.2.

Table 5.2: Related school subject (domain-specific)

Subjects	science	moral	Chinese	fine art	math	music	sport	Total
Frequency	80	76	16	9	8	2	2	193
Percent	41.5%	39.4%	8.3%	4.7%	4.1%	1.0%	1.0%	100.0%

In terms of characteristics of study issue, the analysis showed that most of the lessons concerned the problematic character and uncertainty of environmental issues (67.9%).

In terms of the focused problem, the data revealed that the majority of the lessons (86.5%) studied environmental problems that are real, practical, and specific at the same time.

In terms of solution and conclusion, the data showed that more lessons (68.9%) predefined true or correct conclusions/solutions than those leaving it open for the students to develop their own (31.3%).

In summary, the results showed that the analyzed domain-specific lessons are related to all existing school subjects. In other words, the knowledge or information contributions are from every disciplinary school subject, from natural science, humanities and social sciences. Most of the lessons (67.9%) focused on problematic environmental issues. The majority of lessons (86.5%) studied environmental issues that are real, practical, and specific. And only in 31.3% of the lessons are the conclusions or the solutions kept uncertain for the students to explore.

2.3 Result comparison

We have examined to what extent the rationale defined in the teaching materials is in line with the theoretical assumptions in terms of disciplinarity, focused problem, characteristics of the study issue, and conclusion/solution. The data revealed that environmental components can be found in all existing subjects, and the lessons designed in the domain-specific mode also included knowledge or information from all subjects. The results show that in integration only 25.3% of the studies environmental issues are of a problematic character, while 67.9% of the domain-specific lessons have shown such a focus. Furthermore, we measured whether and to what extent the studied issues meet the criteria of being real, practical, and specific at the same time. We found 52.6% in integrated materials, and 86.5% in domain-specific lessons. Lastly, in terms of whether and to what extent the teaching materials allowed the students to develop their own conclusions or solutions rather than provide predefined correct ones, we found 11.6% in integrated materials and 31.3% in domain-specific materials. In all, the analysis of the rationale revealed that the analyzed teaching materials considered multi-disciplinarity, but showed a minimal concern to leave conclusions or solutions open to the student. The two modes of teaching materials provided varied cases that studied problematic environmental issue that are real, practical, and specific. The comparison shows that domain specific materials provided more cases that meet the theoretical assumptions than the components integrated into exiting disciplinary subjects.

3 Goal

According to our instrument, in environmental education the function of knowledge is for immediate use for a sustainable and emancipated quality of life. In environmental education, knowledge is not merely directed toward action, rather to prepare for inquiry and taking action in exerting influence on the environment.

Based on the assumptions, there are three categories to identify the goal: whether the knowledge is related to sustaining people's quality of life of which environmental quality is a part (sustainable life); whether the students may already apply the knowledge to improve their life or their environment in particular, and do not need to wait until they become adults (immediate use); and whether at the end of the lesson the students are required to act or to do something for the environment, for example, writing a complaint letter, planting trees, recycling, designing cars that use eco-energy, and designing a campaign to spread knowledge on environmental protection (taking action).

3.1 Multi-disciplinary integration

As shown in table 5.3, in most of the integrated information pieces we identified knowledge that is related to sustaining people's life quality (83.4%). In a minority of information pieces, we found that the knowledge is for immediate use, and that students are invited to take action for exerting influence on the environment (17.9% for either category).

Table 5.3: Goal (multi-disciplinary integration)

Goal	for sustainable life	for immediate use	for action
Frequency	85	17	17
Percent	83.4%	17.9%	17.9%

A cross-table analysis showed that in 17.9% of the information pieces, the students are suggested to immediately use the knowledge for achieving a sustainable quality of life, and knowledge is directed in the end towards action in exerting influence on the environment.

3.2 Domain-specific subject

In most of the domain-specific lessons, we can define that the knowledge is for a sustainable life quality (83.4%). And we also found that the knowledge is for immediate use in improving the environment and people's quality of life (85%). Slightly lower counts were found for the lessons in which the knowledge is defined for taking actions for environment in the end (72.5%) (see table 5.4). A cross-table analysis showed that 70.5% of the lessons meet all three criteria.

Table 5.4: Goal (domain-specific)

Goal	for sustainable life	for immediate use	for action
Frequency	161	164	140
Percent	83.4%	85%	72.5%

3.3 Result comparison

We have examined to what extent the goals defined in the teaching materials are in line with the theoretical assumptions in terms of three categories, knowledge for sustainable life, knowledge for immediate use, and knowledge for taking action in the end. The results show that in most of the materials (83.4%) of both modes, the knowledge is related to sustaining people's quality of life of which environmental quality is a part. Furthermore, we measured whether and to what extent the students may already apply the knowledge in the teaching materials to improve their life or their environment in particular, without needing to wait until they become adults. We found that in 17.9% of the integration elements, and 86.5% of the domain-specific lessons. The measurement of taking action is to see whether the materials required the students to act or to do something for the environment. We found that 17.9% of the integration materials and 72.5% of the domain-specific lessons required taking action. Lastly, we measured to what extent the teaching materials meet the previous three goals criteria all together, and found that in 17.9% of the integration materials and in 70.5% of the domain-specific lessons. In all, the goal analysis revealed that the majority of the domain-specific lessons are designed in accordance with the theoretical assumptions, while only a small proportion of integrated environmental education components meet these assumptions.

4 Content

According to the assumption of our instrument, the content of environment education is built from complex and contradicting information resources (information source). Content is of high relevance to real life world problems (relevance to students). Content arises when students are involved in environmental problem inquiry so that knowledge is developed by students rather than directly provided to them as facts (knowledge development path).

Under the three sub-codes, we identified eight categories in the cluster to evaluate the content, in viewing whether the information is from multiple sources; whether the information introduces contradicting aspects of the issue or multiple viewpoints about the issue; whether and in which aspect the issue is relevant to students' life world; and to what extent the content is built of factual knowledge which does not require the students to engage in knowledge development.

4.1 Multi-disciplinary integration

Firstly, the results show that in terms of information resources, 7.4% of the information pieces included content from multiple information sources, and 7.4% built the content from information that included contradicting aspects of the environmental issue, or different viewpoints about the issue. A cross-table analysis revealed that only 1% of the information pieces can meet these two criteria together.

In terms of relevance to students, most of the information pieces included content that is relevant to the student's life world (78.9%). Specifically 16.8% shows a relevance to the students' family life, 16.8% is relevant to students' locality of residence, 10.5% is relevant to school life and 3.2% to the local community (see table 5.5). As the content may be relevant to the students on more than one aspect, the content of each lesson can be counted more than once.

Table 5.5: Relevance to students (multi-disciplinary integration)

Relevance	student's life	family	local place	school	community
Frequency	75	16	16	10	3
Percent	78.9%	16.8%	16.8%	10.5%	3.2%

Furthermore, we measured to what extent the content includes factual knowledge which does not require the students to engage in knowledge development, and found that most of the information pieces included factual knowledge in the content (92.6%). We further measured which proportion of each information piece was filled with factual knowledge. The results show that in the majority of the information pieces (87.4%), factual knowledge takes more than 50% of the total text (see table 5.6).

Table 5.6: Fact knowledge proportion (multi-disciplinary integration)

Fact knowledge proportion	Frequency	Percent	Cumulative percent
=100%	38	40.0%	40.0%
(3/4,1)	7	7.4%	47.4%
(1/2,3/4]	8	8.4%	55.8%
(1/4,1/2]	30	31.6%	87.4%
(0,1/4]	5	5.3%	92.6%
=0%	7	7.4%	100.0%
Total	95	100.0%	

In summary, the data illustrate that only in 1% of the information pieces the content is built from multiple information sources and shows the complex nature of the issue. However, most of the information pieces included content that is relevant to the student's life world (78.9%). And a majority of the information pieces did include factual knowledge, of which 87.4% included factual knowledge that took half of a page.

4.2 Domain-specific subject

In terms of information sources, 45.1% of the analyzed lessons included content from more than one information source, such as students' experiments, internet searches, news collection from media, and interviewing parents. And 15.5% of the analyzed lessons included content from the information that includes contradicting aspects of the environmental issue, or different viewpoints about the issue. A cross-table analysis revealed that only 7.8% of the lessons combined the two criteria, namely that content from multiple information sources is included, and that the content shows the complex nature of the issue.

In terms of relevance to the students, in most of the lessons, the content is relevant to the student's life world (70.5%). And we further observed in which specific way the contents showed relevance. The data show that 37.3% of the lessons is relevant to the students' family life, 22.8% to the location where the students live, 21.8% is relevant to school life, and 13.5% is related to the local community (see table 5.7).

Table 5.7: Relevance to students (domain-specific)

Relevance	student's life	family	local place	school	community
Frequency	136	72	44	42	26
Percent	78.9%	16.8%	16.8%	10.5%	3.2%

Finally we determined to what extent the content includes factual knowledge which does not require the students to engage in knowledge development. As is shown in table 5.8, most of the lessons included factual knowledge (86.5%), and in 50.3% of the lessons factual knowledge took more than half the number of pages.

Table 5.8: Fact knowledge proportion (domain-specific)

Fact knowledge proportion	Frequency	Percent	Cumulative percent
=1	27	14.0%	14.0
(3/4,1)	24	12.4%	26.4
(1/2,3/4]	14	7.3%	33.7
(1/4,1/2]	32	16.6%	50.3
(0,1/4]	70	36.3%	86.5
+0	26	13.5%	100.0%
Total	193	100.0%	

In summary, in terms of information resources, less than half of the lessons include content from more than one information source (45.1%), and in even fewer lessons the content included complex or contracting information (15.5%). Only 7.8% of the lessons combined the two criteria in the content development. Furthermore, most of the lessons are relevant to the student's life world (70.5%). And finally, most of the lessons include factual knowledge (86.5%). In half the lessons factual knowledge takes more than half the number of pages. This implies that the students are not invited to engage in knowledge development.

4.3 Result comparison

We analyzed the content of the teaching materials on three aspects, information sources, relevance to students, and knowledge development. The data illustrate that only in a very limited number of materials is the content from multiple information sources included, showing the complex nature of the issue (1% in embedded components, 7.8% in domain specific lessons). Most of the materials include content that is relevant to the student's life world (78.9% in embedded components, 70.5% domain specific lessons). Factual knowledge takes a large amount of the content of the majority of the materials, namely, in 87.4% of the embedded components and in 50.3% of the domain specific lessons, factual knowledge takes half the number of pages. In all, in the teaching materials of both modes, very few of the selected content includes information from multiple and complex sources. Most of the materials show relevance to students' daily life. Factual knowledge takes a large space in the content of most of the materials. Comparatively, the domain-specific lessons provided more cases that meet the criteria of multiple information sources, and the criteria of students' engagement in knowledge development path, while the integrated components had slightly more cases showing relevance to students' life.

5 Process

In environmental education, the teaching and learning process is a collaborative one (cooperation). In teaching and learning processes, students are actively participating (participation). The students are engaged in dealing with environmental problems (engagement).

Under the three sub-codes, twenty categories are clustered to determine how the process is defined in the teaching materials. The categories have to identify whether the students are required to engage in finding a problem, conducting an inquiry, and solving a problem; whether the process allows the students' participation and in which specific ways the students are participating (playing a game, doing an experiment, observing, visiting, sharing information or others); whether the process requires cooperative learning and in which specific ways the students cooperate (such as cooperating in proposing questions, in solving problems, and in collecting information).

5.1 Multi-disciplinary integration

In terms of the students' engagement, only a limited number of environmental education components invited the students to engage in dealing with environmental problems (9.5% of the information pieces invited the students to find problem, 21.1% allowed the students to inquire into the problem, and 15.8% engaged the students in solving the problem) (see table 5.9). Further, a cross-table investigation showed that only 4.2% of the information pieces encouraged the students to engage in the environmental problems throughout the entire process, from finding the problem, inquiring into it, to solving it.

Table 5.9: Engagement (multidisciplinary integration)

Engagement	finding problems	inquiry into problems	solving problem
Frequency	9	20	15
Percent	9.5%	21.1%	15.8%

In terms of student participation, the majority information pieces invited the students to participate (91.6%). We further investigated in what specific way the students could participate in learning and learning processes. In total, eight types of participation were found, i.e. participating to play a game, to do an experiment, to observe, to visit, to share information, to collect information, to express thoughts, and to describe life experiences. Since more than one type of participation may be adopted, each lesson component can be counted more than once. As is shown in table 5.10, each participation type received various proportions in the measurement. Among them, the most frequently adopted participation type is to let the students express their thoughts about environmental issues (85.3%), and the two least adopted types are requiring the students to observe (7.4%) and to visit (5.3%).

Table 5.10: Participation (multi-disciplinary integration)

Participation	participating	game	experiment	observe	visit	share info	collect info	express thought	describe life
Frequency	87	28	37	7	5	18	23	81	29
Percent	91.6%	29.5%	38.9%	7.4%	5.3%	18.9%	24.2%	85.3%	30.5%

Concerning collaboration, only a limited number of the information pieces considered the students' collaboration in the teaching and learning process design (15.8%). We further identified in what specific way the students can cooperate in teaching and learning processes. Six types of cooperation are found in the materials, collaborating in proposing a question, in collecting information, in sharing information, in finding environmental problem, in inquiring into a problem, and in solving a problem. As is shown in table

5.11, every type of cooperation received rather low counts, but relatively, cooperation in sharing information has been most frequently considered in the design (14.7%).

Table 5.11: Collaboration (multi-disciplinary integration)

Collaboration	collaborating	propose question	collect info	share info	find a problem	inquire into a problem	solve a problem
Frequency	15	6	8	14	7	9	7
Percent	15.8%	6.3%	8.4%	14.7%	7.4%	9.5%	7.4%

In summary, only a few information pieces encouraged the students to engage in the environmental problems throughout the entire process (4.2%). Furthermore, we found that the majority of the information pieces invited the students to participate (91.6%), especially to let the students express their thoughts about environmental issues, while observing and visiting are the least considered. Finally, only a limited number of the information pieces considered the students' collaboration in teaching and learning processes (15.8%), mostly for sharing information.

5.2 Domain-specific subject

Concerning students' engagement in dealing with environmental problems, 63.7% of the lessons engaged the students in inquiring into a problem. Engagement in solving the problem is found in 59.1% of the lessons, and only in 36.3% of the lessons, students had the opportunity to find problems by themselves (see table 5.12). In addition, a cross-table analysis revealed that only 31% of the lessons encouraged the students to engage in the environmental problems throughout the entire process, from finding the problem, to inquiring into the problem, until solving the problem.

Table 5.12: Engagement (domain-specific)

Engagement	finding problems	inquiry into problems	solving problem
Frequency	70	123	114
Percent	36.3%	63.7%	59.1%

Considering students' participation in teaching and learning processes, the majority of the lessons invited the students to participate (95.3%). Participation to collect information is the most frequently counted type of participation (see table 5.13).

Table 5.13: Participation (domain-specific)

Participation	participating	game	experiment	observe	visit	share info	collect info	express thought	describe life
Frequency	184	47	61	152	114	111	171	154	134
Percent	95.3%	24.4%	31.6%	78.8%	59.1%	57.5%	88.6%	79.8%	66.4%

Half the lessons considered the students' collaboration in teaching and learning processes (50.8%). The six cooperation types have various rates of adoption in the process design (see table 5.14). Relatively, sharing information is the most frequently adopted way of cooperation (44%).

Table 5.14: Collaboration (domain-specific)

Collaboration	collaborating	propose question	collect info	share info	find a problem	inquire into a problem	solve a problem
Frequency	98	21	51	85	22	59	45
Percent	50.8%	10.9%	26.4%	44%	11.4%	30.6%	23.3%

In summary, considering students' engagement in dealing with the environmental problems, one third of the lessons encouraged the students to engage in environmental problems throughout the entire process (finding, making inquiry, and solving) (31%). Furthermore, we found the majority of lessons invited the students to participate (95.3%), especially in collecting information. Half the lessons considered the students' collaboration in teaching and learning processes (50.8%), and sharing information is the most frequently recommended task for cooperation.

5.3 Result comparison

We determined how teaching and learning processes are defined in the teaching materials according to the three sub-categories, the students' engagement, participation, and cooperation. We identified to what extent the materials encouraged the students to engage in the environmental problems throughout the entire process (finding, making inquiry, and solving) and found 4.2% in integrated components, and 31% in domain-specific lessons. The majority of the teaching materials invited the students to participate in teaching and learning processes (91.6% in integrated components and 95.3% in domain-specific lessons), especially to let them express their thoughts about the environmental issues. Furthermore, we investigated to what extent students' cooperation is included in the teaching and learning processes. We found that it was included in 15.8% of the embedded lesson components, and in 50.8% of the domain-specific lessons. Sharing information is the most frequently adopted way of cooperation in both modes. In all, the analysis shows that a very limited number of designs engaged the students in the entire inquiry process. The majority of the materials invite the students to participate, especially in expressing their thoughts. Participative activities that require technical support or need to be held outdoor, e.g. to experiment or to visit, are included to a limited extend. Student cooperation is moderately adopted in the design of the materials. Sharing information is most frequently included. Comparatively, the domain-specific lessons provide more observable cases that meet the theoretical assumptions.

6 Teacher

According to the analytical assumptions, teachers are agents having their own view and ideology about environmental education which shapes their decisions on the curriculum and pedagogy. Based on these assumptions, two categories (whether the teacher may shape the content and the pedagogy) are identified in the cluster to grasp the teacher's role as defined in the teaching materials.

6.1 Multi-disciplinary integration

None of the analyzed embedded lesson components provided information about the teachers' role.

6.2 Domain-specific subject

None of the lessons in the textbooks provided information on the teachers' role. However, from the two sets of teacher's manuals, all the lessons clearly approved the teacher's freedom to adapt or select content, and to make pedagogical choices.

6.3 Result comparison

In the textbooks of both modes, integrated and domain-specific, no information was provided defining the teacher's role. Only in the two sets of teacher's manuals developed for environmental education, all lessons clearly stated that in implementing them teachers have the freedom to choose pedagogy and to select or adapt content.

7 Student

The analytical instrument postulates that students should be critical thinkers, and active generators of knowledge. Based on these assumptions, eight categories are identified to characterize the role of the student. In order to identify the critical role, we coded for whether students have opportunity to provide different answers. To identify the active role in generating knowledge, we coded whether the students may select a study topic by themselves, whether they may propose their own questions rather than merely respond to the teacher's question, whether they may search for answers by themselves rather than directly give predefined answers, whether they may provide their own action plans, and whether the material provides the student with factual knowledge rather than asking them to collect it by themselves.

7.1 Multi-disciplinary integration

Considering students' role as active thinkers, we measured whether students are encouraged to give various answers, rather than being limited to standard answers. We found that a large proportion of the information pieces (42.1%) did not encourage the students to give various answers.

We identified furthermore the students' role as active generators of knowledge. The results show that in the majority of the information pieces, the study topic is predefined rather than to be selected by the students themselves (92.6%). In terms of the students' role in proposing questions, more than half of the analyzed materials merely raised questions for the students without giving them the opportunity to propose their own questions (56.8%). There is even a type of material in which the predefined answers are presented to the students, and there is no need for them to find their own answers (22.1%). And in terms of the students' role in making action plans, most of the information pieces did not require the students to take action (83.2%), and among the information pieces that did require taking actions, half provided pre-defined action plans rather than giving the students the opportunity to develop their own. Most of the information pieces provided factual knowledge to the students (71.6%), rather than giving them the opportunity to collect or to discover the required information themselves.

In summary, in terms of students' roles as critical thinkers, a large proportion of embedded environmental education components does not encourage them to provide different answers, but requires standard answers. Considering the active role in generating knowledge, in the majority of the materials the study topics cannot be selected by the students. The students mostly are required to respond to the questions rather than proposing their own question. In some materials, the answers to the predefined questions are already given. In the majority of the materials the students do not have the opportunity to make their own action plans. Factual knowledge is provided directly, and there is no need for the students to collect the required information themselves.

7.2 Domain-specific subject

Considering the role as critical thinkers, quite a few lessons did still not encourage the students to give their own answers (38.9%). And considering the students' role as a generator of knowledge, study topics are predefined in almost all lessons (99%). Most of the lessons only raise questions without giving students the opportunity to propose their own questions (68.4%). There is a type of lessons in which the predefined answers are presented to the students (34.7%). Most of the lessons required the students to take action (74.6%), and half of the lessons directly provided the students pre-defined action plans rather than giving them the opportunity to decide their own action plans. We also identified how the lessons give students a role in acquiring the needed factual knowledge, and found that many did not invite the students to access factual knowledge by themselves (43.5%).

In summary, critical thinking as shown in encouragement for multiple students' answers is not evidenced in a considerable number of lessons. In almost all lessons, study topics are not selected by the students. In most of the lessons, questions are raised to the students rather than that they are invited to propose their own. In some lessons the answers are even provided together with the raised questions. In half the lessons that require students to take action, the action plans are predefined and the students are not invited to make their own. And in a large number of lessons, the students do not need to access factual knowledge by themselves.

7.3 Result comparison

We measured how the students' role is defined in the materials by analyzing two aspects, that of a critical thinker and that of an active generator of knowledge. Concerning the role of critical thinker, in the materials of the two modes, a considerable amount did not encourage the students to provide their own answers (42.1% in integrated components, 38.9% in domain-specific lessons).

Concerning the student's role as an active generator of knowledge, both in the integration and domain-specific designs, almost all the study topics are predefined rather than up to students to select (92.6% in integrated components, 99% in domain-specific lessons). More than half of the analyzed materials only raised questions to the students without giving them the opportunity to propose their own questions (56.8% in integrated components, 68.4% in domain-specific lessons). And in some materials the students even received ready answers for the predefined questions. In both modes of materials, in half the lessons which required students to take action, the action plans were predefined and students were not invited to make their own. In accessing the needed factual knowledge, a large amount of the materials was directly provided rather than collected by the students themselves (71.6% in integrated components, 43.5% in domain-specific lessons). In all, most of the expected criteria are not supported by the designs of the teaching materials, although comparatively, the domain-specific lessons better meet the assumptions than the integrated components.

8 Assessment

As to the analytical assumptions, the assessment of environmental education evaluates the process of inquiry, critique, and reflection, as well as the extent to which students develop and defend their own environmental beliefs and choices, and are able to act according to their choices. Based on these assumptions, five categories are defined to characterize the assessment, in viewing whether the teaching materials evaluate the students' learning processes or evaluate the extent to which students develop their competences, whether there are multiple evaluators, whether students may conduct self-evaluation, and whether the teachers use standards to evaluate.

8.1 Multi-disciplinary integration

Most of the analyzed information pieces did not provide any information on assessment (68.4%). For the information that did define assessment (see table 5.15), all the assumed features (development assessment, process assessment, self-assessment, and multi-actors) have been supported in the information pieces to various extents. However, standard evaluations by the teacher are still largely adopted (43.3 %). Concerning the point that the lesson components may define the assessment on more than one aspect, the assessment of each information pieces can be counted more than once.

Table 5.15: Assessment (multi-disciplinary integration)

Assessment	assess development	assess process	self-assessment	multiple actors	teachers use standards
Frequency	17	4	4	3	13
Percent	56.7%	13.3%	13.3%	10%	43.3%

8.2 Domain-specific subject

Again, most of the analyzed lessons did not give any information about assessment (74.6%). Among the lessons that did define assessment, all the assumed features can be found in the information pieces (see table 5.16). Among them, the teacher's standard evaluation still exists (32.7 %). To note, multiple coding is also applied.

Table 5.16: Assessment (domain-specific)

Assessment	assess development	assess process	self-assessment	multiple actors	teachers use standards
Frequency	22	22	5	28	16
Percent	44.9%	44.9%	10.2%	57.1%	32.7%

8.3 Result comparison

The results inform that both in integration and domain-specific designs, most materials did not define how to perform assessment. When the lesson components or the lessons did provide information on assessment, both in integrated and domain-specific materials around half adopted assessment of students' development (56.7% in integrated components, 44.9% in domain-specific lessons). Students' self-assessment was least considered (13.3% in integration, 10.2% in domain-specific). Moreover, both in integrated components and domain-specific lessons, standard evaluation by the teacher still exist (43.3% in integrated components, 32.7 % in domain-specific lessons). Relatively, process assessment and students' self-assessment were more supported in domain-specific lessons (44.9% against 13.3%, 57.1% against 10% respectively).

9 Discussion and preview

Since we selected samples purposefully, inferential statistic analysis is not suitable to examine how well the frequencies observed from the sample represent the population distributions. The sample of domain-specific teaching materials is not randomly selected, but it is a purposeful sample from the experts' recommendations, based on their judgment that the selected materials would rank among the best designed teaching materials of environmental education in China. The sample of integrated environmental education components is also nonrandom, but purposefully selected to get an overview of how environmental education is included in grade 5 across all school subjects. Grade 5 was selected, among other reasons, because grade 5 students were chosen as participants in the next phase of our study. Knowing the coverage of integrated environmental education components in grade 5 is most interesting in helping with the development of a more focused design of a scenario and in implementation in schools. Even while the results of these chapters may not be representative for environmental education in China in general, they provide a fair picture of a significant and high-end part of this education.

In this chapter, we investigated the 'link' block. By analyzing the teaching materials with the seven curriculum elements, we characterized the potentially implemented curriculum of environmental education. The possible formalizing gap will be revealed in comparing the 'rhetoric' and the 'link' blocks. Namely, the formalizing gap exists when the intended curriculum of environmental education (as stated in the documents and the interviews) is different from the potentially implemented curriculum (as presented in teaching materials). With the acknowledgement of the involved actors in policy making accounting for the gap as presented in chapter 7, we will be able to conclude about the formalizing gap in chapter 8.

Chapter 6 Implemented Curriculum

1 Introduction

In this chapter, we analyze the 'practice' (the implemented curriculum) of environmental education. On the basis of the teaching practices observations, the implemented curriculum is characterized by coding the theme's seven curriculum elements as defined in chapter 3, appendix VII, in accordance with the analytical assumptions as explained in chapter 3, section 3.1. Together with the results for the potentially implemented curriculum, this description can reveal the existence and nature of the 'operational gap', as explained in chapter 3, figure 3.6. As was explained, environmental education takes two modes, integrated into existing subjects, and as a domain specific subject in a separated course or in extra-curricular activities. We observed in all the visited schools that a separate course of environmental education is not provided to the students. It only exists in course tables and final exam papers, as a formal measure responding to inspections by upper level administrations. Therefore, the observable environmental education practices are in intra-curricular integrated lessons and in extra-curricular activities. The observations of the implementation of intra-curricular lessons were conducted in the seven lessons (chapter 3, table 3.2) that integrated environmental education components. The seven lessons are from the subjects of Chinese, morality and life, science, music, and fine art respectively. The observations of extra-curricular activities were conducted in the sixteen activities (chapter 3, table 3.3) that took environmental education as a domain-specific subject. Each intra-curricular lesson and each extra-curricular activity is considered as an independent and complete unit for analysis. The results are presented by the seven curriculum elements. In each of the elements, intra-curricular lessons and extra-curricular activities are described individually and then summarized in comparison.

2 Rationale

Our analytical instrument assumes that the curriculum of environmental education takes a holistic, interdisciplinary approach (disciplinarity). The environmental education curriculum has its focus on real, practical, specific environmental problems (focused problem). And the curriculum is determined by problematic, uncertain issues with students' involvement in inquiring, solving, and adapting to students' social constructs; therefore it is highly flexible (characteristics of the study issue). The conclusion of or the solution to the studied problem is uncertain (solution and conclusion). Based on these assumptions, we observed in the integrated courses and in extra-curricular activities, to see how environmental education is carried out in various related discipline subjects, whether and how the practices focus on problematic environmental issues, whether the issues studied are real, practical, and specific, and whether and how the conclusions or solutions are arrived at in the practices.

2.1 Intra-curricular teachings

Disciplinarity

Cross-disciplinary components or perspectives are evidenced in all the observed lessons. Especially, social, humanity, and natural disciplinary integrations are evidenced in the classroom practices. For example, the morality and life lesson *'Green Action'* included knowledge about society, environmental science, and biology. And in the Chinese lesson *'Inspirations from Nature'*, the students were required to practice speech communication skills on the topics of ecology and bionics. As remarked by the Chinese teachers, Chinese is a very integrative subject in its nature; basically it focuses on language teaching, but often the lessons are related to knowledge from other subjects, mostly on science and morality. Such disciplinary integration is also well recognized by the students. In the interviews, the students reported that they could easily notice that the lesson was about the natural environment. Some students could even relate the content of the Chinese lesson to other lessons, e.g. a science lesson in their grade 3 and a lesson of morality in grade 4.

Despite the well-affirmed cross-disciplinary integration both by the teachers and the students, the observations also revealed the limitation that the integration occurs spontaneously. In the classroom practices, the integration of other disciplinary information relies mainly on the teachers' awareness, interest, time available, and top-down administrative requirements. An example is the lesson *'Whale'*, which describes whales' anatomy and life habits, with a focus on teaching the students how to compose an expository prose text. The teacher admitted in the interview that, without knowing the observation is on environmental education, he could have ignored the extended discussion part on the topic of whale distinction, although it is recommended in the textbook. He remarked, *'It is just an extension, not compulsory; teachers can decide whether to conduct, if you have time you can hold a discussion, if you haven't, then not.'* Similarly, the music teacher reported that she would have shifted the focus to music culture rather than on the environmental crisis if it had not been required by the school principal to integrate environmental education in the lesson.

The design of the integrated lessons is unsystematic and untrained, because it is merely based on the teacher's intuition and common sense. All seven teachers reported that the educational designs of integrated environmental education were based on their prior knowledge, and information searches on the internet, with no training on how to teach environmental education in their subjects, nor was there discussion among colleagues. The teachers shared with us that in their instructional designs, the pedagogical structures, the scientific concepts, the related information were all selected and elaborated by themselves. As we observed in the classes, the lessons were sometimes overloaded with environmental concepts, and all concepts were touched very superficially. As featured in the music lesson *'Hello, Nature!'*, the teacher played a video on the global environmental crisis for the students, that broadly presented issues of population, water pollution, air pollution, climate change, deforestation, solid waste management, wildlife protection and so on. Next, the students were asked to express their thoughts about the issues and to propose action plans, but the entire process took only five minutes of the class. And in some other cases, the lessons introduced too abstract and complex concepts. As in the morality and life lesson *'Green Action'*, the teacher briefly introduced photosynthesis, a concept that is officially taught to children in secondary schools. And some practices were in fact not as beneficial to the environment as the teachers claimed they were. For example, in the fine art lesson *'The Home of Birds'*, the students were asked to hang their handicraft products - bird nests - in the shrubberies, which caused many branches to break. And 'do not litter' was proposed in every class, as if this would be a cure-all for various environmental problems.

The cross-disciplinary integration takes only a small proportion of the class teaching and lacks further scientific underpinning. The Chinese teachers stressed that the course is intended for improving students' language learning after all. As observed in the lesson *'Inspirations from Nature'*, the teacher repeatedly emphasized the principles of a good speech communication and gave no comment on scientific knowledge of ecology and bionics mentioned by the students. As the teacher confirmed, *'whether the information collected on ecology or bionics is scientifically correct or wrong, we do not bother.'* She further clarified that *'If we only talk about bionics, it goes too far and becomes another subject…We must* *teach something that is relevant to the subject of Chinese because I am not a biology teacher. If the students are interested, they may find it out for themselves.'*

Focused problem and characteristics of the study issue

Firstly, six of the observed lessons studied problematic and uncertain issues. Only the science lesson was conducted in a way that merely passed factual knowledge to the students. However, in the after class interview, the science teacher explained it has become more popular to engage students in scientific inquiry into real problems. And sometimes factual knowledge delivery is still going on when the teacher finds that students must prepare such knowledge, e.g. students should at least be able to name the species of trees planted in their campus.

Secondly, all the lessons focused on real environmental problems, namely, the problems that exist in reality, rather than abstract and theoretical ones, e.g. the solid waste problem, deforestation, loss of biodiversity, and so on. And six of the lessons have a specific focus, rather than dealing with general environmental issues. Only in the music lesson, the discussion was based on a video about the global environmental crisis which included many aspects. All the lessons studied issues that may involve students' practices. And when it was not possible to conduct practical activities, the lessons included at least a discussion part for posing action plans. For example, in the morality and life lesson, the students discussed deforestation and proposed the action of planting trees. And in the science lesson, the students studied the local common plants and were required to take care of them, e.g. watering them.

Conclusion/solution

In all the class discussions, the students were allowed to present their answers, proposals, definitions, etc. The teachers did not use verbal or physical expressions to limit the students' answers. The openness was such that the teachers did not even bother to reason or question about whether and how the students' answers were relevant to specific problem solving, for example, 'do not litter' was mentioned in all the lessons as a solution for various problems.

Secondly, in the observed Chinese lessons the teachers provided the students with predefined conclusions or pre-written summaries of the reading texts, for the reason that standard evaluation is still applied in exams. As typically illustrated in one class, the teacher dictated the students a note about the main conclusion of the lesson, a pre-written text prepared word by word by the teacher. The teachers explained that in final exams, the conclusions the students draw from the lesson should mention two focal points suggested in the teacher's manual. The teachers remarked, theoretically speaking, no standard needs to be applied to judge the students' understanding of a reading text, and any way of understanding is allowed in the classroom teaching. However, in exams students can only get marks when their answers include the focal points listed in the standard answer sheet authorized by the local educational administrations. This issue will be further elaborated in the section 8.1 on assessment.

2.2 Extra-curricular activities

Disciplinarity

In extra-curricular activities of environmental education, students refer to their knowledge learned from various disciplinary subjects. In the observed gathering speeches, blackboard newspapers, and essays selected in contests, students need to apply their learning from the Chinese course (e.g. writing, expressing, editing), from a science course (e.g. factual knowledge about climate change), and from the fine art course (e.g. drawing, photography).

Focused problem and characteristics of the study issue

In extra-curricular activities, environmental problems were introduced merely to make the students realize the urgency of taking certain recommended actions. The most investigated extra-curricular activities covered study issues that are specific and observable in the students' real life, that they can do something about, for example, paper saving, tree protection, cleaning and beautifying the campus.

Conclusion/solution

In all observed extra-curricular activities, the conclusion was meant to show the main idea that human beings are encountering many urgent environmental problems, so that everyone including primary school students should contribute to a better and healthier environment. In the class meetings, blackboard newspapers, and morning assembly speeches, etc., the environmental problems are introduced together with clearly recommended do's and don'ts, instructing students to change their behavior in school, at home, and in the local community, such as do not litter, do not trample the grass, and adopt a tree and take care of it.

2.3 Result comparison

In summary, referring to the analytical assumptions, the practices of environmental education, either in intra-curricular integrated lessons or in extra-curricular activities, are not fully in line with the expectations. Affirmative observations were collected in terms of disciplinarity, as both modes of teaching practices were conducted in integrating multi-disciplinary knowledge from social science, natural science, and humanities. In terms of the focused problem, both modes of practices tried to put forward real and specific environmental problems that exist in the students' daily life, and also included practical concerns for students to do something about the problem, or at least to propose action plans. However, contradictions were obviously observed in terms of characteristics of the study issue. Though in intra-curricular lessons integrated environmental education mostly studied problematic and uncertain issues, in extra-curricular activities, problematic environmental issues were introduced for the students to realize the urgency and to take the recommended actions, not for the students to explore and construct their own knowledge and reach their own conclusions or solutions. In terms of conclusions or solutions, all the observed extra-curricular activities gave pre-defined correct conclusions and solutions for the students to follow. And in intra-curricular lessons, the open discussion was only allowed during classes, but for final exams, the students were required to present pre-defined conclusions for safe performance. In addition, several problems were revealed during the observations. Intra-curricular integration was conducted spontaneously, depending upon the course time and the teacher's favor. Integrated environmental education is designed unsystematically, by untrained teachers, and remained on the fringe in the integrated subject courses.

3 Goal

The analytical instrument assumes that in environmental education the function of knowledge is for immediate use for a sustainable and emancipated quality of life. Knowledge is not merely directed toward action, but rather to prepare for inquiry and taking action in exerting influence on the environment. In the observations, we have to confirm, both in the integrated courses and in the extra-curricular activities, whether the knowledge is related to sustain people's life quality of which environmental quality is a part, whether the knowledge can be immediately applied by the students in improving their life or their environment without having to wait until they become adults, and whether by the end of the lesson the students are required to act or to do something for the environment.

3.1 Intra-curricular teaching

As confirmed by all the teachers, in all the lessons, the goal is to raise students' awareness of sustaining the quality of life for people and the environment, albeit from different perspectives. For example, the music lesson and the fine art lesson focused on emotional cultivation of loving and caring for nature, while the morality and life lesson and the science lesson paid more attention to the acquisition of scientific knowledge.

All the lessons required the students to propose action plans or take actions that can be executed immediately in students' daily life aiming for environmental improvement, instead of for future use. For example, at the end of the fine art class of *'Home of Birds'*, the students already placed their product, the bird nests, in the shrubberies in the school campus with the intention to contribute to bird protection. In other lessons, although no action was taken during the class, the students were required to propose action plans which mostly promise behavioral changes in their daily life, e.g. saving paper and conserving water.

3.2 Extra-curricular activities

As introduced by the main designers of the extra-curricular activities, namely, the directors of Young Pioneer Departments (YPD) and school principals, environmental education is aimed at: firstly, developing the students' concern for our living system, and awareness of the urgency to sustain the quality of life for our future; secondly, establishing the students' responsibility for society and for the environment; and lastly, building habits in daily life and take actions within the scope of students' competence and safety. In all the investigated extra-curricular activities, the students were requested to immediately apply knowledge and take action for environmental improvement, although in rather behaviorism-style instructions. This was apparent in most of the gathering speeches and blackboard newspapers, which firstly introduced environmental crises such as pollution and climate change and then called for immediate actions such as do not litter, save paper, raise potted plant, and water trees in the campus.

3.3 Result comparison

In summary, with the reference to the analytical assumptions, affirmative observations and remarks were collected both in intra-curricular integrated lessons and in extra-curricular activities. The stated goal by the teachers and designers is very much in line with the assumptions. Nevertheless, behavioral instruction was observed in most cases of intra- and extra-curricular teachings, with the students being asked to take action directly rather than firstly be prepared by knowledge development through inquiry.

4 Content

According to the assumption, the content of environmental education deals with complex and contradicting information sources (information source). Content is of high relevance of real life world problems (relevance to students). Content arises when students are involved in environmental problem inquiry so that knowledge is developed by students rather than directly provided to them as facts (knowledge development path). In the classroom observations, we have to investigate whether the information is from multiple sources, whether the information introduces contradicting aspects of the issue or multiple viewpoints about the issue, whether and in which aspect the issue is relevant to students' life world, to what extent the content is built of factual knowledge which does not require the students to engage in the knowledge development.

4.1 Intra-curricular teachings

Information sources

In all the lessons, teachers and students used information from multiple sources. Teacher's manuals and internet are the main sources in making teaching plans. The students collected information from the internet, additional books, mass media, and by asking their parents.

Only three of the lessons included contradicting aspects of the study issue, to reveal the complexity of the environmental issue, or for making contrasts to stress the necessity of taking action for environmental protection. For example, the music lesson and the fine art lesson adopted an approach of first showing the beauty, the wonder, and the delicateness of nature and then turning to the fact that such wonder is in crisis, to make the students realize the urgency of doing something for environmental protection. And in the morality and life lesson *'Green Action'*, rather than merely teaching them to save energy as the only correct choice, the teacher pointed to the dilemma of energy consumption need and energy depletion.

Relevance to students' real life world

In the classroom teachings, we saw an effort from all the teachers in steering class discussions to relate with student's daily life experiences, when the textbook content is general or lacks local relevance. As illustrated in the morality and life lesson *'Green Action'*, the teacher made a selection from the recommended green action examples. As the teacher explained, based on her knowledge of local people's living habits, the example of obtaining water from a traditional well was excluded because such traditional wells no longer exist in the city. Therefore it is considered irrelevant to the urban students' life. Instead, the teacher introduced the water level depression in Qinghai Lake as an example of climate change effect.

In relating the class discussion to the students' life, the most frequently used approach is that the teachers pose questions like '*How should we begin with little changes in daily life?' or 'What action should we take in the school campus?'*. As confirmed in the interviews, the teachers believed the study focus should be on doing small things in daily life, such as preventing waste or saving water, rather than aiming for big or general tasks, such as to protect the ozonosphere that is out of the students' reach.

Knowledge development path

We also observed in the classroom teaching, the extent to which the content consists of factual knowledge which does not require students to engage in knowledge development. All lessons included factual knowledge, but to help students to develop an awareness of maintaining a sustainable life quality, rather than learning to reproduce facts. For example, the fine art lesson *'Home of the Birds'* included biological facts of bird species, their habitat and nests, and numeric data showing evidence of bird species extinction. However, factual knowledge was not for the students to memorize, but to help them realize that action is needed to save the remaining specimens. Similarly, in the science lesson, though the students merely acquired factual knowledge about local common trees, their names, species, and biological characteristics, the teacher believed that better knowing the natural species is a basis to raise students' awareness of sustainable coexistence of humans and nature.

4.2 Extra-curricular activities

Information sources

The main designers, the YPD directors and school principals reported that internet is the main information source for their designs. On the internet, they can easily find example designs proposed or implemented in other primary schools, and even drafts of gathering speeches, and videos that are suitable to play in class meetings.

From the coding analyses of the drafts of assembly speeches and the transcriptions of type records, we found that in some cases one-way information was introduced for urging the students taking recommended actions. And in other cases, contrasting information was included to raise the students' concerns about the environmental crisis, which always start with the enjoyable side of nature and then turn to problems of endangerment, e.g. showing the beauty of a healthy forest and then turn to the problems caused by deforestation.

Relevance to students' life world

As featured in most extra-curricular activities, the content design begins with global environmental problems, and then directs students' attention towards recommended actions for solvable problems in the students' life in school, at home, and in the local community, e.g. saving paper, recycling garbage, and recycling batteries, etc.

Knowledge development path

The investigated extra-curricular activities included a very limited amount of factual knowledge, which the students did not have to remember, but which was provided to show evidence of the environmental crisis and then call for certain actions.

4.3 Result comparison

In summary, the observed practices are fairly in line with the assumptions. All the practices, both in the intra-curricular lessons and in the extra-curricular activities, made use of multiple information sources. Contradicting aspects of the studied environmental issues were introduced in some of the practices, mostly for comparing enjoyable aspects with the endangered aspects of nature. All the practices showed an effort to steer the students' attention towards solvable environmental problems in their daily life, i.e. at home, in school, and in their local community. And for all the observed practices, factual knowledge was unavoidably included, but served for raising students' environmental awareness, rather than for reproduction.

5 Process

The analytical instrument hypothesized that teaching and learning of environmental education is a collaborative process (cooperation). Students are involved in inquiry into and solving the environmental problems (engagement). In the teaching and learning process, students are actively participating (participation). In the observations, we have to identify in the integrated courses and extra-curricular activities whether the processes require cooperative learning and in which specific ways the students cooperate, whether the students are required to engage in finding problems, making inquiry, solving problems, and taking action on the problems, whether the teaching and learning processes allow the students' participation and in which specific ways the student are participating.

5.1 Intra-curricular teachings

Cooperation

Cooperative learning is well accepted in all the lessons. Though the teacher did not require cooperation among the students in the design of the science lesson, he explained in the interview that in the science lessons, generally a cooperative learning approach is adopted. In the observed lessons, the students were mostly cooperating in group discussion and class discussion. In the discussions, the students propose questions, share information, report problems they found, analyze the problems, and propose action plans to solve the problems. The groups consist of four students, formed by the two sharing one desk, who then turn backwards to the two sitting behind them. In a group, every student in turn takes the role of leader. In the after class interviews, the students expressed positive opinions about the classroom cooperation. According to the students, collecting information independently before the class discussion is helpful for taking initiative so that they already have something to say during the class. In group learning, students can expand their information source by exchanging and sharing; and receiving feedback from other group members is also considered as fruitful.

Engagement

Students' engagement is encouraged in all the lessons. In six of the classes, students were engaged in finding problems, proposing action plans, or taking action to solve problems. The science teacher did not engage students in inquiry in the observed lesson, but confirmed that in some other lessons students are indeed engaged in doing experiments. However, the observed classes revealed a rather behavioral mode of instruction where most often the students were directly engaged in taking actions or proposing action plans promising behavioral changes. In other words, the students' engagement was not with the entire learning process, from finding problems, to inquiry about problems, to solving them.

Participation

In all the observed classes, the students participated actively in teaching and learning processes. The participation took various ways. Participation in collecting information, sharing information, expressing thoughts, and describing their life practices concerning the environment were often observed. Participation in a role playing game, in hands-on activities, and taking action was only observed in the fine art lesson. And only in the science lesson did the students have the opportunity to observe plant species. As the teachers explained in the interviews, safety is their prior concern considering the big class size (47-67 students).

All the class and group discussions revealed that there is a large proportion of information overlap. And in most discussions, all the students merely bring their notes prepared as prior study homework and read them to each other. In the interviews, the students described their habits of information collection. Internet is their main reference. Collecting information relevant to the lesson is assigned as prior study homework one day before the class. In the assignment, the students receive no instructions on what information should be collected and how to collect it. As a result, the students merely use very general key words in their web search, as exemplified in the Chinese lesson *'Inspirations from Nature'* where most students used the same key words, 'bionics example' 'inspiration of nature' 'learning from plants and animals', which brought them to the same webpages. As a teacher commented in the after-class interview the students are rather weak in showing their different interests and in their ownership of the collected information.

In the majority of the class discussions, proposed action plans were stated as a slogan addressing an undefined subject, e.g. *'We should stop human beings destroying the environment.'; 'We should love nature.'; 'We should stop human beings lumbering.'; 'Human beings should plant more trees.'*

Some of the proposed action plans lack relevance to specific problem solving. And the teachers did not bother to guide the students to reason about whether and why their proposed practices are relevant to problem solving, or to question whether they are practical in reality. As illustrated in the Chinese lesson *'Whale'*, during a three-minute long discussion, in answering the teacher's question, *'What should we do to protect the endangered whale, beginning from 'myself', and in every day life?'* the students proposed actions such as do not litter in the campus, taking public transportation. No further discussion was made about whether and how these actions would possibly help to save whales. And in the fine art lesson *'Home of Birds'*, though with an intention to provide more nesting places and contribute to diminish the bird diversity loss, the students' action of placing their bird nests in the shrubberies in the school campus had more symbolic or ritual meaning than actual use in helping birds as intended, for various practical reasons. There were not sufficient bushes to hold all the nests; the branches were too weak to support oversized nests and some branches were snapped; the shrubbery was too low to be safe enough to really host birds. As interviewed, to the teacher's mind, whether the nests could be used in reality is not the main concern, but developing the students' environmental awareness. And she remarked: *'Maybe after a few days they (the nests) get wet in rains, perhaps* [they] *will be thrown to garbage, I think. And I don't expect the birds will really go to rest there, the bushes are too low to be safe.'*

5.2 Extra-curricular activities

Cooperation

In extra-curricular activities, for example on excursions, the students were grouped mainly for rule keeping. Students are grouped with a volunteer leader for each group to help the teacher to supervise, to keep the groups complete and protect the students' safety, and to leave no litter in parks. Grouping is also observed when the students received tasks from YPD such as adopting a tree in the campus, or in their local community, which is rather loose and spontaneous without a specific goal or plan.

Engagement

In most cases, after introducing the severity of environmental problems, the students were directly engaged in taking required actions, rather than stimulated to investigate the problems, improve their understanding of the interrelationship between their lifestyle and the problems, and then propose their own actions to solve the problem. The required actions presented in do's and don'ts demanded behavioral choices such as save water and do not litter.

Participation

The students participated in various extra-curricular activities, i.e. excursions to city parks, adopting and taking care of a tree or a piece of grassland on the campus or in their community, raising a potted plant in the classroom, making blackboard newspapers and assembly speeches, organizing an essay contest or an art festival on environmental protection. However, all the activities were characterized by one-way communication, in which the students were to follow certain actions suggested by their teachers, or to read blackboard newspapers, listen to speeches, or watch performances by a few selected student representatives.

5.3 Result comparison

In summary, with reference to the assumptions, the students' cooperation, engagement, and participation were all evidenced in the observations both in intra and extra curricular practices. However, the problems are obvious and demand improvement. The cooperation in extra-curricular activities was mainly for rule keeping and lacked a specific plan. Comparatively, in intra-curricular lessons, cooperation has a specific function, and the members have assigned roles. In terms of the students' engagement, a behavioral mode of instruction was observed both in intra- and extra-curricular practices, and as a consequence the students had little opportunity to engage with the entire inquiry process, from finding the problem, inquiring the problem, and then solving the problem, because they were immediately engaged in proposing action plans or taking the recommended actions. In both modes of practices, the students were participating in teaching and learning processes in various ways, but hardly in outdoor activities, such as visiting, and observing. As reflected in the interviews, safety is the top concern for the teachers who have to take care of large classes. The students need to be supported in the development of their skills in collecting information in respect to their own study motives and interests. Also, it is necessary to expand participation from a few elite student representatives to average students, and to improve the communication from one-way to two-way style. Lastly and maybe needed most urgently is for the students to be guided in their participation in proposing action plans, which are often too abstract and lack relevance to address specific problems.

6 Teacher

The analytical instrument assumed that the teacher should be amenable to students' autonomous decisions. Teachers are agents having their own view and ideology about education which shapes their decisions on curriculum and pedagogy. Based on these assumptions, we observed environmental education in the integrated courses and in extra-curricular activities, to see whether and to what extent the teacher may shape the content and the pedagogy, and what the teacher's role is in giving autonomy and freedom to the students.

6.1 Intra-curricular teachings

In all the observed classes, the teachers showed respect for the students' own thoughts. The students were at ease to express their different opinions and even their disagreement with the teachers, for example in the morality and life lesson, some students even shouted to the teacher, *'I don't believe you!'; 'Impossible!'* In the after-class interview, the teacher confirmed that she did not feel offended, and was even glad that the students were not afraid of her. Other teachers affirmed that the students' autonomous, creative, and critical thoughts are welcomed in the classes. Nevertheless, the teachers revealed that in the final evaluation the students are still urged to present standard answers. For this reason, the teachers on the one hand are liberal about students' various thoughts and decisions during the classes, and on the other hand they are strict on training the students to reproduce predefined conclusions and standard answers in exams. More detail will be given in section 8.1.

The teachers are free to make their content design in accordance with teachers' manual and textbooks. The teachers reported that as along as learning objectives are met, the teachers can make their own selection of content. For example, in the morality and life lesson *'Green Action'*, the teacher did not use the examples introduced in the textbook, but rather guided the students first to discuss the concept of 'green action' itself, which is not included in the textbook. In the music lesson *'Hello, Nature!'* the teacher designed the lesson to integrate environmental education without indications from the textbook or the teacher's manual, which basically provides disciplinary content and learning objectives of music. And the observed science lesson on local plant species is an autonomous design by the teacher and is not even included in the textbook. The science teacher explained that as a subsidiary course, science is limited by available course hours and laboratory appliances. Being so, the science teacher may purposefully select some topics from the textbook, or sometimes design additional lessons with more local relevance to Qinghai, e.g. by telling the students stories about changes in the city's landscape, or by introducing common local plants as in the observed outdoor lesson.

The teachers have full freedom in making pedagogical choices, but felt uncertain about the appropriateness. None of the teachers were supported with instructional advices about how to organize integration of environmental education. The teachers made their design mainly based on intuition and common sense. In the observed classes, the most common practice was that the teacher introduces environmental problems and asks the students to discuss about how to solve the problems. However, in the fine art lesson and the music lesson, the teachers showed a remarkable effort in introducing contradicting aspects of environmental problems, namely comparing the aesthetic aspect of nature and the environmental crisis with the aim of emotionally motivating students' environmental concerns. In the interviews, all the teachers expressed their uncertainty about the pedagogy they have chosen. As illustrated in the lesson fragment of *'Green Action'*, the teacher used 'appeal to fear' as a teaching strategy. The teacher attempted to make the students sense and be afraid of the harshness of mistreated other species by using metaphorical punishment. For example, when explaining the urgency to protect the earth, she invited the students to imagine:

'What we have done to the earth? If right now, I catch one of you and I splash dirty water on you, spit on you, tear your clothes, and I will dump you in the garbage, how would you feel?'

And when explaining the urgency to conserve forest resources, she compared a tree with the student's body:

Teacher: 'Er… listen, in you daily life, everything made from wood requires a life sacrifice of trees. And this sacrifice is for your living convenience. However, when you write your assignments, when you use the notebooks, you are very crude and pitiless. If you now imagine, I walk to one of you, tear your ear and tear it down, how would you feel?'

Students (shouted in panic): 'Gee!...Eww…'

In the after-class interview, the teacher shared her hesitation in using this strategy. She applied this strategy more with the grade 4 students (age 11 or 12), but for the younger students in grade 2 (age 7 or 8), she thought that it would better to build positive and joyful things for them. Out of this concern, she already skipped even more terrifying examples.

6.2 Extra-curricular activities

In the majority of the extra-curricular activities, the YPD directors and class teachers put the students in the role of passive recipients, either to follow what the YPD directors and teachers asked them to do, or to receive what the student representatives showed them. Only a few student representatives have the opportunity to show their own ideas when making blackboard newspapers, giving assembly speeches, or performing in art festivals, etc. Only the class meetings gave all students the opportunity to speak and discuss freely. However, class meetings on environmental education are held only once or twice per semester.

In the extra-curricular activities, content is selected by three actors, school principals, YPD sections of local educational administrations, and education and communication sections of local environmental protection administrations. From these actors, the content is assigned as educational themes or learning activity plans to YPD directors in every school, and then further assigned to the chief teachers in every class. In the schools' implementation, the YPD directors and class chief teachers design learning activities according to the assigned themes and plans and carry them out school-wide or class-wide.

The pedagogy is free to be decided by YPD directors and chief teachers as long as it falls under the given theme and within the agenda. As proved in all the observed cases, the pedagogy was rather in a behavioral mode, namely to convince the students of the severity of the environmental problems and then call for action to solve them.

6.3 Result comparison

In summary, with reference to the assumptions, the teachers of intra-curricular integrated lessons provided generous freedom for students' various expressions, while the teachers in extra-curricular activities are only open to students' autonomous views to a very limited extent. In these activities elite student representatives had more chance to express themselves than others. The teachers in environmental education practices of both modes had the freedom to make their own selection of content and choices of pedagogy.

7 Student

The analytical instrument postulates that students should be active and critical thinkers, and the generators of knowledge. In order to identify whether the students take a critical role in teaching and learning, we observed to what extent the teacher accepts multiple answers and disagreement from the students. In order to identify whether the students take an active role in generating knowledge, we observed to what extent the students may decide a study topic by themselves, to what extent they may raise their questions rather than merely responding to the teachers' question, or even to what extent the answers are provided to the students, and to what extent factual knowledge is provided to the students to collect the required understanding by themselves.

7.1 Intra-curricular teachings

The critical role

In six of the lessons, the students had plenty of opportunities to give different answers. As every teacher reported, they personally found it enjoyable to be surprised by the students' creative ideas and alternative opinions. In classroom teaching, the students' diversified and creative answers were encouraged by teachers' verbal affirmative commentaries or rewarded with a class applause. Concerning the final exams, the teachers admitted that it is necessary to let the students write down a pre-defined conclusion or standard answer to guarantee that the students do not lose points on their exam.

In six of the classes, the teachers and the students were confident and comfortable in disagreeing with each other. The students could correct mistakes by the teacher and by other students, or argue with the teacher and other students if they had a different opinion. The lower grade classroom atmosphere was even more open, so that students could explicitly express their disagreement. The students may freely interrupt in raising their hand or just speaking out and laughing out such as *'Eh! Can't be!'; 'Ha Ha! That looks ugly!'*, when they wanted to add comments to the teacher's or other students' views.

The active role

In all the lessons, the study topics were not selected by the students. The study topics were defined in the textbooks and teacher's manuals, and then either directly passed on to the students, as observed in one lesson, or expanded and specified by the teachers, as observed in five lessons. However, there is also room for the teachers to select the study topics, based on their own prior knowledge and teaching experience, as observed in the science lesson.

In all lessons, the students were allowed to raise questions to the teacher and to other students. However, the questions were not to initiate a study topic. In most cases, the students' questions to the teacher were intended to ask for clarification, for example, *'What is photosynthesis?'; 'How is it possible that the Qinghai Lake is getting smaller?'; 'Why the leaf of this three is longer?'; 'Is the flower edible?'* And the students' questions to each other were mainly for clarifying, correcting or criticizing, such as, *'I didn't understand the work, can you explain more?'*; *'Can you pronounce the word again? I am afraid you have just pronounced it wrong.'* and *'How can you use that example?'*.

In six of the lessons, the students were fully free to propose their action plans to solve the problems, but all the teachers indicated a direction that the actions should focus on what the students can do by themselves, and start with 'doing small things' in everyday life.

Except in the Chinese lessons, necessary factual knowledge was directly provided to the students rather than collected by them. The observations show that in all the lessons, the teachers did not require the students to memorize the factual knowledge, but it was taken as basis to help students develop an awareness of maintaining a sustainable life quality. For example, the factual knowledge on photosynthesis and root function was to explain the necessity of the action plan of tree planting; the numeric data on bird species extinction intended to guide students' reflections about inappropriateness of human activities.

7.2 Extra-curricular activities

The critical role

In the majority of the extra-curricular activities, the students had very limited opportunities to express different answers or viewpoints, or to show their disagreement with the teacher. In reading blackboard newspapers, and listening to assembly speeches, the students had no opportunity to give feedback. In essay contests and art festivals, only the student representatives who attended had the opportunity to show their thoughts, interests and talents. And only once or twice were all the students invited to speak out in class meetings.

The active role

In all the extra-curricular activities, the topics were not selected by the students, but by the school principal, local educational administration, or local environmental protection administration.

Only in class meetings that were once or twice organized under the theme of environmental education, did the students have the opportunity to raise and discuss their own questions. In the majority of the learning activities, the students were put in the passive role of recipients or audience.

In the majority of the cases, actions were proposed by YPD directors, chief teachers, or student representatives.

Factual knowledge was included in most of the extra-curricular activities. Especially in assembly speeches and blackboard newspapers, the information consists mainly of facts, such as definitions of what World-Earth Day is, and what global warming is. In knowledge quizzes organized for *'Green School'* nomination, the students were asked to replicate factual knowledge as such.

7.3 Result comparison

In summary, with reference to the assumptions, intra-curricular teachings showed more evidence confirming that the students are taking an active role in generating knowledge, and a critical role in expressing their thoughts. In most of the observed classes, the students were comfortable to give different answers, to disagree with each other. And in all lessons, the students propose their own questions and action plans. But in most lessons, the students were provided with the required factual knowledge rather than collecting it themselves. In extra-curricular activities, the students were put in a passive role, with very limited chance to show different viewpoints, to propose questions and action plans. Factual knowledge is provided directly to the students in one-way communication. And the *'Green School'* nomination required the students to replicate factual knowledge in quizzes. In extra-curricular activities, only a small number of student representatives had the opportunity to show their different thoughts and talents. And in all intra- and extra-curricular teachings, the students did not contribute to the selection of the study topics.

8 Assessment

Our analytical instrument assumes that the assessment of environmental education evaluates the process of inquiry, critique, and reflection (process), and the extent to which students develop and defend their own environmental beliefs and choices, as well as their ability to act according to their own choices (development). In the observations, we used five categories to characterize the assessment, in viewing whether the teaching evaluates the students' learning processes; whether it evaluates the extent to which students develop and defend their own environmental beliefs and choices, as well as their ability to act accordingly; whether the evaluators are multiple; whether students may do self-evaluation; and whether the teacher use standards to evaluate.

8.1 Intra-curricular teachings

In the observed schools, intra-curricular environmental education is either integrated into existing subjects, or as a domain-specific subject given as a separate course. However, as a separate course environmental education only consists of course tables and final exam papers as a response to the inspection of upper level administrations. Therefore, for environmental education as a separate course, we were only able to analyze its assessment in the standard final exams.

Process evaluation

In the integrated classes, the teachers evaluated during the students' learning processes, rather than as a final judgment of what students had said or done. In all the observations, instead of giving a judgmental remark, the teachers used affirmative verbal commentaries to either encourage the students to come up with more, e.g. *'Good, what else?'*, or indicating direction when the answer went out of the focus e.g. *'To remind you, we are now talking about…'*, or acknowledging good performance, or summing up discussions or keeping rules, e.g. *'Attention now, a good listener always has good findings.'* During the discussions, the students were also invited to give evaluative comments to clarify, correct, and criticize each other in a process of learning and reflecting together.

Development evaluation

All the teachers of the integrated lessons approved that the focus of evaluation is on the students' improvements in developing and defending their own knowledge, competences, beliefs, and choices. In the classes the teachers used affirmative comments to encourage the students to give different and creative answers, and no negative comments or correction words, such as 'no', 'that is not right', etc. The students were also comfortable with giving feedback to each other. During presentations, class discussions, and group discussions, the students straightforwardly expressed comments, corrections, additional thoughts, and even disagreements to each other. In the interviews the teachers emphasized that the students' competence developed during the teaching-learning process is the focus in their evaluation.

Self-assessment

Students' self-assessment is accepted well by all the interviewed teachers of integrative lessons. As illustrated by the teacher in the fine art lesson *'Home of Birds'*, though there are some basic skills in handicrafts making for the students to begin with, she believes that no judgments should be given about the student's handicraft making process and the product, as long as they enjoyed the process and are satisfied with their own products. In all the lessons, the teachers invited the students to give feedback on each other's answers, by asking for example *'Do you agree with him/her?'; 'What do you think of this action plan?'* or by giving a class applause to compliment excellent answers.

Multiple actors

In all the integrated lessons, the teachers as well as the students took the role of evaluator. The teachers provided evaluative remarks merely on the disciplinary part, such as handicraft skill in the fine art lesson and presentation skill in the Chinese lesson. The integrated environmental education part was left out of the evaluation. In the interviews, all the teachers affirmed that multiple actors are involved in the evaluation, the teacher, the students, the parents, the local educational administrations. The parents' participation mainly takes the form either of helping and proving the homework completion or of attending parents' meetings organized at the end of each semester. In most of the lessons, the students' homework needs to be handed in with the parents' signature on it showing they have checked its completion. Other innovations were also adopted. As the teacher of the morality and life lessons introduced, the parents are invited periodically to comment on their children on a 'praise card', a card on which the parents keep notes of commendable things that their children have done. Specifically, for the observed lesson *'Green Action'*, the parents are invited to list on the 'praise card' their children's environmentally friendly behaviors in daily life. The interviews with the teachers and the principals pointed out that the local educational administrations take the authority role in designing the final exam paper, defining standard answers to the exams, to determine and promote the teachers' professional quality.

Standard evaluation

As a separate course, environmental education only exists in course tables and in final exam papers. From casual talks with students, we found that the teachers of environmental education are often their math teachers, and the course hour is used for doing math homework. The school principals admitted and explained that this is due to the requirement in '*Syllabus on*

Environmental Subject for Students in Secondary and Primary Schools' (CEE1). In the schools, environmental education is listed and printed in course tables just to show to the local educational administration that the subject has been included in the curriculum. However, in implementation, the math teachers are assigned as environmental education teachers to purposely extend their course hours in teaching math, since math is often short of course hours compared to other main courses like Chinese. Main course exam marks are ranked for judging the teaching quality of the teachers and the school, but for a subsidiary course like environmental education, the local educational administrations do not organize exams or rankings. In the final exams, the schools only have to keep records in the form of exam papers in case of inspection. As we observed, the schools held paper pencil exams with questions merely on factual knowledge, and the students were asked to copy the given standard answers on the exam papers which would make records ready for inspection. In short, the measure taken by the schools to cope with the local educational administrations inspection is to list environmental education in the course table in the beginning of the semester, and compile exam papers at the end of the semester, but during the semester the course hour is actually given to the math teachers to extend time for students doing math exercises.

When environmental education is integrated into existing subjects, the assessment as observed was rather focused on students' active involvement in learning processes and the development of environmental awareness. Nonetheless, in the final exams, the standard evaluation is still applied to integrated environmental education. For example, in the final Chinese exams, students are required not only to provide standard answers on basic knowledge, but they also need to show the correct ideology orientation in a more open test, such as reading and composition. As confirmed by the teachers, being a language subject, the evaluation focus of Chinese should be on the students' competence in expressing their thoughts. It is therefore difficult though advantageous for them to demand the students to reproduce answers showing the expected correct ideology orientation (si xiang dao xiang).

In the Chinese class of *'Inspiration of Nature'*, we observed that the teacher, although she gave generous freedom to the students throughout the class discussions, at the end of class, she dictated the students word by word a pre-written paragraph with the main conclusion drawn from the two stories in the lesson, for the students to remember what the right answer should look like in order to get a good mark. Specifically, the students' conclusions should include the two focal points, as suggested in the teacher' manual: in an ecosystem every element is in coexistence and we should respect this as a natural law; and all species may inspire us for technological inventions, so we should learn from them. As the teachers explained the two focal points imply a humble and harmonious ideology that we should respect nature, learn from it and live in harmony with it. When the students' answers present contrary ideas, it is considered to be wrong in ideology. For example, humans can dominate nature and manipulate arbitrarily.

Another typical example is also highlighted in the interviews. One Chinese lesson tells a story in which a poor man bought a lottery token for his friend, a rich man, who then actually won a big prize. The students were asked to discuss whether the poor man should honestly inform the real winner, the rich man, and give back the lottery token. In the class, most of the students could grasp the expected right choice, namely he should return the token because the prize should belong to the rich man, except two students who insisted that the poor man shouldn't return it because he is the one more in need. The teachers remarked that they personally found both choices have a reason, honesty or equity. In the classes, both opinions were allowed to be expressed freely, but the teachers still claimed to the students that honesty is the right ideology expected in final exams; other opinions can be discussed in class, but cannot be presented in the exam papers.

As observed in the exams of the science lesson, the exam papers were handed out to the students together with the correct answers. In the exams, the students are asked to copy the correct answers on the exam papers to make records ready for inspection. As the teachers and school principals explained, for subsidiary courses, local educational administrations do not require them to mark, and therefore the evaluation of the subsidiary courses is not included in ranking of teachers' teaching quality. Nonetheless, the local educational administrations do inspect whether the schools have organized the exams. As a response measure, the schools hold paper pencil exams with questions merely on factual knowledge, which is easy to do and easy to records.

As evidenced in the observations and confirmed in the interviews, the teachers do not apply, nor do they prefer to apply standard evaluation in their classes. The classroom evaluations represented the teachers' opinion that the focus should be on the students' development all along the learning processes, and that students should be given an active role in evaluation. However, the teachers also admitted that standardization is applied in final exams. In the interviews, all the teachers shared their confusion in coping with evaluation in two contrasting ways, encouraging students to be creative and autonomous during classes on the one hand and restricting them with a certain expected direction of thinking in exams one the other hand. Several teachers reflected that the evaluation principles advised in the new curriculum standards are more ideal and favorable for their teaching practices. Nevertheless, the final exam determined that the level of the local education administration is fundamentally leading the entire teaching practice at school and classroom levels. As we have known from the document analysis, ranking students by their exam marks is no longer allowed (SE4, SE5; see chapter 4, section 2.7). According to observations in the schools, this policy is effectively implemented. Nevertheless, instead of the students, the teachers are ranked by the average mark of their students and are financially awarded accordingly. A teacher whose class ranked at the bottom is asked to have a critical reflection with the school principal, which is seen as losing face. Being driven forward by the monetary and honorary impetuses, the teachers are under pressure to train their students in how to get good marks in standard exams.

8.2 Extra-curricular activities

Process evaluation and development evaluation

An 'end-of-pipe' evaluation is applied in the extra-curricular activities. Data collected in the schools indicate that the evaluation of extra-curricular environmental education is conducted via two routes. One route is that schools receive study tasks from the YPD sections of the local educational administration and report to them about the implementation. The other route is through the nomination for *'Green School'*, for which schools need to compile all available records and show the board what extra-curricular activities have been done in environmental education. In the YPD task evaluation route, the interviewed school YPD directors admitted that operationally the evaluation focus is merely on completion of the tasks, for example by inspecting whether the students have put name cards on their adopted trees, or checking whether they have made blackboard newspapers on the given environmental themes. In the *'Green School'* nomination route, the candidate schools have to compile all available records of what they have done in extra-curricular environmental education, such as assembly speech manuscripts, photo records of blackboard newspapers, class meeting minutes, and photos of excursions. In the nomination, the candidate schools receive a check list on the conducted environmental education, in which the educational process is one of the indices. Under the index titled 'educational process', the candidate schools are asked to provide files to prove the completion of required specific activities. To name a few: environmental education has been conducted in class meetings, the school has used a blackboard newspaper or school broadcasting to disseminate environmental knowledge, and the school has permanently posted slogans of environmental protection. The interviewed school principals complained that such an evaluation of the 'process' is too time consuming and unproductive. As one school principal commented: *'I wish they could come in person when the activities are going on, give us instruction and support, rather than come in the end when everything is done and simply mark on their checklist what has been done.'*

Self-assessment

In the observed seven lessons, students' self-assessment was not included in the evaluations, but a top-down administrative evaluation is applied to all the investigated extra-curricular activities.

Multiple actors

In the observed extra-curricular activities, multiple administrative actors took the role of evaluator. In the YPD task evaluation route, schools' YPD directors are under the supervision of the Moral Education Division (in some school indicated as the Political Education Division). YPD directors receive tasks such as an essay contest or art festival, either from the YPD section of the local educational administration or education and communication section of the local environmental protection administration and report to them about its implementation. In the *'Green School'* nomination route, the inspection board members are the local educational administration, the local environmental protection administration, and the local publicity administration.

Standard evaluation

Both in YPD task evaluation and in *'Green School'* nomination, the focus is on checking whether the required activities have been completed. As a YPD director remarked, *'Anyway, the activities have been formulized year by year. It has a fixed agenda that we must follow periodically, for example, what to do on Arbor Day, and what information we should disseminate on World Earth Day.'* As proved in all the schools, the *'Green School'* nomination merely implies inspection of files that recorded schools' environmental education activities. In the evaluation sheet of the *'Green School'*, a checklist included five indices specifying the required educational activities that the candidate schools have to conduct. In the checklist, large amount of activities have a standard measurement, for example, the candidate schools have to provide files to prove that school leaders have at least twice organized meetings on making environmental education plan, and to prove that environmental knowledge has been tested in at least three final exams. All the interviewed school principals commented making proof files, e.g. keeping minutes, photographing is very time consuming and tiring. And some of the principals explicitly disapproved of such an evaluation focus on the standard measurement of results rather than on the educational process and students' development during the lessons.

8.3 Result comparison

In summary, in school practice, the assessment of environmental education is both applied to the extra-curricular activities, and to intra-curricular teachings in two forms, integrated courses and separated courses. As a separated course, environmental education only exists in the course table and in the final paper pencil exams, in responding to administrative inspections. The final exams are merely to keep record of the inspections, in which students are asked to note down given correct answers of factual knowledge. In the integrated courses, process evaluation, developmental evaluation, self-assessment, and multiple evaluators are featured during the classes, and approved by the teachers. Nevertheless, in the final test, environmental education is combined with other disciplinary content in which the students are required to show a correct direction of thinking in order to receive good marks in the exams. The evaluation in extra-curricular activities is a top-down administrative evaluation, in which the activities are judged only on their completion. Administrative actors take the main role in the evaluation, i.e. YPD section and *'Green School'* nomination organized by the Center for Environmental Education and Communication (CEEC) of the Ministry of Environmental Protection (MEP), the Ministry of Education (MoE), and the publicity department of Communist Party of China (CPC). To conclude, environmental education in schools is assessed according to the theoretical assumptions during the classes, but in final exam, administrative power is leading the practice and continues to give effort on training the students to perform according to the expected standards. From the 'bottom', the teachers, the directors, and the principals all showed a supportive attitude to the evaluation principles intended in the curriculum standards, but from the 'top', the local education administrations are still setting standard measurements to schools, teachers, and consequently in the end also to the students.

9 Summary and preview

In this chapter, by analyzing the teaching practices with the curriculum elements, we described the pattern of the implemented curriculum of environmental education. With the observations and interviews, we investigated the 'practice' block. The possible operational gap will be revealed in comparing the 'link' and the 'practice' blocks. An operational gap exists when the potentially implemented curriculum of environmental education (as presented in teaching materials) is different from the implemented curriculum (as evidenced in teaching practices). After the analysis of involved actors in implementation as presented in chapter 7, we will conclude on the operational gap in chapter 8.

Chapter 7 Curriculum Actors

1 Introduction

By the curriculum element analysis, we described the 'rhetorics' of school education and environmental education (in chapter 4), the 'link' and the 'practice' of environmental education (in chapter 5 and 6). In this chapter, we correspondingly analyze the actors involved in the curriculum activities to draw a conclusion about the emergence of possible gaps. The actors involved are inferred from the documents and the interviews with designers and policy makers. The goal of the actor analysis is to reveal the actors involved in creating the rhetoric-practice gap, by identifying who are necessitated in the curriculum activities of policy making, design and development, implementation, and evaluation. Namely, the actors involved in making the intended curriculum in forms of the policy and curriculum documents, in making the potentially implemented curriculum in forms of textbooks and other materials, in actual teaching practices in schools, and in assessing the learning outcome. To identify the curricular actors involved in general school education, we analyzed the eight overarching educational policy documents (SE1-SE8). And to identify the curricular actors involved in environmental education, we analyzed the sixteen policy documents (EE1-EE16), the two curricular documents (CEE1, CEE2), and the interviews with policy makers and designers of environmental education (Interviewee A-I).

2 Curricular actors in school education

In this section, we identify the curricular actors involved in general school education (see methods in chapter 3, section 4.1, 4.2). We identified the actors in the eight overarching educational policy documents (SE1-SE8). In addition, the document analysis also provided an overview of the on-going curriculum reform in China.

2.1 Curriculum reform and landmark documents

China's curriculum reform is no exception from the observed international trend moving towards decentralization in education, especially in curriculum design, an increased autonomy at local and school level with diversified textbook choices (Daun, 2007; Fiske, 1996; Hawkins, 2000; Welsh and McGinn, 2008). The on-going eighth curriculum reform was officially initiated in 1999, and it is considered as a further promotion of the shift from examination-oriented schooling (ying shi jiao yu) to essential-qualities-oriented schooling (su zhi jiaoyu). In brief, this curriculum reform is a response to the crisis that occurred in examination-oriented education, which emphasized factual knowledge, the passive role of students, disciplinary subjects, curricular overload, centralization, and quantitative evaluation.

The policy of the eighth curriculum reform is framed and defined in several landmark documents. In January of 1999, *'21st Century Action Plan for Invigorating Education'* was approved by the State Council (SE1)[1]. In this document, the orientation towards essential-qualities of education is clearly stated, *"by 2000, it is to initially build up the basic education curriculum framework and standards, to reform the content and pedagogy, to implement a new assessment system, to carry out teacher training and start new curriculum experiments.'* Shortly after, in June of 1999, the CPC Central Committee and the State Council jointly approved '*Resolution to Comprehensively Promote the Essential-qualities-oriented Education*[2]' (SE2). Following this, by the end of the year, MoE presented the '*Project Overview of the Basic Education Reform*' (SE3).

In 2001, the State Council passed '*Resolution on Basic Education Reform'* (SE4). Right after, MoE issued three documents, namely, *'Outline of Basic Education Curriculum Reform'* (SE5), *'Interim Measure for School Textbooks' Composing, Approving and Management, and a Pilot Program for Compulsory Education Curriculum'* (SE6) and *'Pilot Plan of Compulsory Education Curriculum'* (SE7). In 2004, the State Council issued a circular to launch the '*2003-2007 Action Plan for Invigorating Education*' to further catch up the reform of essential-qualities of education (SE8).

In the above mentioned landmark documents, the notions supported by the eighth curriculum reform defined all actors involved in the curricular activities.

2.2 Actors in policy making

The Ministry of Education (MoE), formerly the State Education Commission (SEC), plays the leading role in policy making at the national level, and in

1 A coding number is given to each of the documents. SE represents 'school education', and EE represents 'environmental education'. For example, SE1 names document 1 of school education, and so forth. The coding number is used to show the source of findings for the repeatability of the data analysis. The documents are listed in appendix II.

2 The concept of essential-qualities-oriented education was first mentioned in 1985 in a landmark document of the sixth curriculum reform. And it was proposed in 1993 as the educational orientation in the landmark document of the seventh curriculum reform. The promotion of essential-qualities-oriented education should be understood as a continuous effort since then. In 1996, MoE set up a project team and conducted a nationwide survey to evaluate the quality of the past educational reforms. The results served as a preparation for the eighth curriculum reform.

supervising curriculum plans developed at local and school levels. As regulated in the eight policy documents of general school education, MoE sets overall curriculum policy for basic education (SE4, SE5), as well as making detailed curriculum plans for compulsory subjects and a suggested but flexible time table for each subject (SE4, SE5, SE7). MoE is also responsible for developing basic education curriculum standards which define the framework of the curriculum, its nature, mission, content, and focus (SE4, SE5). The curriculum standards form the basis for curriculum management, evaluation, textbooks designing, teaching and learning, and examination (SE3).

When the implementation of compulsory courses defined by MoE is guaranteed (it is defined in the Chinese national curriculum, see chapter 8), local educational administrations[3] and schools are encouraged to develop local curricula and school curricula. Supervised by MoE, the educational administration at the provincial level may make their local curriculum standards for the province, or the autonomous region, or the directly-controlled municipality (SE5), and may set out their specific requirements about the design and management of their local and school curriculum (SE7).

In sum, MoE is the absolute top policy maker, which outlines the curriculum of general school education, defines compulsory courses, and develops the curriculum standards which fundamentally determine curriculum design. Local educational administrations and schools have some room to maneuver in making more locally relevant curriculum policies, but it is under a top-down administrative supervision.

2.3 Actors in design and development

MoE is responsible for establishing the national committee to approve and validate the textbook designs of the national curriculum and local curricula across provinces (SE4). However, MoE encourages a democratic participation from various social groups in designing curricula for primary and secondary schools (SE5). Any capable institution, organization, or individual can design teaching materials for primary schools and secondary schools, except some specifically involved stakeholders (educational administrations, national civil

3 In the Chinese administrative vocabulary, the concept of local government or local administration is in comparison with the central government. Under the central government, a five level administrative hierarchy of China state is defined as province, prefecture, county, township, and village. These five levels are generally called local levels. Each of the levels corresponds to a level in the Chinese civil service.

servants, members of the committee for examining and approving basic education textbooks). Curriculum designers have to apply to MoE and only when the application is granted they can begin with the design (SE6). The approved teaching materials will be put on the book list for schools to choose and try out (SE6).

Educational administrations at the provincial level are responsible for establishing provincial committees to validate and approve the textbooks of local curricula (SE4). Schools have the full right to develop or choose a school curriculum under the supervision of education departments at all administrative levels (SE4, SE5, SE7). In addition, schools can autonomously develop their extra-curricular activities, e.g. morning gathering speeches, class meetings and young pioneer meetings, activities related to science and technology, and culture and sport (SE7).

In sum, MoE plays still a leading role in setting rules and validating teaching material design for general school education. In actual writing and editing, various actors are allowed to develop their products in a rather independent way. Schools have freedom to design or select school curricula and extra-curricular activities. Even so, the developed teaching materials are finally judged in a top-down administrative hierarchy.

2.4 Actors in implementation

MoE is responsible for supervising the implementation of the compulsory national curriculum (SE4). The educational administrations at provincial level are responsible for implementing the national curriculum in the schools located in their regions and for organizing teacher training for carrying out the new curriculum (SE4, SE5). And schools have to carry out the curriculum defined by national and local level of education administration (SE5).

A wide diversity of stakeholders is encouraged to ensure the implementation of the national Curriculum. *'All groups of society should be mobilized. School, family and social groups have to communicate and cooperate actively with each other for the educational reform'* (SE2, p.11). Curriculum designers, teachers and education administrators all have to follow a systematic training (SE3). Teachers should actively study and participate in the teaching innovation (SE4). Schools should enhance communication and cooperation with local communities and with students' parents (SE4). Home education has to be improved, and parents need to be guided in forming proper ideas about education, in order to build a healthy home environment for children (SE4). Under the lead of educational administrations, educational research institutions should play a full role in research of teaching, guidance, and assistance (SE5). Normal universities shall set up research centers of basic education to conduct research on basic education curriculum reform (SE5). Media have to guide public opinion (SE2) and to play an active role in inviting all social groups into comprehensive discussing, caring, and supporting the curriculum reform (SE5).

In sum, schools are carrying out the curriculum required at the national and local level, under a top-down administrative supervision. From the document discourse, the biggest decision maker, MoE is fully aware of the social pressure that might arise against the curriculum reform. As is indicated in the documents, a wide participation is promoted to guarantee the quality of implementation, from educational administrators, teachers, communities, parents, academic institutions, and public media.

2.5 Actors in evaluation

MoE is responsible also for defining a new curriculum assessment system (SE5). The experimental pilot schools of the curriculum reform were supported by MoE through a reformed evaluation policy in college entrance examination and in high school entrance examination. MoE awards the organizations, groups, and individuals achieving excellent outcomes, when they participated in the basic education curriculum reform (SE5).

In brief, MoE decides the evaluation policy and provides direction to schools about desired outcomes in the curriculum reform.

3 Curricular actors in environmental education

In this section, we identify the curricular actors involved specifically in environmental education (see methods in chapter 3, section 4.1, 4.2). A literature review indicated leading figures in the field of environmental education research, and pointed out pivotal policy documents. The documents included sixteen policy documents (EE1-EE16) shaping the development of environmental education and two curricular documents giving directions for instructional design (CEE1, CEE2). The interviews were done with policy makers and designers. The interview results did not only point out curricular actors, but also difficulties or problems that the actors encountered. We start this section with an overview of the development of environmental education in China.

3.1 Environmental education development and landmark documents

In 1972, China attended the United Nations' first major conference on international environmental issues, the Conference on the Human Environment held in Stockholm, Sweden. In 1973, the year after, the Chinese government organized the first national environmental protection conference in Beijing, which is often marked as the starting point of environment protection and environmental education in China (Huang, 2003; Ma, 2003; Tian, 2010). Since then, three stages in the development of environmental education in China can be considered. Ma (2003) differentiated the three stages by the shift of the leading actors in the growth of environmental education over the past decades. As noted by Ma (2003), from 1973-1984, the State Environmental Protection Administration (SEPA), the former Ministry of Environmental Protection (MEP), was taking the leading role; and from 1985 to 1997, the State Education Commission (SEC) (the former MoE until 1998) joined with SEPA in carrying out environmental education, after the national symposium on environmental education held in 1985, in Liaoning. From 1997 onwards, in the current stage, MoE is supposed to play the major role, in cooperation with the MEP. The turning point to the current stage is marked by a national ten-year project initiated by MoE in 1997, together with the World Wide Fund for Nature (WWF) and British Petroleum (BP), the 'Environmental Education Initiators Program' (EEI) (Ma, 2003; Tian, 2010). Another identification of the turning point to the current stage is the first national environmental education meeting in Suzhou, in November of 1992. Shortly after the Rio Summit, the United Nations Conference on Environment and Development (UNCED), in the same year, SEC (the former MoE) together with SEPA (the former MEP) organized the first national conference of environmental education in China. As remarked by Huang (2003), this meeting emphasized the major role of SEC (the former MoE), and marked the significance of environmental education in the basic educational system of China. Apart from the debate on what marks the start of the current stage, it is well accepted that the environmental education in China has moved into a new epoch with several characteristics. Firstly, environmental education received more and more attention from MoE, of course in cooperation with MEP (Huang, 2003; Ma, 2003). Secondly, environmental education has been more and more institutionalized into the basic educational system, in cooperation with international research projects (Huang, 2003; Tian, 2010). And at last, the growth of environmental education is strongly supported by curriculum policy (Huang, 2003; Ma, 2003; Tian, 2010).

Several landmark documents shaped the current status of environmental education in China. The selection of the policy documents is executed in two steps. First, the literature review on China's development of environmental education suggested ten landmark documents. And second, the analysis of these ten documents further referred to another six documents that are either important references or follow-ups.

In February of 2003, MoE issued a circular requires educational administrations at all levels and all schools to focus on three special subjects: AIDS prevention, drug prevention and environmental education. In the circular's attachment, every subject received a syllabus with instructions for application. The instructions for environmental education are given in the '*Syllabus on Environmental Subject for Students in Secondary and Primary Schools*' (the Syllabus) (CEE1) (MoE, 2003a). The Syllabus provided three pages of instructions on implementing environmental education as a domain-specific subject. Also in 2003, shortly after the Syllabus was issued, MoE approved the '*National Environmental Education Guideline*' (the Guideline) (CEE2), which is a product from the EEI project in cooperation with WWF and BP (MoE, 2003b). The guideline, a 46-page book, gives instructions on all available modes of environmental education implementation in schools, in multi-disciplinary integration, as cross-disciplinary topics, as separated courses, and as extra-curricular activities. The implementation of the Guideline is assigned to educational administrations at the provincial level. Addressing these provincial departments, the Guideline states: *'please organize teachers of primary and secondary schools, instructional researchers (jiao yan ren yuan), teachers of normal colleges and school, and administration staffs of education to carefully study this document, to plan experimental work, and to creatively implement this documents as required'*. Lastly, it is important to notice here that the Guideline was issued after the publication of the new Curriculum Standards in the eighth curriculum reform. Whether and to what extent this time lag had influenced environmental education needs to be discussed further with data from other documents and the interviews.

From the perspective of general school education, 1992 to 1993 can be identified as the initiation years of the previous curriculum reform, the seventh curriculum reform of basic education. In 1992, the same year the first national environmental education conference was held in Suzhou, in basic education, SEC (the former MoE) approved the new set of syllabi for every school subject. The syllabi clearly stated the requirement to integrate environmental education into related school subjects and to implement it in schools from 1993 onwards (Huang, 2003; Ma, 2003). In March 1994, '*China's Agenda 21*' was approved by the State Council (EE1). It indicates that environmental education is considered as playing an important role in capacity building for sustainable development. The increased awareness of environmental education at policy level can be evidenced in the documents for the ninth 5-Year Plan, issued in 1996. In March of 1996, the National People's Congress ratified '*The 9th 5-Year Plan on National Economic and Social Development and the Development Outline by 2010*' (EE6). In April of 1996, SEC issued '*The 9th 5-Year Plan for China's Educational Development and the Development Outline by 2010*' (EE7). In August 1996, the '*Decision of the State Council on Several Issues Concerning Environmental Protection*' was announced (EE3). And in September of 1996, the State Council approved '*The 9th 5-Year Plan for China's Environmental Protection and the Development Outline by 2010*' (EE8). In October of 1996, the '*Decision of CPC Central Committee on Several Issues Concerning Socialist Cultural and Ideological Promotion*' was announced (EE2). And In December of 1996, SEC, SEPA, and the Publicity Department of the CPC joined with the formulation of the '*National Action Outline of Environmental Publicity and Education*' (EE4). It was proposed in this outline to set up '*China's Green School Campaign*'. According to the Center for Environmental Education and Communication (CEEC) of MEP, the '*Green School*' serves as a platform to initiate and facilitate various campaigns for environmental education (CEEC, 2008).

In succession, in 2001, the 10^{th} 5-Year Plan contains a number of documents on China's educational development and on environmental protection (EE9, EE10, EE11). And in 2007, the set-up of the 11^{th} 5-Year Plan was made (EE12, EE13, EE14). In 2004, the State Council approved the *'2003-2007 Action Plan for Invigorating Education'* (EE15) as a follow-up document for the *'21st Century Action Plan for Invigorating Education'* (SE1). And lastly, one overarching document made much earlier is also included in our analysis, *'The National Program for Educational Reform and Development'* (EE16).

3.2 Actors in policy making

For environmental education, the actors of policy making are the policy makers of the sixteen overarching documents. They are MoE and SEC, MEP and SEPA, the Communist Party of China's (CPC) Central Committee, the Publicity Department of the CPC, the State Council, and the National People's Congress. MoE is the only policy maker of the two curriculum documents the '*Syllabus on Environmental Subject for Students in Secondary and Primary Schools*' (the Syllabus) (CEE1), and the '*National Environmental Education Guideline*' (the Guideline) (CEE2). As confirmed in the interviews, the development of environmental education is shaped by the policy documents issued by top administrations such as CPC Central Committee, State Council. However, MoE and MEP are the two major actors in making policy for environmental education. Specifically, the application of the education policy documents falls under the head of MoE and through all levels of educational administrations, while MEP is responsible for formulating environmental protection policy including the related educational aspects.

MoE established the design team for making the two curriculum documents (CEE1 and CEE2), consisting mainly of environmental educationalists from universities, who have also participated in policy making of the on-going eighth curriculum reform (Interviewee A, B, C, F).

Though MoE is in a position of leading education policy making, in its application, environmental education receives more attention from MEP. '*Today, in China, the valuable emphasis on environmental education is more coming from the departments of environmental protection. We can say that these departments use environmental education as a mean to put forward their job of environmental protection*' (Interviewee C). The major effort of MEP is the promotion of *the 'Green School'* campaign, initiated and organized by CEEC (Interviewee F). The *'Green School'* is a strategy for the entire school management, not only concerning environmental education, but also for the management of the campus infrastructure (Interviewee F). Since it adopted many advanced educational strategies such as inquiry study and IPAC, the *'Green School'* is supposed to provide support for the on-going curriculum reform in basic education (Interviewee F). However, since CEEC is not under the educational administration, it can not interfere directly in the teaching and learning activities in the nominated *'Green Schools'* (Interviewee A, F). In practice, except for issuing and auditing the *'Green School'* certificate, the center has no persistent or compulsory administrative presence in schools. As repeatedly emphasized by the interviewees, the current curriculum reform and the *'Green School'* campaign belong to two different systems, the system of education led by MoE, and the system of environmental protection led by MEP (Interviewee A, B, C, F).

3.3 Actors in design and development

In the sixteen policy documents of environmental education (EE1-EE16), no information was found about actors in design and development. The two curricular documents (CEE1, CEE2) indicate that the school is the key actor in curriculum design and development. *'School is to make the overall plan for environmental education to be implemented respectively in discipline-based subjects, in IPAC, in separated special courses, optional courses, and in school's daily living and management activities'*(CEE2, p.33). The Guideline (CEE2) proposed a crucial change that teachers should become curriculum developers.

The interviewed key designers indicated that the design of the teaching materials of environmental education is organized mainly by local educational administrations, local environmental protection administrations, publishing houses, and schools. According to the experiences of interviewee C in designing the teaching materials of local curricula, environmental education receives more attention from MEP than from MoE. *'More often, the design of the teaching materials, the study activities, and the teacher training are organized by environmental protection administrations, and funds are directly allocated. (In comparison) some funds from MoE are to be shared with other educational departments. So, in terms of the design and implementation of environmental education, educational administrations are not as active or focused as environmental protection administrations are'* (Interviewee C).

The main designers are researchers of normal universities, editors of publishing houses, researchers of instruction, and experienced teachers in primary and secondary schools (Interviewee B, C, F, H). The interviewed environmental educationalists all emphasized that teachers play a vital role in developing school curricula. Interviewee D was involved in several programs of developing school-based curricula and programs of teacher training. *'Since the curriculum reform, our work now is to develop local curricula, and school curricula. We do this together with school teachers, to help them to get a good overview of all relevant lessons (on environmental education) and develop their school-based curriculum…Our long-term goal is that we hope to build by training the competence of the educators to design and carry out environmental education independently.'*

In sum, before the two curriculum documents were issued (CEE1, CEE2), the policy documents paid no attention to actors designing the teaching materials. Local educational administrations, environmental protection administrations, publishing houses, and schools are the main actors in the design of environmental education, while, in practice, designers receive more financial support from MEP than from MoE. Researchers, editors, and teachers are the main designers. Teachers are changing their roles, to become designers of their school-based curriculum.

3.4 Actors in implementation

The sixteen policy documents provided very little information on defining the actors involved in the implementation of environmental education. Only in three documents (EE1, EE4, and EE5) did some paragraphs indicate that the implementation actors consist of all levels of educational administrations, environmental protection administrations, and publicity departments of CPC. Among them, educational administrations are supposed to take the leading role; for example, the two curricular documents (CEE1, CEE2) were both issued to every provincial level educational administration for application. In addition to the role of educational administrations, environmental protection administrations are also involved in implementation, mainly through CEEC, which was established to execute environmental publicity and education (EE4). When the educational programs are conducted in disadvantaged areas (e.g. in rural schools), NGOs and trained volunteers are the main actors in implementation (Interviewee D).

The interviewed experts explained one problem in implementation. In MoE, implementing environmental education was to some extent the responsibility of the Departments of Basic Education of MoE (Interviewee B, C, E, F), which have a much broader scope than environmental education. In MEP, environmental education is in particular the responsibility of the CEEC, which has established branches in every province, autonomous regions, and the directly-controlled municipalities (Interviewee A, B, C, D, E, F). The implementation of the *'Green School'* is carried out by these branches of CEEC. As MEP has no administrative execution in the educational practice of schools, putting environmental education into school education was still the responsibility of MoE. However, a central problem in the implementation is that from the top level of MoE to all local level educational administrations, no specific sections, or positions, or persons are appointed for achieving and supervising the actual implementation of environmental education (Interviewee A, B, C, E, F). *'This is why during the implementation situations of randomness, spontaneousness, and impractical evaluation have arisen.'* (Interviewee A) Actual implementation, therefore, is often limited to initiatives arising from personal interest (Interviewee B).

Schools, particularly their principals, and teachers are the key agents in carrying out environmental education (CEE1, CEE2, Interviewee D, E). For successful environmental education, different sections in a school need to collaborate to provide a school-wide mechanism to manage and carry out environmental education (CEE1). The mechanism implies that the administrative section of schools should include environmental education in the work schedule of the school, and create time and space for teachers to carry out cross-disciplinary environmental education. The mechanism also implies that a leading team is established, consisting of environmental educationalists, administration personnel, teachers, and representatives of the local community. '*The team is directly under the leadership of the school principal. The principal appoints particular personnel to organize, implement, and facilitate, such as networking with environmental institutions, and environmental educationalists, to get teachers for environmental education training, to design, plan and manage school-wide programs.'* (CEE1, p.31-32) In the implementation, schools and teachers have the freedom to make their own choices in teaching-learning processes. '*Schools and teachers may creatively reach the goals of environmental education by various means and in various forms, according to their own conditions.'* (CEE2, p.31) And '*The implementation of environmental education must be by means of effective teaching-learning strategies, which can be adjusted according to the assessment at all times during the implementing process'* (CEE2, p.35). However, in fact a very small number of schools received training on how to organize and conduct environmental education (Interviewee F). As we found in the five visited schools, only one school principal and none of the teachers participated in training, which was offered by the *'Green School'* campaign.

In brief, the documents indicated that the implementation actors are all levels of educational administration, environmental protection administrations, and publicity departments of CPC. MoE and its local level educational administrations are in the position to launch the application of the two curriculum documents (CEE1, CEE2). NGOs contributed, especially in disadvantaged areas. According to the interviewed experts, however, the implementation of environmental education realized by these actors is not satisfactory as yet. The reason is that MEP, while it is rather active in putting forward environmental education through the *'Green School'* campaign, lacks the executive authority to interfere with the teaching practices in schools. The schools are under the supervision of educational administrations, to whom environmental education is only one part of their broader mission. And the responsibility for the implementation of environmental education is not yet acknowledged as a distinct mission by MoE. In the end, school principals and teachers are loaded with responsibility to organize and carry environmental education out in their everyday teaching practices, without adequate training and support.

3.5 Actors in evaluation

In the sixteen overarching policy documents (EE1-EE16) no information was found about evaluation actors. Only in the Syllabus (CEE1), are schools and local level educational administrations required to report regularly to MoE about the state and process of the implementation. According to the Guideline (CEE2), plural evaluation is recommended in environmental education, that is to say, all involved actors can be evaluators, schools, teachers, students, local communities, local environmental protection departments, NGOs and so on. The evaluation involves all level of educational administrations, schools, teachers, and students. In assessing students' learning in particular, teachers, students, instructional researchers (jiao yan ren yuan), parents, and community residences can all perform the evaluation.

As pointed out by most of the interviewees, the assessment of environmental education is problematic since the assessment has not yet been established in the education system (Interviewee A, B, C, D, E, F). MoE has not established a specific section, chair, or person to actually guide environmental education. That explains why the assessment can not be carried out (Interviewee A, B, F). To some extent, environmental education is linked to the curriculum section of the Departments of Basic Education in MoE, but the people engaged in this section are all part time (Interviewee F, H). Assessment of environmental education is extremely difficult when it is not included in the educational administrations, since the environmental protection administrations are not in the position to assess schools' educational performances (Interviewee F).

MEP has established the CEEC to promote the *'Green School'* campaign. Nevertheless, the center has no persistent or compulsory administrative execution in schools, except for the *'Green School'* commendation (Interviewee A, F). The *'Green School'* can only provide assessment of campus infrastructure management and extra-curricular activities. The interview with one local educational administrative official showed an example of how the *'Green School'* campaign has been taken on board by the local educational administration. *'Since the campaign is not led by the Department of Education, but by the Department of Environmental Protection, we just assist to the extent of what we can. In the audit, required for the approval of the certificate, we are also invited, so we send someone to go with* *them. Often we are like, alright, it's all up to them. If they approve, we are okay with it too. They have a procedure for the audit, we just go for it.'* (Interviewee I) For educational administrations, environmental education is just one of the special education subjects that they are invited to cooperate on with other administrations, e.g. MEP. *'That is right, we received the Syllabus, but you know, every day we receive many special education* subject*s. Today, the Ministry of Public Security tells that we should conduct safety education, anti-drug education. Tomorrow, another ministry asks for another education subject, almost endless initiation for us to cooperate, to support'* (Interviewee I). Schools that acquire the certificate of *'Green School'* do not receive any award from educational administrations, and the certificate does not add any advantage to the school in the perception of education administrations (Interviewee I). Apparently, environmental education can not be strengthened without sufficient attention from educational administrations. An insightful analysis suggests that if policy is really concerned with environmental education, it should not merely produce a list of policy documents, but also present adequate regulations and facilities of implementation, with detailed rules and proposals, teacher training, and systematic ways of assessment (Interviewee F).

In sum, before the two curriculum documents were issued (CEE1, CEE2), no attention was given to evaluation actors. It is still not explicit in the documents who is actually responsible for organizing the evaluation, though ideally a plural evaluation is recommended in which many actors are invited to perform assessments towards each other. The interviews pointed out the problem that evaluation procedures have not yet been established in the education system. On the other hand, environmental protection administrations only have the authority to join the audit of the *'Green School'* certificate, focused on campus infrastructure management and extra-curricular activities. However, the commendation by the certificate does not add advantages to the schools when being judged by education administrations for their educational quality. Lack of sufficient attention and support from educational administrations has marginalized environmental education in school practices.

In the next chapter, results of the actor analysis will be added to the element analysis of the intended, potentially implemented, and implemented curricula to allow a conclusion about the evidence and nature of the possible rhetoric-practice gap.

Chapter 8 The Rhetoric-Practice Gap in China

1 Introduction

In this chapter, we conclude the findings from previous chapters to obtain a systematic overview about the rhetoric-practice gap evidenced in China. The institutional gap is identified by comparing the intended curriculum of school education and the intended curriculum of environmental education (in chapter 4). The formalizing gap in environmental education is identified by comparing the intended curriculum with the potentially implemented curriculum (in chapter 5). The operational gap is categorized by comparing the potentially implemented curriculum with the implemented curriculum (in chapter 6). For each of the gaps, the involved actors and responsibilities are indicated (in chapter 7). The analytical assumptions, namely the assumed features of school education and environmental education (see chapter 3, section 3.1), are used as a benchmark to compare the differences between each two of the curriculum representations. As in our previous analyses, the curriculum representations are characterized by the curriculum elements. To draw conclusions on the gaps, the findings of the seven elements of the curriculum representations are summarized and then compared, i.e. rationale, goal, content, teaching and learning process, teacher's role, students' role, and assessment. For the two intended curricula, the element analysis is conducted in documents of general school education, and in documents and interviews of environmental education. In referring to the analytical assumptions, the two intended curricula are characterized and compared on the seven elements to reveal the institutional gap. For the potentially implemented curriculum of environmental education, the curriculum element analysis[1] is conducted by the integrated environmental education components in the textbooks of current compulsory subjects, and textbooks and teacher's manuals developed for environmental education as a domain-specific subject. To reveal the formalizing gap of environmental education, we examine whether and how the assumed ideal features of each curriculum element are supported in the intended curriculum and whether these features have been included in the two modes of the teaching materials that may be potentially implemented. Important to remember is that none of the analyzed domain-specific materials have reached our participating schools. In implementation, environmental education is conducted as components integrated into existing subjects, and as a domain-specific subject given either in a separated course or in

1 See operational coding definitions in appendix VI.

extra-curricular activities. However, environmental education as a separated course only officially exists in the schools' course table as a response to an administrative check. Therefore, for the actual implemented curriculum of environmental education, the curriculum elements analysis[2] is conducted on intra-curricular teaching of the existing subjects that integrated environmental education components and extra-curricular activities in which environmental education is taken as a domain-specific subject. To reveal the operational gap, we compare the two modes of the teaching materials with the two modes of the teaching practices respectively, on the seven elements.

2 Institutional gap

2.1 Element analysis

2.1.1 Rationale

The rationale is understood in our study from the four aspects: disciplinarity, focused problem, characteristics of the study issue, and conclusions/solutions. In terms of disciplinarity, multi-disciplinary integration is encouraged in the rhetoric of both school education and environmental education. In general school education, the current eighth curriculum reform has promoted integrative courses and integrative education subjects, such as environmental education. There is room to introduce environmental education as an integrative topic in the discipline-based courses such as the Chinese language course. Nevertheless, the new curriculum standards that serve as the most important curricular policy documents have a disciplinary nature, as they are developed by discipline-based research groups. In environmental education, multi-disciplinarity is well reflected in the documents and the interviews. In terms of the problem focus, in the school education documents, little information is found on defining the problem focus. It is supposed that in the Chinese course the students' practical competence is encouraged. In the environmental education documents, the attention shifted from knowledge transmission to the practical competence of solving real and specific problems, as confirmed by the curriculum designers. In terms of the characteristics of the study issue, in school education, the assumed feature is evident at least in the Chinese course that the curriculum is determined by the predefined issues to attain predetermined specific outcomes. In comparison, the environmental education rhetoric proposes to focus on problematic environmental issues which require students' inquiry with uncertainty to develop their own

2 See analytical codes in appendix VII.

knowledge. In terms of solution and conclusion, it is confirmed in the rhetoric of both curricula that room is left open for the students to find out their own conclusions and solutions by inquiry.

In brief, the rationale defined in school education rhetoric disproves the assumptions that it promotes multi-disciplinary integration, focuses on practical competence, and accepts open-ended conclusions and solutions by the students. However, it confirms the assumed features that the new curriculum standards are discipline-based and the predefined study issues. The assumed rationale of environmental education from all aspects is fully affirmed in documents and supported by the policy makers and designers. To conclude, the assumed contrast of rationale, or to say the institutional gap is only partly evidenced in terms of disciplinarity and characteristics of the study issue, since the new curriculum standards are still made in a disciplinary nature, and it is still possible to predefine the issues to be studied in the intended school education.

2.1.2 Goal

The goal is understood as educational purpose and how the function of knowledge is defined in the curriculum. The school education documents shared a rather similar line with the assumption in stating that it is to provide intellectual support for the country's growth, to prepare students for sharing social responsibilities in the country's system. Knowledge should prepare students for life-long learning to meet societal needs. In addition, the top priority task of school education is to universalize nine-year compulsory education across the country and to eliminate illiteracy. In the rhetoric of environmental education, the assumed goal is not fully manifested. In the policy documents and the environmentalists' perceptions, the purpose of environmental education does not challenge the existing structure of society as long as sustainable development is inherent, but contributes to cultivate students' talents for future society. The function of knowledge is to achieve sustainable development immediately from daily life style changes. And it is affirmed that knowledge is not directed merely to action but to 'know how' to improve the environment.

We can say, in terms of the function of knowledge, that the assumed contrasts are proven fairly in the rhetoric. However, the found contrasts between the intended curriculum goals of school education and environmental education are not exactly like the assumed ones, since environmental education has in common with school education to prepare future talents for the existing structure of society as the purpose of education.

2.1.3 Content

The content is analyzed from three aspects: information source, relevance to students, and path of knowledge development. The policy rhetoric of school education has disapproved of the assumptions but suggests building content from students' inquiry by utilizing multiple resources, instead of providing only factual knowledge. The relevance to students' daily life experiences is highly valued. The passive learning path has been abandoned, and instead students' involvement is the suggested path to acquire knowledge. The assumed features of environmental education are well reflected in the statements of the documents and the interviews. It is recommended to select curriculum content from complex sources for students to encounter different perspectives. The selected content should have the potential to be connected to the students' daily life experiences to recognize that the issue is related to their life world. It is also recommended to inquire into solvable problems to acquire knowledge.

So to say, apparently, the assumed contrasts between the intended features of contents in school education and environmental education are not revealed in the analysis. There is a clear shift in the policy rhetoric of school education from a conventional way of content selection to very similar ideas as required in environmental education.

2.1.4 Process

The teaching and learning process is analyzed by distinguishing the following three aspects: cooperation, participation, and engagement. School education, in its policy rhetoric, has disapproved of the assumption and supports students' cooperative learning and active participation. The approach of inquiry study is recommended, rather than learning passively from the teacher's instruction. In environmental education, the assumed features are fairly well supported in the documents and the interviews. Cooperative learning is suggested for students to share information, exchange ideas, and encounter different perspectives. In all the recommended ideal cases, students are invited to participate in various activities, and engage in finding problems, problem inquiry, problem solving, and taking action.

In sum, the assumed contrasts are not evidenced in our analysis, since the rhetoric of school education has disapproved of the assumed features i.e.

individual learning, limited participation, and non-engagement, but the rhetoric of environmental education has affirmed the assumed ideal teaching and learning process. So to say, the institutional gap is not revealed between the two intended teaching and learning processes, but they have much in common. In addition, it is worth to notice that only a few of the documents included information about the teaching and learning process.

2.1.5 Teacher

In the assumption, the teacher's role is defined as that of a dispenser of factual knowledge in school education or as an agent making decisions on curriculum and pedagogy who is amenable to students' autonomous decisions. Different from the assumption, the school education documents define the role of the teacher as an organizer and guide into democratic instruction in respect to students' interests and study initiatives. In environmental education, the assumptions are reflected well in the documents and the interviews. Teachers are respected as agents to make flexible choices of teaching content and approaches. They are even expected to become developers of student-based school curricula. And it is required for teachers to build an equal interactive relationship with students.

To conclude, the assumed contrasts in the teacher's role are not evidenced in the analysis, since the features in school education disagree with the assumptions and show a common definition of the intended teacher's role in environmental education.

2.1.6 Student

In the intended curriculum, we assumed that the student's role would be defined as passive recipients in school education, and as generator of knowledge in environmental education. However, such contrasts are conclusively disproved by the analysis. For school education in general, the curriculum reform supports the student as the master of learning. The policy rhetoric highly values students' study initiative, active learning attitude, motivation, creative thinking, independent thinking, and practical competence, rather than only gaining factual knowledge. All of these assumed features of the students' role are also fully confirmed in the rhetoric of environmental education.

To conclude, there is no institutional gap in terms of the students' role, since the rhetoric in school education differs from the assumptions and is defined similarly to the intended students' role in environmental education.

2.1.7 Assessment

The assumed ideal features for assessment of school education are surely abandoned as deficiencies of education in the past, such as emphasis on reproduction or mastery of factual knowledge, and testing in artificial situations removed from students' daily life experiences. The policy rhetoric points out a particular need of shift, namely a shift of the assessment purpose in China from selection and making distinctions towards enhancing students' development. Innovations are made in the current curriculum reform that promotes holistic, democratic, and developmental approaches, and value the progression that the students made during the learning process. Moreover, the policy rhetoric highly concerned the enrollment of the examination system from secondary school to college, and the cultural traditions in Chinese society, in which competitive distinction is still highly favored, and therefore may hinder fundamentally the reform of the assessment.

When environmental education in the form of multi-disciplinary integration into the existing subjects is evaluated, the assumed assessment features are well confirmed in the documents and the interviews. As fairly in line with the assessment defined in the current curriculum reform, the main concern of assessment in the rhetoric is the development of students' competence in participative learning processes. But on the other hand, in the evaluation of extra-curricular activities, an end-of-pipe approach is still applied with the focus on results.

In sum, the contrasts between the two intended assessments are not evidenced as assumed. Both in school education and in environmental education, there is a clear preference for evaluating the students' learning process and the development of their own ideas and choices, a preference of respecting students' self-assessment, and involvement of multiple actors. However, in environmental education when evaluated as domain-specific subject in the extra-curricular activities, an end-of-pipe assessment is still applied, which does differ from the assumption, as well as from the intention in school education.

To conclude, in terms of the assessment, the institutional gap only exists between the intended school education and the intended environmental education in its extra-curricular activities. But when environmental education is embedded in the intra-curricular teachings, the intended assessment is fully in agreement with what is intended in general school education.

2.2 Actor analysis

In school education, MoE[3] is the leading policy maker and responsible for the development of curriculum outlines, compulsory courses, and especially the new curriculum standards, which form the basis for curriculum management, textbook designing, teaching and learning process, and evaluation. The new curriculum standards are developed by discipline-based groups. Local educational administrations and schools have some room to maneuver in defining more locally relevant curriculum policies, but still remain under the top-down administrative supervision of MoE.

In environmental education, various actors are involved in making the policy documents: MoE, MEP, CPC Central Committee, the Publicity Department of CPC, the State Council, and the National People's Congress. Among them, MoE and MEP are the major actors. Environmental education in China has been developed in three stages by a shift of leading actors, from SEPA (the former MEP) to SEPA and SEC (the former MoE), and then to MoE. In the current stage, MoE is the official leading policy maker with the cooperation from MEP. The only two curriculum document i.e. the Syllabus (CEE1) and the Guideline (CEE2) are developed by design teams established and under the supervision of MoE. Officially, the application of all educational policy is under the lead of MoE, while MEP is responsible mainly for policy making of environmental protection, of which environmental education is a part. MEP initiated and organized the *'Green School'* campaign, and established a particular section CEEC to be responsible for making policy of the *'Green School'* nomination. In the nomination, the emphasis is put not merely on environmental education, but also on eco-friendly campus infrastructure management, since MEP is not in an authorized position to interfere directly in the educational practices in schools.

2.3 Conclusions

We have compared the intended school education with environmental education for each curriculum element. An institutional gap is evidenced only for the 'rhetoric' of intended rationale, goal, and assessment. The institutional gap is refuted in the intended curriculum content, teaching and learning process, teacher's role, and students' role, since the rhetoric of school education has clearly disapproved of the assumption but share the intentions with environmental education. MoE has the responsibility for the

3 See abbreviation list in Appendix I.

gap that occurs because it has the leading role in making curriculum policies, especially assessment policies, and the new curriculum standards. And all educational policies are applied under a top-down administrative supervision of MoE. By the *'Green School'* nomination, MEP makes evaluation policies for environmental education as in extra-curricular activities. Therefore, MEP has a responsibility for the extra-curricular assessment gap.

3 Formalizing gap

3.1 Element analysis

3.1.1 Rationale

As indicated in section 2.1.1, the rhetoric of environmental education fully reflected the assumed rationale with regard to the multi-disciplinarity, the shift from knowledge transmission to building practical competences of solving real and specific problems in daily life, and the focus on problematic environmental issues which require students' inquiry with uncertainty to develop their own conclusions and solutions.

The teaching materials of both modes have well presented multi-disciplinarity, as we found environmental topics are integrated in most existing subjects, and all the domain-specific lessons included knowledge or information from other disciplinary subjects. The problematic character of environmental issues is reflected fairly in the domain-specific lessons, but is rarely concerned in the integrated materials, as most of the integrated materials are built on predefined environmental issues. In both modes, most of the materials are designed with a focus on real, practical, and specific problems, but some materials are still focused on abstract, theoretical problems, and this is more often the case in the integrated than in the domain-specific materials. Both modes of teaching materials showed minimal concern to leave conclusions or solutions open for the students to develop.

To conclude, a formalizing gap is evident between the rationale intended in the rhetoric and the rationale presented in the two modes of potentially implemented materials. The gap lies in that the teaching materials are not yet fully developed to introduce problematic environmental issues for the students to inquiry, or to give students the chance to develop their own conclusions and solutions. The domain-specific materials received more counts than the integrated materials that meet the assumed ideal features of environmental education rationale, especially in terms of the problem focus and the characteristics of the study issue.

3.1.2 Goal

As found in section 2.1.2, in the rhetoric of environmental education, the educational purpose is not perceived exactly as assumed. The purpose of environmental education in China does not challenge the existing structure of society, but contributes to cultivate students' talents for future society. While the assumed curriculum goal in terms of the function of knowledge is well confirmed in the rhetoric, namely, knowledge is not directed merely to taking action but to 'know how' to improve the environment, to achieve sustainable development immediately from daily life style changes.

When designed into domain-specific materials, the assumed goals of environmental education are well presented in support for sustainment of environmental life quality, immediate use of knowledge rather than only future use, and taking action to exert influence. When designing integrated components in the textbooks of existing subjects, the assumed goal that is confirmed in intended environmental education is poorly supported. A very limited number of integrated lessons suggested the students to apply the knowledge to improve life quality, or to take actions for improving the environment. Nonetheless, most of the integrated materials still recognize the value to sustain life quality of which the environment is a part.

To conclude, the assumed features are fully confirmed in the rhetoric, and are well presented in the domain-specific materials, but not fully reflected in the integrated teaching materials. The majority of the integrated textbooks is developed unaware of the postulated ideal goal for environmental education. So to say, the formalizing gap exists between the intended goal in the rhetoric and the goal presented in the environmental education components integrated into the existing compulsory textbooks.

3.1.3 Content

As indicated in section 2.1.3, the assumed features of content are well reflected in the rhetoric in stating that the curriculum content should be selected from complex sources for students to encounter different perspectives. The selected content should have the potential to be connected to the students' daily life experiences. And the knowledge should be developed by the students by inquiry into solvable problems and not by transmitting ready facts.

In the teaching materials of both modes, the relevance of the content to students' daily life experiences can be recognized. However, only in a very limited number of materials, the content is developed from multiple or contrasting information sources to show the complex nature of environmental issues. In the content, in the majority of the integrated materials and in half the amount of the domain-specific lessons factual knowledge is given in a large space.

In conclusion, the formalizing gap is evidenced between the intended content and the content featured in potentially implemented teaching materials. The evidence is that in both modes of materials, most of the content is not developed from multiple or complex sources, and that factual knowledge is largely transmitted ready-made rather than to be developed by the students themselves through inquiry. Nevertheless, the teaching materials of both modes well reflected the intention to select content related to the student's daily life experiences.

3.1.4 Process

As indicated in section 2.1.4, the assumed features of teaching and learning process are fairly well supported in the rhetoric. The students are invited to cooperate and to participate in various activities, and engage in finding problems, problem inquiry, solving problem, and taking actions.

In the teaching materials of both modes, a very limited number of designs engaged the students in the entire inquiry process. The majority of the materials invite the students to participate, but especially in expressing their thoughts or collecting information. Cooperative learning is adopted in only half the amount of the domain-specific designs included cooperative learning activities and in even fewer of the integrated materials.

To conclude, in terms of the teaching and learning process, the formalizing gap exists because the assumed ideal cooperative learning, engagement, and participative activities are confirmed in the intended curriculum but are not supported in the teaching materials of both modes. Especially, the material design should be improved to give full opportunity for the students to engage in the entire inquiry process, as intended, from finding problems, problem inquiry, solving problem, to eventually taking action, instead of only experiencing a part of the process. Additionally, the students should have more opportunity to cooperate and participate in large variety of activities.

3.1.5 Teacher

As indicated in section 2.1.5, the assumptions about the teacher's role are reflected well in the rhetoric. Teachers are respected as agents to make flexible choices of teaching content and approaches and even to become school curriculum developers. Teachers are required to build an equal relationship with their students.

In both modes of the textbooks, no information was provided about the role of the teacher. Only in the two sets of teacher's manuals developed with the domain-specific textbooks, it is noticed that teachers can freely select or adapt content and pedagogy but still without any indications about what kind of relation they should build with their students, and how to build it.

In conclusion, we can say, in terms of the teacher's role, the formalizing gap exists just because of the absence of information in the integrated textbooks and the incomplete information in the domain-specific materials to help the teachers to identify their role. Despite the notification of teacher's freedom to choose or adapt contents or pedagogy, more detailed suggestions are needed for the teachers to develop their role as agents and to build the intended relation with their students.

3.1.6 Student

As indicated in section 2.1.6, the rhetoric highly values students' study initiative, active learning attitude, motivation, creative thinking, independent thinking, and practical competence, rather than only learning factual knowledge. Therefore, it confirms that the intended role of students is well in agreement with the assumed ideal role.

Concerning the role as critical thinker, we found that in a considerable amount of materials the students are not encouraged to give various answers, but are limited to the predefined standard answers. Concerning the role as active generator of knowledge, in almost all the teaching materials, the students do not have the opportunity to select the study topics from their interests. More than half the materials only raise questions for the students to answer without giving them the opportunity to propose their own questions. In some of the materials, the students even receive ready answers for the predefined questions. In half the materials, the students are required to take suggested action plans rather than giving them the opportunity to develop their own action plans. In a large portion of the materials, the needed factual knowledge is provided directly rather than collected by the students themselves. These findings about the students' role indicated in both modes of materials do not meet the intended features, although the domain-specific materials relatively have more cases that meet the intended features than the integrated.

To conclude, the formalizing gap exists in terms of students' role because of the disagreement between the intended and the potentially implemented roles in environmental education. The findings show conclusive evidence that the intended student's role though confirmed in the assumption is poorly recognized in both modes of the teaching materials, although domain-specific materials meet the expectation relatively better.

3.1.7 Assessment

As concluded in section 2.1.7, the evaluation shows that in the multi-disciplinary integration into the existing subjects' mode of environmental education, the assumed assessment confirms the rhetoric well. There is a clear preference of evaluating the students' learning process and the development of their own ideas and choices, a preference of respecting students' self-assessment, and participation of multiple actors. However, in the evaluation of extra-curricular activities, an end-of-pipe approach is still applied with the focus on results.

Most integrated and domain-specific materials do not provide any information about assessment. When the materials do define the assessment, in the integrated materials only about half the amount focuses on the assessment of students' development. Other assumed ideal assessment features such as the assessment of the students' learning processes, students' self-assessment and the involvement of multiple actors are evidenced in only a very limited number of the integrated materials. When assessment in the domain-specific materials is considered, it shows that only about half indicates the assessment of students' development, their learning processes, and students' self-assessment. Only a very limited number of the domain-specific materials include multiple evaluators. And both in the integrated and domain-specific materials, a considerable amount of the materials suggest that the teacher is to use standard evaluation.

In conclusion, in most of the studied materials, it is unclear how to perform the assessment. Among those that do provide information about assessment, the intended assessment approaches that conform with the assumed ideal features are inadequately adopted in the materials, although relatively more of the domain-specific materials are designed reflecting the intended assessment.

So to say, the formalizing gap exists since the desired assessment approach is only applied in a moderate number of the materials in both modes. In addition, as a domain-specific subject in extra-curricular activities, the potentially implemented materials have a preference for evaluating results by standards. This preference is also accepted in the rhetoric for environmental education in extra-curricular activities. Therefore, the formalizing gap is also evidenced in that for extra-curricular environmental education, the undesired standard-based end-of-pipe assessment is evident in the intended curriculum and in the potentially implemented materials.

3.2 Actor analysis

To identify the actors involved in the formalizing gap, we need to consider the actors in making the policy rhetoric (see section 2.2) together with the actors designing the teaching materials.

Environmental education, when integrated into other discipline-based subjects, is defined by the policy makers of school education rhetoric, namely, MoE and local educational administrations. Under the top-down hierarchy of educational administration, schools are given some room to make school curriculum policies. The compulsory textbooks of school education, in which environmental education components are embedded, are developed by various institutions, organizations, or individual designers under the supervision of MoE. Schools are given freedom to develop or choose their school curricula and extra-curricular activities, but within a top-down administrative hierarchy under MoE.

Environmental education as a domain-specific subject is defined in a series of overarching policy documents made by the national political agents. On a more practical level, MoE and MEP are the two major actors. At the current stage, MoE is the official leading policy maker who developed the only two curriculum documents. MEP initiated and organized the *'Green School'* campaign. As a domain-specific subject, the design of the teaching material is organized mainly by local educational administrations, local administrations of environmental protection, and publishing houses. The designers are editors from publishing houses, experienced teachers from primary and secondary schools, and university researchers from various disciplinary backgrounds but mainly from the natural sciences. In practice, designers receive more financial support from MEP than from MoE. Schools are encouraged to develop a school curriculum specifically for environmental education. The vital task of school curriculum development is assigned to the teachers. As a part of general school education, the teaching materials designed domain-specifically for environmental education should be proved and validated also under the administrative supervision of MoE.

3.3 Conclusions

In this section we have compared the intended curriculum as expressed in the rhetoric with the potentially implemented curriculum consisting of the teaching materials, to see if the intentions have been elaborated into the curriculum products. The formalizing gap exists when there is a difference between the rhetoric and the products. The formalizing gap might also be an expansion of the institutional gap, if the assumed ideal features of curriculum elements are disapproved of in the general schooling rhetoric and also in the products.

The formalizing gap exists in terms of the curriculum elements of rationale, content, teaching and learning process, teacher's role, and students' role, since the assumed features are well supported in the intended curriculum, but are inadequately presented in the two modes of teaching materials. The formalizing gap is evident when the goals intended in the rhetoric and presented in the integrated materials are compared, since the majority of the integrated materials are developed without being informed about the intended goal for environmental education. In terms of the assessment, the formalizing gap exists since the ideal assessment approach supported in the intended curriculum is only applied in a moderate number of the materials in both modes. The formalizing gap of assessment is also apparent because the undesired standard-based end-of-pipe assessment is already adopted in the rhetoric and further applied in the material designs, especially for extra-curricular activities that are domain-specific for environmental education. Noticeably, the domain-specific materials received more counts than the integrated materials that agree with the assumed ideal features. In addition, a prominent finding is that the teaching materials are designed without sufficient information about the teacher's role and assessment.

The actors responsible for the occurrence of the formalizing gap are the actors involved in making the intended curriculum and in designing the potentially implemented curriculum. MoE is the absolute leading actor in both policy making and in the design of teaching materials. MEP is another important actor involved in both curricular activities, though apparently it may participate, but without authority in formalizing the educational policy in the teaching materials. In fact, MEP has strongly supported the design of domain-specific teaching materials. In multi-disciplinary integration, the designers of embedded environmental education components are the designers responsible for the integrated materials, who can be any institution, organization, or individual designer without requiring an expertise in environmental education. The new curriculum standards and the textbooks are designed by discipline-based groups, organized and supervised by MoE. When environmental education is taken as a domain-specific subject, local administrations of environmental protection join with local educational administrations, and publishing houses in organizing the design of the teaching material. They also recruit the designers who have experience, expertise, or interests in environmental education in particular. Notably, many actors at the national level are involved in policy making, but in the end the vital task of school curriculum development is given to teachers. If we consider the freedom of making school curriculum policies and products a sign of decentralization, there is a pitfall in putting all the work on teachers who in fact receive hardly any training and even no practical information about how to identify their role.

4 Operational gap

4.1 Element analysis

4.1.1 Rationale

As concluded in section 3.1.1, the intended rationale that has the assumed ideal features is not fully evidenced in both modes of teaching materials. Multi-disciplinarity is well represented both in integrated and in domain-specific materials. Most of the materials in both modes focus on real, practical, and specific environmental issues. Most of the domain-specific designs include only a limited number of integrative designs showing a concern with the problematic character of environmental issues. In both modes of materials, very few are designed to leave conclusions or solutions open to the students.

In actual practices of environmental education, affirmative observations were collected. In terms of multi-disciplinarity, both integrated into intra-curriculum teaching and applied as a domain-specific subject in extra-curricular activities. The integrated intra-curricular teachings mainly introduced the problematic environmental issues to explore by the students. In the extra-curricular activities, however, the environmental crisis is introduced mainly for calling the students to take pre-defined actions. In actual practices of both modes, the teachers have a clear preference to focus on real, specific, and practical problems that exist in the students' daily life. In the integrated intra-curricular teachings, the students are still required to present pre-defined conclusions in final exams, although they are allowed to engage in open discussions during the classes. However, all observed extra-curricular activities requested the students to accept pre-defined solutions.

In sum, a definite agreement is found between the multi-disciplinarity evidenced in the potentially implemented and the implemented curricula. Most of the materials are designed with the focus on real, practical, and specific problems. And such a problem focus is also found in the actual practices in both modes. Although studying problematic and uncertain issues is not considered in most of the integrated materials in actual implementation, it is largely evident in the integrated intra-curricular teachings that the problematic environmental issues are introduced for the students to explore. To study problematic and uncertain issues is confirmed in most of the domain-specific materials; however, in actual implementation, problematic environmental issues are introduced in the extra-curricular activities as an urgent call for the students take the pre-defined actions. The materials in both modes generally do not allow the students to develop their own conclusions or solutions, but provide them with predefined ones. To conclude, the findings show a good agreement between the potentially implemented and the implemented curricula in terms of the disciplinarity and the characteristics of study issue. However, an operational gap exists in terms of conclusion and solution, since the assumed open features, though intended in the rhetoric, are not adopted in the majority of the designed materials and in the actual practices of both modes. An operational gap also exists in terms of the problem focus, because most of the domain-specific materials do confirm the intended but the domain-specific extra-curricular activities are conducted on the contrary. In integrated environmental education, the possible operational gap is enclosed because most integrated materials do not confirm with the intended problem focus, but the integrated intra-curricular teachings largely do.

4.1.2 Goal

As argued in section 3.1.2, when designed as integrated components, the curriculum goal is not desirable for environmental education, though most of the components show a concern to sustain people's life quality in which an environmental perspective plays a part. When designed domain-specifically, most of the lessons are developed with a good reflection on the assumed goal of environmental education, in supporting immediate knowledge application rather than only future use, and encouraging the students to exert influence on environment by taking actions.

In the implementation of both modes, the assumed goal in terms of function of knowledge is affirmed to a fair level in the observations and in the practitioners' perceptions, namely to sustain the life quality for people and for the environment, to immediate use of knowledge, and to take action for exerting influence. However, different from the desired goal, in most of the teaching practices of both modes, the students are requested to propose action plans (in intra-curricular teaching) or take actions directly (in extra-curricular activities) for behavioral changes rather than being prepared by the development of their own inquiry.

In sum, the intended goals that have assumed features in terms of function of knowledge are not fully presented in the majority of the material in which environmental education is embedded as components. The desired curriculum goal is well reflected in the materials designed domain-specifically. However, in implementation, both in the extra-curricular activities and in teaching the intra-curriculum subjects, environmental education is given mostly in line with the intended curriculum goal, except that in the teaching practices knowledge is merely directed toward behavioral chances, unlike in the intended curriculum where knowledge has to prepare for taking action after inquiry. To conclude, as a domain-specific subject, a mutual agreement is found between the curriculum goal as presented in the materials and as perceived in practices. A possible operational gap is enclosed in integrated environmental education, because the goal perceived in the integrated intra-curricular teachings fairly confirms the intended goal, although it is largely disapproved of in the integrated materials.

4.1.3 Content

As concluded in section 3.1.3, in both modes of the materials, the content is not exactly selected as the intended curricula that have assumed ideal features, though the content shows relevance to the students' daily life experiences. Most content is not selected from multiple or complex sources, and factual knowledge is largely presented as ready-made rather than that students can acquire it by inquiry. Relatively more domain-specific materials are reflecting on the intentions.

Though both the integrated and the domain-specific teaching materials are not designed in full agreement with the intended curriculum, the actual teaching of the two modes is carried out fairly in line with the desired approaches, both in the integrated intra-curricular teachings and the domain-specific extra-curricular activities. The content is introduced from multiple information sources, and is introduced with open discussions among the students to show multiple perspectives. The content is introduced with specified attention to solvable problems relevant to the students' daily life. And the content is introduced by comparing the enjoyable aspects with contradicting endangered aspects of nature, while introducing the needed factual knowledge, which serves for raising environmental awareness rather than for reproduction.

To conclude, an operational gap is enclosed, because, although the intended content is lacking in the developed materials, in the actual teaching practices content is introduced that is well in line with the intended approaches and therefore has the assumed ideal features. This occurrence of the operational gap indicates that the practitioners have the competence to develop the content in accordance with what is desired in environmental education. Since none of the studied materials has reached the participating schools, the practitioners developed their own content based on their prior knowledge even without professional training on environmental education.

4.1.4 Process

As discussed in section 3.1.4, the teaching and learning process designed in the materials does not fit with the intended curriculum which confirms the assumed ideal features. In the two modes of the materials, a very limited number of them engaged the students in the entire inquiry process. The majority of the materials invite the students to participate, but merely in expressing their thoughts or collecting information. Cooperative learning is adopted only in half the amount of the domain-specific materials and in even fewer integrated materials.

In implementation, the teaching and learning process is carried out in a way that lacks many of the assumed features. In terms of cooperative learning, it is conducted in integrated extra-curricular activities merely for rules keeping without specifying roles or tasks, but it is better planned in intra-curricular teachings. In terms of engagement, in both modes of practices, little opportunity is given to the student to engage with the entire inquiry process, from finding the problem, inquiry into the problem, and taking actions to solve the problem, but mostly the students are requested to immediately propose action plans or even taken the recommended actions. In terms of participation, in both modes of the practices, the students hardly participate in outdoor activities, for the sake of safety and large class sizes. When participating in collecting information, there is a need to support the students to search information more from their own interests or motives rather than responding to the teacher's request. More average students need more opportunity to participate like the few elite student representatives. Especially, when students participate in proposing action plans, there is a need to support the students to take actions that are more focused on specific environmental problems, rather than making a general proposal in a slogan format.

In conclusion, the operational gap exists in both modes, since the assumed features that are supported in the intended cooperative learning, participative learning, and engagement into inquiry are neither fully presented in the designed materials, nor fully implemented in the two modes of teaching practices.

4.1.5 Teacher

As indicated in section 3.1.5, in the domain-specific materials, the information about the role of the teacher is incomplete. It merely states that the teachers can make flexible choices of teaching content and approaches. And in the integrated textbooks, teachers cannot find suggestions about how to choose contents or pedagogy, and practical guidance about what kind of relation to be built with their students and how to build it.

In the intra-curricular lessons, the teachers are generous in giving freedom to students to express various opinions. In the extra-curricular activities, the teachers limit the chances for the students to express autonomous views. The elite student representatives have more chances to express themselves than the majority of the average students.

To conclude, the operational gap exists in domain-specific environmental education, since the intended teacher's role in interaction with students, which has assumed ideal features, is undefined in the material, and also in the implemented domain-specific extra-curricular activities, the teachers only offer a few elite students the opportunity to develop an autonomous view. Moreover, in extra-curricular activities, the teachers are notified to make their own choice of content and pedagogy, but it is not sufficient to simply pronounce the freedom in the teaching material, since in implementation the teachers may struggle with making an appropriate instructional design, in which more interaction can be guaranteed.

Nonetheless, a possible operational gap is narrowed, since, although the integrated materials do not contain any information about the teacher's role, in its actual implementation the teachers performed rather as assumed and intended in giving students the freedom to express autonomous views, in making flexible choices of content and pedagogy. One explanation is that the teachers are familiar with the intention in the on-going curriculum reform of general school education, and therefore elaborated the intention in teaching the integrative intra-curricular subjects in which environment education is embedded as components. Since we have concluded in section 2.1.5 that there is an agreement between the teacher's role intended in school education and in environmental education, it follows that, even without specific indications about the teacher's role in environmental education, when teachers perform as they are requested to in general school education, their role is in agreement with the intention in environmental education also.

4.1.6 Student

As indicated in section 3.1.6, the intended students' role that has assumed features is poorly recognized in the teaching materials of both modes, though domain-specific materials meet the expectation relatively better. It has been largely observed that both modes of teaching materials are designed without being aware of the intended role of students as generators of knowledge and critical thinkers.

In the integrated intra-curricular teachings, the students' role is put in practice rather as intended. We have largely observed in the integrated classes that the students are comfortable to give different answers, to disagree with each other and that they are able to propose their own questions and action plans. However, it still happened in most of the integrated classes that the required factual knowledge was directly provided to the students rather than that they were encouraged to collect it by themselves. In the extra-curricular activities which take environmental education as a domain-specific subject, the students are put in a passive role. In those activities, only a small number of students have the opportunity to show their talents and different viewpoints, and the majority of students is mainly requested to follow recommended action plans or replicate factual knowledge in quizzes. In both modes, none of the teachings invited the students to select a study topic of their own interest.

To conclude, a possible operational gap is narrowed, since, although the intended students' role is not described in the integrated teaching materials, in the implementation the students are well respected as generators of knowledge and critical thinkers. An operational gap, however, does exist in domain-specific environmental education, since the passive role favored in most of the materials is also observed in the implemented extra-curricular activities.

4.1.7 Assessment

As explained in section 3.1.7, most of the materials provide no information about assessment. Among those that defined assessment, the assumed ideal assessment approaches are only applied in a moderate number of materials of both modes. And for extra-curricular environmental education, the undesired standard-based end-of-pipe assessment is still evident in the potentially implemented materials.

In implementation, the assessment of environmental education is applied either to extra-curricular activities in which environmental education is treated as a domain-specific subject, or applied to intra-curricular teachings in two forms, integrated in existing courses and given domain-specifically as a separate course.

When integrated into other courses, the assumed process evaluation, developmental evaluation, self-assessment, and multiple evaluators involved are well featured in the observed classes. However, in final exams, environmental education is combined with other disciplinary content which requires the students to draw conclusions along the predefined direction of thinking to get a good mark.

As a domain-specific subject, the separated course does not exist in actual school practice, but only in the course table and in final exams as a response to the administrative inspection. In the final paper-and-pencil exams of the not actually implemented separate course, the students are asked to note down the distributed correct answers to keep record for the inspection. Considering the situation of environmental education as a separate course, environmental education as a domain-specific subject is only actually carried out in extra-curricular activities. The extra-curricular activities are evaluated mainly by the *'Green School'* campaign. A top-down administrative evaluation is applied to the extra-curricular activities, with a standard-based end-of-pipe approach focusing on results and task completion.

To conclude, in both modes of the designed materials, the assumed assessment is not defined clearly in most materials, and inadequately defined in the rest. Despite this, in implementation of environmental education in the integrative mode, the assessment in class is performed rather in line with the assumed assessment, but not in the final exams. The domain-specific evaluation is conducted clearly in a way that is contrary to the intended assessment approaches. So to say, the operational gap exists in integrated environmental education, since the assumed assessment is absent in the majority of the designed materials and is also ignored in the final exams. The operational gap exists also in domain-specific environmental education, not because of the assumed disagreement between the potentially implemented and the implemented, but rather because the undesired standard-based end-of-pipe assessment is already preferred in the intended assessment for extra-curricular activities, is also accepted in the materials, and is still carried out in a top-down administrative way.

4.2 Actor analysis

To identify the actors involved in the operational gap, we need to consider the actors developing the teaching materials (see section 3.2) together with the actors involved in implementation.

In multi-disciplinary integration, the designers for embedded environmental education components are the designers for the integrated materials, who can be any institution, organization, or individual designer who is not necessarily qualified for environmental education expertise. The new curriculum standards and the textbooks are designed by discipline-based groups, organized and supervised by MoE. When environmental education is taken as a domain-specific subject, local administrations of environmental protection join with local educational administrations, and publishing houses in developing teaching materials. They also recruit the designers who have experience, expertise, or interests in environmental education in particular. All the designed materials should be validated and approved by committees established by educational administrations at national or provincial levels.

The actors in the implementation of integrated environmental education are the actors implementing the general school education subjects, in which environmental education is embedded. Schools are to put any required curriculum into real practice, under the supervision of a top-down educational administration from MoE. However, in term of environmental education integrated in intra-curricular teaching, there is no specified actor in this educational hierarchy who is responsible for the implementation. Formally it is within the scope of the Department of Basic Education of MoE, but its scope is much broader than only environmental education.

The actors implementing domain-specific environmental education are MoE, MEP, the Publicity department of CPC and their local administrations. NGOs also have a contribution, especially in disadvantaged areas. Schools, particularly their principals, teachers, and YPDs are the key agents in carrying out environmental education. Except for the actual practitioners in schools, there is however a problem to pinpoint the exact actors responsible for the implementation of environmental education. MoE is the official leading actor, in cooperation with MEP, in launching and supervising the implementation. However, in MoE and all its administration at the local level, to implement environmental education has not yet been acknowledged as a distinct mission, and it is only assigned to their staffs as a part-time task, and no specific sections, positions, or persons are appointed for taking the responsibility. MEP is the most active actor in implementing environmental education, mainly through the *'Green School'* campaign. MEP established CEEC and its local branches to carry out the campaign across the country. However, since an executive authority to interfere in teaching practices in schools is missing, MEP and its local administrations can only implement environmental education in extra-curricular activities. In the *'Green School'* campaign, teacher training is provided, but can cover only a limited number of schools; none of the practitioners of the observed schools received the training.

Therefore, in fact, with ineffective supervision from MoE, and with limited contribution from MEP, school principals and teachers are loaded with the responsibility to organize and carry out environmental education without adequate training and support.

4.3 Conclusions

The operational gap exists when the assumed features that are supported in the intention are well designed into the teaching materials but not adequately adopted in the practices, such as in the curriculum rationale in terms of the problem focus in domain-specific environmental education. The operational gap might also exist if the desired ideal features are not adopted in most the materials and no more in the practices. Such an operational gap is found in the curriculum rationale in terms of conclusion and solution in both modes, in the teaching and learning process in both modes of environmental education, and found in the student's role and assessment in domain-specific environmental education. The operational gap also exists if the intended curriculum has assumed ideal features that are not even defined in the majority of the designed materials, and are also disapproved of largely in actual practices, such as the role of the teacher in domain-specific environmental education, and the assessment of the integrated environmental education. Sometimes, the possible operational gap is narrowed or avoided, since the school level practitioners have shown the competence to perform well in line with the intended curriculum that has assumed ideal features, although most of the designed materials show the reverse of what is intended or the designed materials fail to define some of the intended elements. This concerns the curriculum rationale in terms of the problem focus, the curriculum goal in integrated environmental education, and the curriculum content in both integrated and domain-specific environmental education, and also the role of the teacher and students in integrated environmental education.

The actors involved in the creation of the operational gap are the actors developing the teaching materials and the actors performing the teaching practices. The operational gap occurs largely because of the inadequate presence or even absence of the assumed features in the materials. MoE cannot dismiss its responsibility, for it is the leading actor to establish design teams, validate and prove the products. As revealed in our analysis, in comparing to the integrated materials, the domain-specific teaching materials are better designed to meet the intended curriculum that has assumed ideal features. What is different in comparing the actors involved in the two modes of materials is that the domain-specific materials are designed with the participation of MEP; consequently it shows that a particular environmental perspective is taken into account in designing the domain specific materials. However, the compulsory textbooks are designed according to the new curriculum standards without taking any notice of the two curriculum documents of environmental education. MoE established discipline-based groups and developed new curriculum standards, before the Guideline and the Syllabus in cooperation with, or to say encouraged by, MEP and WWF, as we recall from chapter 7. A problem here is that environmental education is not yet a distinct mission in MoE and its local administrations. The operational gap occurs also because the implementation is not fully in accordance with the desired features, no matter how they have been included in the materials.

In implementation, the major and real practitioners are the school principal, teachers, and YPDs in schools; if they are lucky, the implementation took place with training from MEP or help from NGOs. Although the school level practitioners fail to carry out environmental education in some curriculum elements as an ideal, they have shown remarkable competence to perform well as desired and even narrowed, enclosed, or avoided the operational gap on some curriculum elements. The operational gap occurred more in the domain-specific course and activities. MEP, as the leading actor in the extra-curricular practices via the '*Green School*' campaign, cannot dismiss its responsibility regarding the inadequate performance in domain-specific environmental education. Since any educational practices in schools are under the supervision of the MoE, it has the responsibility for the undesired implementations in both modes.

5 Conclusions and discussion

Referring to our overall analytical framework (see chapter 2, figure 2.2 and 2.3), the rhetoric-practice gap may initially appear as an institutional gap. Referring to Stevenson (1987), the institutional gap exists if there are contrasts between the rhetoric of environmental education and general schooling. Our analysis shows that such an institutional gap is clearly disapproved of in China in terms of most of the curriculum elements. Promoted by the current curriculum reform, the rhetoric of general school education has clearly abandoned the assumed conventional features as deficiencies of the past, and shifted to a set of new features that has much in common with the intentions of environmental education. However, the assumed contrasts still receive some evidence. In terms of the rationale, general school education in its rhetoric still confirms the predefined study issues, and the new curriculum standards are still developed by discipline-based design groups. In terms of the goal, the rhetoric of general school education is to share a similar line with the assumption that has to provide intellectual support for the country's growth, and to prepare students for sharing social responsibility (with environmental responsibility being considered one) in the country's social system. And in terms of assessment, the rhetoric of environmental education still supports a standard-based end-of-pipe evaluation for the domain-specific extra-curricular activities.

The formalizing gap is measured in the two modes of materials to see how much the assumed features are included in comparing what is supported in the intended curriculum. The formalizing gap is demonstrated in most of the curriculum elements, and the assumed ideal features for environmental education are well supported in the rhetoric, but are inadequately adopted in the two modes of materials. The formalizing gap is concluded also because the few assumed features that are not supported in the rhetoric are further disapproved of in the products. In terms of the rationale, in the integrated materials, the embedded environmental education is largely built on predefined issues. The majority of integrated materials are developed without awareness of the assumed goal for environmental education. The undesired standard-based end-of-pipe assessment is adopted especially in the domain-specific extra-curricular activities of environmental education.

The occurrence of the operational gap is of a more complicated nature. The assumed difference is only found partly in the rationale, since the potentially implemented teaching materials have well adopted the assumed features as they are supported in the intention, but the implemented teaching practices largely ignored them. Mostly the operational gap occurs because the teaching materials of both modes (more often in integrated materials than in the domain-specific) are designed ignoring the assumed features that are supported in the intention or even fail to give any information in defining the curriculum elements. Even so, the actual implementation, especially in integrated teaching, could be well in line with some of the assumed ideal features and thus a possible operational gap is narrowed, enclosed, or avoided at the operational level. By doing so, the school practitioners have shown a certain competence to understand, design, and carry out environmental education well in line with the assumed ideal features for environmental education. This may be explained by the fact that in the current curriculum reform, a nation-wide promotion program including teacher trainings is carried out, covering all of our participating schools and teachers. As we now know, the rhetoric of general school education has much in common with environmental education.

If we compare the two modes of environmental education, detailed evidence underpins the conclusion that in integrated environmental education domain-specific teaching materials that have assumed ideal features are more in agreement with the intended curriculum than the integrated materials, whereas integrated teaching practices are implemented relatively closer to what is intended than the domain-specific practices. The identified rhetoric-practice gap and the difference between the integrated and the domain-specific environmental education are due to the administrative problem as we explain in the following.

The materials of general school education, in which environmental education is embedded, are designed according the discipline-based new curriculum standards without a specific concern regarding the integrative nature of environmental education. MoE is the leading supervisor for materials for general school education, who established design groups for the new curriculum standards, and also organized committees to validate and approve the designed products. Our interviews pointed out that environmental education is not yet a distinct mission for MoE and its local administrations. In the very broad scope of MoE, there are too many special concerns to be included in the general school education, including environmental education, health education, national defense education, and others. This may be the reason why MoE began to develop the new curriculum standards a long time before it cooperated with MEP and NGO's to issue the two mile stone curriculum documents for environmental education. However, in the implementation of integrated intra-curricular teachings, when the teachers proceed with the new spirit that they met in the current curriculum reform, they can carry out the integrated environmental education components fairly in line with the desired features.

In domain-specific environmental education, besides MoE, MEP is actively participating in the design of teaching materials and extra-curricular activities. The designers are recruited specifically for environmental education, so that the domain-specific materials are designed more in agreement with the intended curriculum that has assumed ideal features. However, as a domain-specific subject, environmental education is inadequately implemented. The reason is that MEP has no executive authority to supervise educational practices, and cannot yet provide training to every school in the country.

Perhaps, one solution is having an ambition to entirely greenify MoE in its general curriculum policy making, for instance through a set of greener new curriculum standards. By doing so, the integrated environmental education components may be re-designed to better reflect its desired nature. As we have seen that the integrated materials are well reflecting the rhetoric, what is approved in the policy rhetoric is also adopted in the design, what is disapproved of is also neglected. The ambition to change the top of the administrative pyramid is beyond our research scope and aim. It is more realistic and scientifically meaningful to find a solution to narrow or enclose the formalizing gap by improving the materials with the admission that the new spirit in current curriculum reform is basically affirming environmental education, and to find a solution to further narrow or enclose the operational gap by improving the teaching practices with an acknowledgement of school-level practitioners' needs and competences. The solution lies in whether we can solve a design problem. Our analysis reveals that to have robust teaching materials which fully meet the assumed ideal features of environmental education would narrow or enclose most of the formalizing gap. Such a robust design should be developed in cooperation with school level practitioners, taking into account their perceptions, understandings, and feedback, and tested in real teaching practices for improvement, to narrow or enclose the operational gap. It was decided to conduct a design study in the next phase of study, to find a solution to close the rhetoric-practice gap in primary schools in China.

Chapter 9 The Application of Environmental Education in the Curricular System of China

1 Introduction

After having defined the rhetoric-practice gap, a design study is conducted with the intention to improve the quality of environmental education in its design and implementation, so that the gap can be reduced and environmental literacy can be improved. For conducting the design study with a better focus, we need to gain knowledge about how environmental education is applied in the current curriculum system, what obstacles are, and where tensions occur. In this chapter, we argue which curriculum level and mode are most appropriate as target for the design study. To provide a background to this argument, we briefly depict the three-level curriculum system in China, and the application of environmental education in the current curriculum system. This description partly borrows from what we described earlier in the chapters 3, 5, 6 and 7, where we defined different modes of environmental education and the involved curricular actors. We then focus on the obstacles and tensions encountered in environmental education. On the basis of this analysis of the application of environmental education, we then make a choice of curriculum level for the design.

2 The three-level curricular system in China

The aim of redefining the curriculum levels in China is to improve the relevance and applicability of curriculum at local and school levels (SE3, SE5). In 1996, to prepare for the eighth curriculum reform, MoE set up a project team and conducted a nationwide survey to evaluate the quality of past educational reforms. From this investigation, several obstacles in achieving essential-qualities-oriented education are identified. In the report, centralization of the curriculum and lack of relevance is one of the crucial problems (MoE, 1997). The recommended solution is to adjust curriculum levels with more attention for the particularity of every locality, and the diversity of economy, culture, and education across the country. The result of this survey contributed to a redefined three-level-curriculum system, which was repeatedly presented in the landmark policy documents. The three-level-curriculum is addressed in the seven documents following the *'21st Century Action Plan for Invigorating Education'* (SE1). In 1999, an overall plan, consisting of a three-level curriculum, i.e. the national curriculum, the local curriculum, and the school curriculum (SE2) had already been presented for a trial to

China's management system. The reform of the curricular system is meant to change the past situation that curricula focus too heavily on disciplinary knowledge, are outdated, and are irrelevant to developments in society and to students' experiences (SE2). The new curriculum system should pay more attention to complexity, integration and practicability (SE2). The three-level curriculum is defined in China as a system of curriculum management. The management system of the three-level-curriculum is implemented officially in the autumn of 2001 (SE4). The overarching policy documents SE1-SE8 allow a definition of the three-level-curriculum. In defining the three curriculum levels, we cannot avoid introducing involved actors, therefore in this section we recapitulate parts of chapter 7, where we identified actors involved in curriculum policy making, design & development, implementation, and evaluation.

2.1 The national curriculum

The national curriculum is the curriculum set by MoE, which includes curriculum management policy on basic education, national curriculum school subjects, national curriculum lesson hours, national curriculum standards, and a new assessment system (SE4, SE5). In the *'Pilot Plan of Compulsory Education Curriculum'* (SE7), MoE defined the national curriculum goals, principles, compulsory subjects, and lesson hours.

One set of new '*National Curriculum Standards*' replaced the past syllabi, and has become the overarching curricular document for the design and development of the national curriculum. *'The national curriculum standards define the framework of the curriculum nature, mission, content and focus. The standards serve as a basis for curriculum management, evaluation, teaching material design, teaching, and examination'* (SE3).

Several subjects are to be offered in schools by integrating them into the national curriculum subjects, and environmental education is one of them. *'Every school subject should perform moral education compatibly with its disciplinary nature; environmental education, health education, and national defense & security education etc. should also be embedded into relevant school subjects.'* (SE7)

2.2 The local curriculum

When the implementation of the national curriculum is guaranteed, the development of local and school curricula (SE4) is encouraged. The local curriculum is the curriculum planned and implemented by educational administrations at the provincial level, under the supervision of MoE (SE5). As we mentioned in chapter 7, the provincial administrations may make course plans and define local curriculum standards that are to be applied within their provinces, or autonomous regions, or municipalities, directly under the central government (SE5). Provincial level educational administrations may plan various curricula according to different social-economical and cultural circumstances, but should fit into the yearly total course hours defined by MoE (SE7). The local curriculum together with IPAC takes 16-20% of the total course hours (SE7). The provincial administrations may also set down specific requirements for local curriculum design and management, as well as requirements on school curricula under the supervision of MoE (SE7).

A local curriculum can also be a locally interpreted national curriculum. The national curriculum in some subjects only defines compulsory course hours, suggests principles in implementation and evaluation, and leaves the content undefined for the provincial level educational administrations to develop, and for the school to implement. One typical example can be found in the curriculum standard of 'Sport and Health' which highly emphasized the freedom and flexibility to build the course in taking benefit of geographical features, for example due to differences in climate and landscape, sport and health education can be very different across the country (CSE8).

2.3 The school curriculum

Schools have to carry out the national curriculum and the local curriculum (SE4). When the implementation of the national curriculum is guaranteed, schools may develop or choose their school curriculum (SE4). Schools can make autonomous plans on morning gathering, class meetings and young pioneer meetings, and other activities related to science and technology, culture, sport, etc. (SE7). The documents of SE4, SE5, and SE7 indicate that schools have the full right to develop or choose their school curricula. The design and the choice of the school curriculum should be based on the social-economical status of the area, take advantage of the school tradition, and serve students' needs and interests (SE5). The development and implementation of school curricula are supervised by educational administrations at all levels (SE5).

School curricula can also be the school implemented national curriculum, since the national curriculum in some subjects leaves the content undefined.

The further development of these curricula, e.g. Sport and Health and IPAC, which schools are to implement, is the responsibility of provincial educational administrations.

3 The application of environmental education

The curriculum levels have not been mentioned explicitly in the sixteen overarching policy documents on environmental education (EE1-EE16), but in the two curricular documents (CEE1 and CEE2) some statements are found defining environmental education in the current curriculum system. In this section the data are mainly gained from the two curricular documents and the interviews with the environmental educationalists. In defining environmental education as applied in the three-level curriculum, we also refer to chapter 7 to review the involved actors, and browse partly from chapter 3, 5 and 6 where we mentioned different modes of teaching materials or teaching practices.

3.1 Three modes of application

As was found in chapters 3 and 5, there are two types of teaching materials in environmental education, multidisciplinary integrated and domain-specific materials. There are also two types of teaching practices, intra-curricular integration and extra-curricular activities. According to CEE1 and CEE2, three modes of environmental education curriculum can be defined, 1) integrated into all relevant school subjects, 2) as a cross-disciplinary topic, 3) and in separated courses as a domain-specific subject. In multidisciplinary integration, environmental education becomes a component infused in existing school subjects, namely, the subjects indicated in the national curriculum. For example, in grade 5 the subjects of Chinese, mathematics, English, morality and society, science, art, and sports are indicated. As cross-disciplinary study topics, environmental education is carried out in IPAC, and in extra-curricular activities, such as class meeting, young pioneer meeting, and daily school activities. Given in a separate course, environmental education is conducted as a domain-specific subject, taking place in either the local curriculum or the school curriculum.

The three modes can be further identified in the three-level-curricular system. In the national curriculum, environmental education is integrated in existing subjects. In the local curriculum environmental education is given in a separate course as a domain-specific subject. According to the Syllabus, environmental education is given in four lessons in every school year. The Syllabus suggests that environmental education should take place in the local curriculum or in the school curriculum. In the school curriculum, environmental education is conducted also in a separate course, as a domain-specific subject. Along with intra-curricular teaching of the three levels, environmental education can also take place in various extra-curricular activities, such as morning gatherings, class meetings and young pioneer meetings.

3.2 Environmental education in the national curriculum

Most of the interviewed experts confirmed the definition presented in '*National Environmental Education Guideline*' (the Guideline, CEE2) (Interviewee A, C, D, E, F, G), namely, that the national curriculum of environmental education is infused[1] (shen tou) in all relevant school subjects. The national curriculum therefore includes the embedded components into the existing subjects, regulated as national curriculum for general school education, and the subjects are defined in the '*Pilot Plan of Compulsory Education Curriculum*' (SE7) (SE5, SE6, SE7). For primary school students in grade 5, the national curriculum of environmental education is the infused component in the eight subjects, i.e. Chinese, English, Mathematics, Morality and Society, Science, Art (Music or Fine Art), Sport, IPAC.

Nevertheless, the interviewees debated two issues in defining the national curriculum of environmental education. One issue is whether there is a national curriculum of environmental education. Most of the interviewed environmental educationalists agreed that a national curriculum of environmental education does exist, except for interviewee B, who held the opinion that since there is no regulation or definition given by the national government for implementing environmental education in the national curriculum, environmental education cannot be defined as a national curriculum. The other issue is whether the two curricular documents (CEE1 and CEE2) should be included in the national curriculum of environmental education. One opinion holds that the national curriculum of environmental education is merely the multi-disciplinary integration in the national curriculum subjects (Interviewee F and G). Another opinion is that the national curriculum of environmental education includes only the '*Syllabus on Environmental Subject for Students in Secondary and Primary Schools*' (the

1 'Infuse' is literally used in some of the policy documents or by some policy makers and designers. It is equivalent to 'integrating' or 'embedding' environmental education components into the subjects.

Syllabus, CEE1) (Interviewee H). One other opinion is that both the multi-disciplinary integration and the Syllabus constitute the national curriculum of environmental education, with the reason to exclude the Guideline (CEE2) that it has no executive demand for school application (Interviewee A and C). A broader definition includes the multi-disciplinary infusion, the Syllabus (CEE1) and the Guideline (CEE2), with the argument that the two curricular policy documents are both issued by the MoE, the national administration of education (Interviewee D and E). Yet another broader definition even counted all policy and curricular documents in considering their role in shaping the national curriculum of environmental education, as affirmed by interviewee C, *'the current multi-disciplinary integration is according to the policy document, 'Outline of Basic Education Curriculum Reform'…and the curriculum standard of every subject in fact includes some components about sustainable development.'*

From these debates and argumentations, the following picture of the national curriculum emerged. The national curriculum of environmental education is the curriculum defined at the national level; from the broadest view it includes: (1) the embedded components in the teaching materials of each school subject of the national curriculum, (2) the documents that shaped the development of the teaching materials, i.e. the policy documents (SE1-SE8, EE1-EE16), the curricular documents, the curriculum standards (CSE1-CSE8), the Guideline and the Syllabus (CEE1-CEE2). In respect of disciplinarity, the national curriculum of environmental education takes mainly the mode of multi-disciplinary integration (or infusion). In this mode, various components of environmental education are embedded in the national curriculum subjects. In addition, in the national subject of IPAC, environmental education is recommended to apply in cross-disciplinary topics, to integratively bring the knowledge from the various school subjects together for a more comprehensive and holistic implementation.

3.3 Environmental education in the local curriculum

All of the interviewees are well agreed that the local curriculum of environmental education is the curriculum defined and developed by provincial level educational administrations, with the intention to provide environmental education from a systematic perspective. The provincial educational administrations are responsible for developing the teaching materials. As confirmed in the interviews, currently in China, environmental education is mainly developed as a local curriculum. The local curriculum mainly contains the teaching materials developed at the local level. The Syllabus

(CEE1) is the reference for designing teaching materials. With the given four lesson hours in the Syllabus, several provinces (for example Zhejiang, Shandong, Jiangsu, Heilongjiang, and Yunnan) have developed their local textbooks. Although the Guideline (CEE2) proposes to apply environmental education in a separate course as a domain-specific subject in the local curriculum, some of the interviewees remarked that it is not preferable to offer environmental education in a separate course, in considering the already overloaded curriculum for the students, and the interdisciplinary nature of environmental education.

3.4 Environmental education in the school curriculum

The school curriculum is the curriculum defined or developed at the school level, by the school teachers (Interviewee B, C, E, F, H). According to the experiences of designing the school curricula, both the Syllabus (CEE1) and the Guideline (CEE2) may work as useful references for designers (Interviewee D, E). Although it is defined in the Guideline that environmental education in school curriculum is to be carried out in a separate domain-specific course, it is not perceived as ideal to offer environmental education separately, similar to the local curriculum, in view of the already overloaded curriculum and the interdisciplinary nature of environmental education (Interviewee A, G).

4 Curriculum level choice for the application of environmental education

In terms of the actual application of environmental education, we also discussed with the interviewed environmental educationalists which curriculum level is the most appropriate to carry out environmental education. Their opinions differ but their insightful explanations will contribute to our analysis about which curriculum level is most feasible and worthwhile to conduct the design study.

4.1 The national curriculum: in integration

Infusion in the national curriculum, namely the multi-disciplinary integration, is considered as the most feasible way of implementing environmental education into the school agenda (Interviewee D). *'From a practical point of view, infusing environmental education into existing subjects is easier to apply'* (Interviewee D). Nonetheless, the disadvantage is that environmental education is touched upon only superficially in each individual subject (Interviewee B). To interviewee G, the main concern is the overload of the current curriculum and environmental education is a highly integrative subject by its nature, so it requires contributions from all subjects, for example, natural science studies contribute natural laws and the contribution of humanities is to shape value, to conduct empathic learning.

However, to guarantee the actual implementation and its quality, an integration plan is required, as it is also recommended in the *'Green School'* campaign (Interviewee A and B). *'Because environmental education in itself is related to too many disciplinary subjects, it should be in complement of every subject, not in overlap of the subjects, or each subject does its own'* (Interviewee A). However, making a multi-disciplinary integration plan is a too difficult task for the schools to achieve (Interviewee A, B). As interviewee B noted, developing the multi-disciplinary integration plan of environmental education implies systematic planning and cross-disciplinary collaboration among teachers. Schools would need to get through the curricula of all subjects from grade1-6, to consider where and how to integratively apply the embedded environmental education components, to take care of consistency, coherence and to avoid overlaps. Interviewee A also commented that making such integrative implementation plan should be the task for education administrations at the upper level, and not of the schools, although some schools may be conditioned to succeed in making such plans. Interviewee A introduced a successful effort of the Chang An Primary School of Beijing. With a chosen topic on the Yellow River, a one-day program was designed for grade 5 students, consisting of nine units, developed from nine subjects of grade 5 respectively. Teachers from the nine subjects were all engaged in developing the teaching program in collaboration. Although the teachers had to put much effort into the collaboration, the program received very positive feedback from the students. Nevertheless, interviewee A highlighted that the success of this integrative program relied highly on the director of that school, who is a very experienced teacher in various subjects and very enthusiastic in innovations. Developing the integrative curriculum plan on environmental education should not be a task for schools. *'In my view, planning such curriculum integration should not be the job for schools. It is too difficult. The curriculum integration is up to the top administrative level, and should be achieved in re-building the entire national curriculum. From the level of national curriculum, the developers of the curriculum standards, the designers working for the key publishers should consider the issue of such integration, e.g. to solve the problem of overlap. This job should not be done at the bottom level, by the teachers.'*

In our follow-up interview conducted one year after, interviewee A introduced that since 2009, the leading publishing house of MoE has been working on integrating the fragmented multi-disciplinary infusions in the national curriculum, reconnecting subjects and reducing overlap. *'This is a very good thing, to have the concern from the macro level. And I believe, EE or ESD* [Education for Sustainable Development] *can promote this shift toward integration, because it is an integrative subject, and once it enters education, it will cause disciplinary integration. '*

4.2 The local curriculum and the school curriculum: in a separate course

The school curriculum and local curriculum are preferred platforms to offer environmental education, and ideally offer environmental education as domain-specific subject in a separated course, according to interviewees C and H. Interviewee C highlighted, *'My suggestion is to develop a local curriculum, and a school curriculum of environmental education in different areas, according to their actual conditions based on the Guideline.'* Interviewee H commented that since environmental education is not compulsory in the course plan of the national curriculum, it shall be largely up to schools to carry it out according to their actual conditions. Interviewee H approved that the advantage to offer environmental in a separate course is to address environmental issues deeper and from a more systematic perspective. To the design experiences of interviewee C, as a domain-specific subject, no teaching material of environmental education has yet been developed in the national curriculum for primary schools, and currently environmental education in China is mainly developed as local curriculum teaching materials.

4.3 The school curriculum: within given course hours

The school curriculum should be the major route to applying environmental education in the school agenda, as proposed by interviewees A, E, and F. Due to the variations in geographic locations, differences in the teacher qualifications and equipment, schools cannot copy from each other how to introduce environmental education in their agenda. Interviewee A has in mind that, working on cross-disciplinary topics such as water, the school curriculum can inquiry into all related problems about water, such as water sources and water shortage. The school curriculum may inquire from their particular perspectives, e.g. in Beijing, many conventional cottages have the water tap outside, and schools may investigate how people's water using habits are different in winter and in summer. From the design experience of interviewee E, the focus of developing a school curriculum is on empowering the teachers, in line with the rationale in the Syllabus and the Guideline. In the programs organized by interviewee E, the aim is to train the teachers to become teacher developers of the school curriculum. The teachers were encouraged to play a role as agents in developing school curricula, with the idea of making a close connection to the real conditions of the schools or the places.

As interviewee A pointed out, in the school curriculum the implementation of a new separate course of environmental education is not preferable, considering the already overloaded current curriculum. Rather, it should be conducted as a domain-specific subject within the given course hours. Interviewee A affirmed that the Syllabus produced in 2003 defines how to design environmental education as a domain-specific subject, namely, as a special topic in four lessons in every school year.

In addition, the interviews pointed out the importance of teacher training in school curriculum development. The first concern is the necessity to gain expertise supports from outside, 'Since *currently, the national, local, and school three-level-curricular system has not yet well been grounded, the research awareness and competence of school-based curriculum is still weak. Given this condition, to expect schools to take the full initiative and develop the school curriculum independently is obviously unrealistic, to a large extent'* (Interviewee B). The second concern is the urgent need to take on the approach of inquiry study in teacher training itself, to guide teachers to experience the process of inquiry study to understand how to apply it (Interviewee A, D, E). *'Rather than announcing the policy documents to the teachers or playing videos, the teachers should be enabled in the training program to authentically experience the inquiry study. Let them participate in the study activities and in playing games, to understand what inquiry study is about'* (Interviewee A).

4.4 Extra-curricular activities: a tradition

In addition to multidisciplinary infusion, interviewee D and E observed that to carry out environmental education in extra-curricular activities, class meetings and YPD meetings are equally practicable to introduce environmental education into the school agenda, since the intra-curricular course hour is rigid, but time for extra-curricular activities is more flexible. Being so, schools have a long tradition in organizing activities on environmental education.

4.5 Flexible and combined choices

There is no definite choice for environmental education to be best implemented into the school agenda, according to interviewee B. *'Firstly, in the current curriculum of primary and secondary school, none of the discipline-based subjects can hold environmental education on its own. No such subject can be found even in university (curriculum). Secondly, environmental education cannot be divided over every subject, because when every subject is doing that, it would mean no one is doing it.'* Whether offered as multi-disciplinary infusions or in a separate course as a domain-specific subject, it depends on schools' conditions of geographic location, level of teachers' qualification, students' pre-knowledge etc. Even within one school, some content knowledge may be more suitable for infusion and other topics may be better dealt with as a domain-specific subject.

4.6 Conclusion

In conclusion, the interviewed environmental educationalists debated on which level of application is most appropriate to offer environmental education. The current modes of application in the three curriculum levels all received some support, the intra-curricular teaching in national, local, and school curricula as well as the extra-curricular activities. In actual practices, environmental education is mainly carried out as multi-disciplinary infusions, as extra-curricular activities, and developed into teaching materials as local curricula. Although some advantaged schools may succeed in integrating the multi-disciplinarily infused components, it is a task supposed to be fulfilled at the macro level in re-organizing the national curriculum. The interviewed environmental educationalists revealed a trend that environmental education should be based on school, community, and local circumstances. From this perspective, the school curriculum and local curriculum are preferred by most of the interviewees to enhance environmental education in the school agenda. For the reason that offering environmental education in a separate course may further burden the already overloaded curriculum, it is therefore preferable to conduct it within the regulated four lessons hours. Retaining these suggestions from the interviewed experts, we will be ready to make our decision on a curriculum level to carry out the design study, while being further aware of the obstacles in applying environmental education in the current curriculum system.

5 Marginalization of the application of environmental education

The interviewed environmental educationalists jointly pointed out that in actual application, environmental education remained on the fringe of the school agenda. The marginalization revealed obstacles in the implementation of environmental education and more fundamental reasons that create tensions. With this discussion, it is not to propose that environmental education should have priority in the current curriculum system, but to learn from the marginalized situation what contribution is needed to reduce the tensions and enhance the quantity and quality of the application of environmental education.

5.1 Obstacles of teachers and parents

In terms of current obstacles in applying environmental education, interviewee D listed the lack of knowledge of teachers, and when the teachers are prepared with the required knowledge, the complains can also be from the parents that their children are overloaded with too many learning tasks. *'We sometimes see from the kids' reports telling that I do like these activities so much, but my parents don't like to me to take part in, since it may take time from major course studies and may influence their children's performance in the final evaluations.'* And to the experience of interviewee D, in some schools, *'the teacher would not be willing to 'sacrifice' one lesson hour to do such an, in their view, fancy, funny, and interactive activity'*.

5.2 Obstacles of time shortage

Shortage of course hours is the obstacle highlighted by most of the interviewees. In term of implementation, the Syllabus defines that the course hour for environmental education as a special subject is to be found in IPAC, the local curriculum and school curriculum. Interviewees C and E emphasized even within the defined course hours, time is also tight because it has to be spent on other educational themes, not only on environmental education. As interviewee C repeated, *'Three topics are assigned in the Syllabus, anti drug, anti aids, and national defense. Of course, also many other contents, such as, Chinese medicine, agriculture, everything can be considered. …It is impossible to include all educational topics… The course hours are the main problem.'* From the experiences of interviewee E, time is to be found in extra-curricular activities such as class meetings and young pioneer meetings.

5.3 Obstacles of grouping

Difficulty of grouping is pointed as another crucial obstacle in the practices of environmental education in schools. The difficulty of grouping is simply because of large class sizes, and the large number of students in Chinese schools. *'It is very hard to carry out interactive teaching and learning. Grouping is not easy. It won't work if too many groups are made; neither if the group is too big.'* (Interviewee E) For this reason, many interviewed teachers found it unmanageable and hesitated to try it out. The inconvenience of grouping in large sized classes in schools of China may also explain why, when applied, the communication style in environmental education remains superficial and one-way (Interviewee D).

5.4 Explanation of discipline-based curriculum

From the analysis of interviewee B and F, the discipline-based curriculum system is considered as a reason to explain the marginalization of environment education. As interviewee B stated, '*In my opinion, the fundamental reason is that in China's current basic education, the discipline-based curriculum system has not been suspended completely, so that it is very difficult for integrative or cross-disciplinary (kua xue ke) content, such as environmental education, to take the major role. This condition cannot be changed in one day. It requires a holistic reform of the entire curriculum system.'* Interviewee F added that teachers' development is also through a discipline-based curriculum system. In preparing the pre-service, normal universities set up discipline-based departments, such as education in Chinese and mathematics education, but no department of environmental education.

5.5 Explanation of educationalists environmental awareness

From the analysis of interviewee A, lack of environmental awareness in educationalists is one of crucial reasons for the marginalization. From the experiences of interviewee A working with leading educationalists in basic education, 'Some *people in the educational academia even don't know what EE or ESD is about. They understand it is to sustain the development of education itself. … To build their concept of environmental education takes some time. Gradually through discussions, their concept and understanding can be greenized. This process itself can be an interesting research topic.'*

5.6 Explanation of the application of the Guideline and the Syllabus

The value of the Guideline and the Syllabus were fully affirmed. According to interviewee B, the role, rationale, goals, content, pedagogy, course hours, and assessment of environmental education are for the first time defined officially. Nevertheless, from the analysis of interviewees A, B, and D, the insufficient implementation of the Guideline and the Syllabus is a major reason that environmental education has remained on the fringe of school agenda. As introduced by interviewee D, *'the implementation of the Guideline and Syllabus remain low. Teachers from places other than Beijing have rarely accessed the two documents. Even some officers of local department of education have not yet studied the Guideline themselves (though they are in the position to circulate the policy documents). Environmental education is far less important compared to the entrances exams of junior or senior secondary schools.'* As approved by most of the interviewees, the Guideline does not demand application, nor does it give direct instructions for implementing environmental education in the national subjects. As commented by interviewee B, *'The Guideline and the Syllabus defined the framework, together with recommendations for the teaching and learning, but these are not something that you must apply.'* Interviewee A stressed, *'The Guideline is an overarching curriculum document. It is not meant to be applied directly in the classroom setting.'* The Guideline was intended to serve as a referential document for developing the new curriculum standards. The Guideline to its ideal is to provide a 'green' guidance to the developers of the new curriculum standards, to include environmental education into the national subjects. Nevertheless, the Guideline could not play its role in time, since it was produced after the new curriculum standards came into being.

5.7 Explanation of examination-oriented assessment

Examination-oriented assessment is the most emphasized reason to explain the marginalization of environmental education. As most of the interviewed environmental educationalists remarked, although essential-quality oriented education has been proposed for many years in China, in reality, schools' educational practices are largely influenced by examination-oriented education.

As pointed out by interviewee B, *'If a teacher is interested, all right, but (we have to ask) are your course hours enough for your own subject teaching? How is your part of your work on environmental education to be evaluated in the end? These are all problematic.'* And interviewee H analyzed that *'selective competition is a very important factor. To put it simply, (as a teacher,) I would only teach what is tested in the National College Entrance Examination (NCEE), and I teach what is tested in the High School Entrance Examination.'* Interviewee A added that *'the selective mechanism of the NCEE, the competitions that students will encounter in future fundamentally affect classroom practices.*

Compared to developed countries in America or Europe, this (competitive pressure) is still very obvious in Chinese society.' As interviewee G argued, although college attendance in China has grown in numbers since 1998, but when expressed as percentages of the entire population, the promotion rate is still very low, especially in comparing with developed countries. The competition pressure of NCEE remains to deeply influence all of education, because in Chinese society, being educated at a good university still adds an advantage for job seeking or career development. In this sense, the pressure of NCEE goes all the way down to the admittance from primary school to junior high school and from junior to senior high school.

Interviewee I is an official from a provincial educational department, who confirmed that in school admittance, selecting and competing for a better quality school is still happening. Although we found a change in the policy documents that the students should attend the nearest school in the community according to students' resident addresses, and no more by taking selective exams. As interviewee I explained, *'although the primary school to junior high school no longer take selective exams, from junior high to senior high school, the attendance is still competitive, and through examinations. Then from the junior high schools' view, good exam performance comes from students' learning experience in their primary schools. In the first year of junior high school, right before placing the students into different classes, there is an exam in order to equalize the qualifications of the students placed into each class. In this exam, the educational quality of every related primary school is shown. Anyway, the entire macro environment is like this. It is societal pressure, not something that can be decided by primary schools.'* Interviewee I shared one interesting detail about the principals of famous good schools. *'At the end of the summer holiday, right before the new school year, the principals' mobile will be shut all day. Otherwise, the classes' size will again go out of control. There are too many parents trying to beg the principal to recruit their kids.'*

The examination-oriented examination cannot merely be blamed on the policy makers, it is rather a product that originated from a social need, because natural resources in China are too limited, and the large population has to compete for living opportunities (Interviewee F). To compete, the only relatively fair approach is by examination, and comparing scores is the only way that can be accepted by society. MoE may have cutting edge educational ideas, but it may not be possible to put them forward in practice. As interviewee G emphasized, in considering that China is still a developing country, for students from poorer regions, or from rural areas, being educated in university is a very important route to change tough living conditions, to change their life and destiny. *'It can be said that unbalanced regional development, and social competition caused by the pressure of resources in respect to the population are to some extent decisive for examination-oriented education'* (Interviewee G).

5.8 Explanation of administrative concern

A fundamental analysis is provided by interviewee F, that at the administrative level, environmental education lacks emphasis from either the educational administrations or the environmental protection administrations.

Firstly, environmental education lacks emphasis from educational administrations. Particular evidence for this is that, within the educational system, no chair, no personal is set specifically to carry out environmental education. As introduced by interviewee F, in schools, for example, to respond to the nomination of *'Green School'*, the staff in charge is not always from one particular unit; they may work for the ethnic education section, or sport and health. In schools and even in MoE, the personnel engaged in environmental education is all part time. Other evidence pointed out by interviewee F is that *'in the policy documents published by MoE, including the ones on the basic education reform, information on environmental education, or education of sustainable development can rarely be seen.'* For example, *'the United Nations Decade of Education for Sustainable Development (2005-2014), this internationally concerned topic is hardly presented in our educational policy documents, not even mentioned.'* Interviewee B also supported this comment, *'The current curriculum system has not yet given an expression of the importance of environmental education. Therefore, no course hours, no specialized teacher, no funding and no competences are available.'* Without an adequate emphasis given by the educational system, the series of obstacles may easily occur, e.g. teachers, assessment, contents, teaching and learning approaches and findings, everything that may make environmental education unsuitable for current school education.

Secondly, environmental education could also be given more emphasis by environmental protection administrations. Regarding the point of view of interviewee F, the administrations of environmental protection put more emphasis on news release, on communications via mass media, than on education, *'because it (news release) is about building up the image about the government, and its policies, a more directly related interest for MEP.'*

5.9 A possible solution in teacher's professional development

A solution for marginalization could be using environmental education as an innovation to improve teachers' professional development. As we observed from the schools in the explorative study, teachers are loaded with the crucial task to develop the school curriculum without sufficient supports, such as trainings and teaching materials. Therefore, some inadequate and especially behaviorist teaching strategies are observed in the teaching practices. Interviewee D highlighted that *'It is to build the confidence of teachers, or to say to make sure that they will gain something for doing environmental education. For example, when the idea of sustainable development is brought in, the teachers will find out that the disciplinary courses (of Chinese or mathematics) become different and new. So to say, we have to show them what they will gain.'* The same idea is introduced by interviewee A, *'initially many teachers did not understand why we do it (environmental education)? A financial reward is actually not that important, but the teachers' most important concern is what it (environmental education) can bring for them.'* And teachers' professional development is considered as the most important of what environmental education can bring to the involved teachers. And according to the experience of research institutes and NGOs working in their pilot schools, environmental education programs became interesting for the participant teachers, when the focus is to empower the teachers with professional development on new approaches such as inquiry learning and cooperative learning, and community-based education, because the programs gave support for the teachers in the on-going curriculum reform (Interviewee A, D, E).

As explained by interviewees B, C and H, general school education, particularly since the curriculum reform, has many features that are coherent with environmental education. *'Actually, I believe that all the features of environmental education can be recognized in our modern education'* (Interviewee B). As interviewee C remarked, *'since the ultimate goal of modern education is to cultivate the full development of people. Having environmental awareness is a symbol of full development, or one necessary element of it. They (environmental education and school education) don't conflict with each other'.*

5.10 A more ambitious solution? Hope in the re-organization

In the follow-up interviews conducted in April 2010, we saw a substantial shift in the institutionalization of environmental education. The Center of Education for Sustainable Development (CESD) has been transferred to the Faculty of Education, Beijing Normal University which is a core unit of educational research in China. This re-organization means environmental education has entered the mainstream educational system. Instead of being marginalized, this re-organization provides an opportunity to 'greenize' the whole curriculum system. The center (CESD) has received several invitations from local educational administrations to cooperate in developing their local curricula, or school curricula. For example, in one cooperative project, '*the executive entry is no more through the center of communication and education in environmental protection administration, rather it is more directly* […] *through the local educational administration'* (Interviewee A). The CEEC of MEP has also shown an intention to collaborate with the CESD for improving the 'Green School' campaign with a more scientifically designed green curriculum. *'We will use a practical method, action research, to do the investigation from the grass-root level, understand the entire process…many things to do, because the practices of environmental education have not yet met our even lowest expectation, far from that'* (Interviewee A).

5.11 Conclusion

In conclusion, the interviewed environmental educationists jointly pointed out the problematic situation that environmental education is marginalized when it is applied in the school agenda. This is not to discuss whether environmental education should receive equal or more emphasis in the school practices, but to understand from the marginalized situation what obstacles and tensions influence the application. From the marginalized situation, we better understand what scientific contribution can be made from this research to enhance the application of environmental education.

Many obstacles can be listed that limit environmental education to the fringe of the school agenda in China, such as a lack of knowledge and motivation from teachers, complaints from parents about the overloaded curriculum, shortage of course hours, difficulty with grouping due to the large class sizes. Several tensions are revealed to explain the marginalization, the disciplinarily built curriculum system, the educational policy maker's environmental awareness, the disregard of new curriculum standards for the environmental education curricular documents, the de-emphasis of administrative concern from both education and environmental protection. All these require a macro level administrative reform. A change in institutionalization would bring fundamental support for 'greenizing' education in China, but the task is beyond the scope and the aim of this research. A possible solution is proposed that teachers recognize the innovation of environmental education may improve teachers' professional development. Therefore, teachers' motivation is no more merely relying on administrative demand or personal interest, but on an ultimate promotion in their professions, to boost the implementation of environmental education in their school agenda.

The analysis of the marginalization of environmental education reminded us that there are several obstacles that need be taken into account when designing the scenario for a solid application into the current school agenda. And the design study will be better focused by analyzing the marginalization, where the tensions are coming from, what particularly we can do to reduce the gap, for example, research effort is needed to empower the teachers to become school curriculum developers, and where there is room in the curriculum levels to boost environmental education.

6 Curriculum level and mode chosen for the design study

Though it is debatable according to the interviews which level is more suitable and practicable for applying environmental education, the above analysis has led us to make a choice for conducting the design study.

We choose to design a scenario of school education, conforming to the course hours regulated in the Syllabus (CEE1); a domain-specific four-lesson on environmental education unit will be developed. In the national curriculum infusion, the embedded components needs to be further integrated to improve coherence and avoid overlap. Making the integrative plan is beyond schools' capacity and responsibility, but should be achieved at the macro level in re-organizing the national curriculum, which is currently being worked on by MoE. As a domain-specific subject, the teaching materials of environmental education have been developed mainly as local curricula. The teaching material development is organized by local educational or environmental protection administrations and designed with expertise. To develop the school curriculum, schools and teachers need professional support from outside; in the current conditions a school curriculum is hardly possible when only administrative demand and teachers' personal interest can be relied on. As we observed in the current domain-specific practices from the explorative study that the separated course is simplified into only files of final exams for administrative inspection and the extra-curricular activities has a strong behaviorism emphasis. However, from the on-going curriculum reform, teachers have prepared some extent of professional competence to become school curriculum developers. The further improved teachers' professional development may boost the application of environmental education, since teachers will benefit from it. In addition, as has been pointed out regarding the time shortage, a separate course may add a burden to an already overloaded curriculum. It is more practicable to design a scenario within the regulated four lessons hours. With this number of course hours, the school curriculum scenario application can be more flexible, since it can be conducted in extra-curricular activities as well, for example in class meetings. The experience learned from the design study process can contribute to the further dissemination and development of environmental education into the local curriculum.

Chapter 10 Methodology of the Design Study

1 Introduction

Starting from the acknowledgement of the design problem that generated the rhetoric-practice gap in China, we will need to take an appropriate research approach. With this approach we are to find a context-based curricular solution to reduce the gap with optimized intentions into the design and its implementation. The solution should be applicable within current schooling in China. Therefore, from the understanding of obstacles and tensions in the current application of environmental education within the curriculum system, a choice is made to intervene at the level of the school curriculum. In this chapter, the methodology choice of the design research approach is presented. With the justification of this approach, design research is introduced, with an overview of its definition, procedures, and outcomes. And lastly, the overall set up of the design research in our study is outlined.

2 Design research approach

2.1 Choosing a design research approach

Following our general research concern, two issues are central to this study. One is to understand the current state of environmental education in schools in China, for the awareness of the rhetoric-practice gap. The other, after having identified the gap, is to improve environmental education by means of an educational intervention in Chinese schools. Therefore the endeavor of this study is twofold — defining the problem and finding the appropriate solution with a careful approach. As the explorative study revealed, for environmental education in China, the main problem lies in the formalizing gap, the operational gap, and the evaluation pressure generated from the competitive social background. This is to say, the attainment of environmental literacy is weakened since the abundant theoretical guidelines and policies could not yet be fully formalized into educational products or be implemented with appropriate understanding from the practitioners, especially in considering the pressure from the competitive social educational background. To solve the problem, what is needed is to recognize a path, along which an educational product may optimally bring the 'rhetoric' into the 'practice'. Therefore, we consider the problem of environmental education in China as a design problem.

In conventional research approaches, identifying, describing and analyzing learning and teaching problems in classroom practice does help to recognize problematic issues, but not sufficiently to cope further with how to improve teaching and learning, and to appropriate the improvement (Westra, 2008). As Lijnse and Klaassen (2004) recognized, much of science education research aims at general theories, but application of such theories results at best in heuristic rules and not in a desired educational process and quality. When we talk about the rhetoric and practice, Vanderlinde and Van Braak's (2009) research offers an interesting insight and draws our attention to the relation between educational research and practice. They investigated how the key actors, i.e. teachers, school leaders, intermediaries and researchers, perceive and value educational research. With reference to Bates (2002), this research showed that a tension exists between researchers and practitioners in their views on: the nature of knowledge, the professional vocabulary, the reward system, time and resources, and authority issues. Vanderlinde and Van Braak recognized the gap between educational research and practice and several factors and barriers that hinder the use of research by practitioners. Their research indicates that by bridging research and practice, new incentives for school improvement can be established, and that bridges can be built by connecting researchers and practitioners. This can be done by encouraging researchers to be more cautious and informed about the actual practices, and by involving practitioners in the design and implementation of research. Lastly, the findings of the study indicate that more cooperation between researchers and practitioners can be realized by promoting design research.

Similarly, from the perspective of comparative education, the gap between academics and practitioners is also highly discussed (Carnoy, 2006; Wilson, 2003). There is an urgent call for more effective communication between the results of the academic and field-based research, and between insights from educational reformers and practitioners (Birmaimah, 2003; Wilson, 2003), in order to exchange context-based empirical evidence that may lead to more general insights on the transnational forces of educational improvement. This urgent need has been affirmed in our explorative study in Chinese schools.

We are convinced that in responding to the methodological call, and in contributing to a cumulative effort to enhance environmental literacy within school education practices, design research is a promising research approach, especially appropriate to address the question of improving environmental education in reducing the rhetoric-practice gap.

2.2 Introducing a design research approach

We introduce a synthetic approach, design research, as our major research approach of this study phase. We have zoomed in with the explicit descriptions contributed by a group of researchers from their experiences of using design research. Reflecting on what have been learned from former practitioners, we may generate ideas and have prospects of how design research can be set up in a way that is appropriate to address our general research question.

2.2.1 Definition

Educational research has long been criticized for a lack of connection with school practices. Responding to such challenges, design research has gained a prominence in educational studies in recent years (Reeves, 2006; Van den Akker, McKenney, Nieveen, & Gravemeijer, 2006). The initiation of design research stems from the desire to strengthen the research relevance for educational practice and therefore also for educational policy. Design research is defined as a common label and an umbrella term that represents a group of educational research approaches and tools for which many different terms can be found in literature, including educational design research, design experiments, design studies, development/developmental research, formative research, formative inquiry, formative experiments, formative evaluation, action research, and engineering research. Several descriptions exist for describing the nature of design research (Lijnse, 1995; Plomp, 2009; The Design-Based Research Collective, 2003; Van den Akker et al., 2006). While there is an ongoing debate about what constitutes design research, a definition proposed by Wang and Hannafin (2005) captures its critical characteristics. Design research is a systematic but flexible methodology aimed to improve educational practices through interactive analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design criteria and theories (Wang & Hannafin, 2005).

2.2.2 Characteristics

Several characteristics are recognized that apply to most design studies (Nieveen, McKenney, & Van den Akker, 2006; Plomp, 2006; Van den Akker et al., 2006).

- Interventionist: the most essential procedure in this research approach is designing and implementing interventions to explore and indentify optimal solutions for an educational problem.

- Pragmatic: The merit of a design is partly evaluated by its practicability for users in a real context. The interventions are aimed at solving real-world problems as well as extending theories (domain specific theory of teaching and learning) and refining design criteria (theoretically and empirically supported assumptions about what makes a valid and effective design).
- Participative and interactive: design research requires collaboration between researchers and practitioners. The role of local stakeholders, mostly educational practitioners, is crucial for diagnosis of the problem in that context to begin the design process, but also for field testing of design outcomes. The role of researcher has multiple facets, designing, researching the design, and being a change agent in a local context.
- Contextual: design research is grounded in the real world. The design process, the product and the expected outcomes are connected to the specific context with concerns of limitations, complexities and dynamics there. Therefore, in considering repetition, it is required for design researchers to keep logging the design process comprehensively for peers to examine the relevance to other particular contexts.
- Cyclic and iterative: design research involves a cyclic procedure of analysis-design-implementation-evaluation-revision. When a certain cycle of intervention does not yield the desired outcomes, the revision joins the analysis of design criteria for the next cycle.
- Explorative: different from a black box model of input-output measurement that has a confirmatory emphasis, design research has a more exploratory emphasis on gaining more insights into the mechanisms behind an intervention.
- Integrative: design research can be defined as a series of approaches. Design research embraces a variety of research methods both qualitative and quantitative.
- Theory based: theory is the beginning and one of the outcomes of design research. Design is conducted based on theoretical assumptions.

2.2.3 Initiation

The initiation of design research can be understood as a response to the disappointment about the impact of conventional approaches in education science (Walker, 2006). As Plomp (2006) recognized, the insufficient quality of much educational research is argued from two perspectives.

Firstly, the insufficient quality of much educational research is argued from the lack of relevance for practices (Reeves, 2006; Van den Akker, 2006; Walker, 2006). As Walker stated, curriculum theorists and developers actually design concrete materials for teachers and students to use directly. However, it is only occasionally taken into account how students and teachers really respond to specific features of the design suggested by a theory.

Secondly, the insufficient quality of much educational research is argued from the over-ambitious claims of much educational research (Van den Akker, 1999; Walker, 2006). As said by Walker, in educational sciences, research findings and theories often functioned as little more than slogans for reformers. In addition, Van den Akker argued that concerning the complex nature of educational reforms worldwide, rather than drawing ambitious reforms, systematic research on implementation processes in various contexts deserves more effort.

To conclude, design research investigates the design process itself in relation to the impact of the designed products. Designers do research to show their designs function in the way that theoretical criteria predict in a certain context. The tests of a design give evaluative suggestions on how a precise configuration in a design needs to be tuned and optimized. Design research is by its nature relevant for educational practices and therefore also for educational policies. In reviewing the state of educational research, we argue in line with Meijer et al. (2008), Plomp (2006) and Reeves (2006) that instead of comparing 'whether method A is better than B in a certain context', and comparing 'why method A is better in context X and why method B is better in context Y', design research is more relevant for recognizing opportunities and developing optimal solutions in addressing complex problems for which no or few solutions are made available.

2.3 Procedures

In this part, we will collectively draw on a group of scholars' descriptions (Plomp, 2006; Reeves, 2006; Van den Akker, 2006) of how design research is carried out. This is to give an in-depth illustration of how the set-up of this approach deals with scientific legitimacy, how what is learned can contribute to theory building, what types of outcomes it achieves, and how the approach is positioned with other research approaches in terms of strengths and weakness. In doing so, we will not only respond to the question of why education design research is an appropriate approach for our study, but also prepare for how we should move on with this approach in addressing the research question of our study.

2.3.1 Identifying and analyzing problems

The starting point is an educational problem for which no or only few validated solutions are available and new innovative routes are needed for exploration (Plomp, 2006). The problem often represents complexities and multi-level conflicts in an educational system within a certain context. Identifying the problems is basically done by researchers in collaboration with practitioners. Design researchers get informed by prior relevant literature, gain insights from practitioners and from carefully studying successful examples. They then would be able to set a purpose, target the need for improvement and would be aware of where the tension lies and what key factors are involved.

2.3.2 Formulating criteria to support a design

Design research aims at designing an intervention as an innovative or optimal solution to a complex problem. The design should be warranted theoretically. A cluster of design criteria is to be formulated from following theoretical and empirical suggestions. Firstly, domain-specific theories (Edelson, 2006) describe the learning and teaching processes in a particular domain, for example, how to teach the concepts that are crucial in environmental education. Secondly, heuristic statements derive from state-of-the-art theories and prior empirically learned lessons (Van den Akker, 2006). Thirdly, available interventions may serve as worked-out examples or sources of inspiration for exploring solutions for the defined problem (Plomp, 2006; Vanderbilt, 1997). Carefully studying such examples in considering the context, ideas will be generated for a new or improved design.

Drawing collectively on the above sources, a theoretical framework, a set of 'design criteria' in the concept of design research (Reeves, 2006; Van den Akker, 1999, 2006), is to be formulated to structure and support designing the intervention. The knowledge formulated into criteria is meant to support design researchers, in the early stage, for their domain-specific and context-based design task. The criteria are intended to predict but cannot guarantee success (McKenney et al., 2006; Plomp, 2006). The aim is to capture the most appropriate knowledge and to make explicit the implicit decisions associated with the domain-specific and context-based design task, transform them into guidelines that seem promising to solve the problems. The value of the criteria will strongly increase when they are convincingly backed up with empirical evidence about the impact of the criteria, and validated in similar interventions in various contexts (Plomp, 2006).

2.3.3 Developing a design

Designing an intervention is essential in design research. Detailed design of a domain-specific lesson unit and a sequence of teaching and learning activities are accompanied by argued expectations on how a sequence or unit is functioning and why (Meijer et al., 2008). It should be noted that the intervention does not have to be absolutely new. As we mentioned previously, the knowledge incorporated into design criteria comes partly from available interventions. The available interventions may also serve design researchers to search for inspiring examples that are useful to start with their domain-specific and context-based design task. Whether the prototyping is based on a useful example or is entirely built anew, the first design is guided by the framework, a set of design criteria formulated in previous studies or from theoretical literatures.

2.3.4 Implementing and evaluating a design

Designing an intervention is in itself not yet a design research (Plomp, 2006). The expectations about the impact of the criteria and the outcome of domain-specific details in the prototype need to be convincingly backed up with empirical evidence and validated in the target context; and designs advance best when the most promising options are compared to one another (Walker, 2006). The designed intervention is used for collecting data with the aim of improving the understanding of the teaching and learning unit, sequence and the trade-offs, and fine tuning of design criteria. The implementation usually involves small-scale interpretive case studies in the target context (Meijer et al., 2008). In the interaction between design researchers and local practitioners, the insights are gained from experiences of teachers, students and other stakeholders. As Meijer and his colleagues shared their experiences of using educational design approach, zooming in on the authentic practices in the target context, 'white spots' in our prior knowledge emerge, and an optimal route towards solving the problem can be recognized. Such enriched understanding gives rise to an improved formulation of design criteria or domain-specific theories of learning, and specifies next versions of more exemplary interventions.

2.3.5 Formulating criteria to build theory

As we stated before, design research, through developing an intervention, aims at identifying opportunities, and defining optimal solutions to complex problems. In doing so, it produces knowledge about whether and why such an intervention works in a certain context, and how an intervention is developed to function. The intervention is based upon theoretical propositions, a cluster of design criteria, which are evaluated and sharpened by implementation in a certain context. The context-bound nature of design research explains why this approach is valuable in striving to strengthen the relevance of educational research to practice. However, here we also touch upon an issue of context-free generalization. The theoretical yield of design research, in contrast to statistical generalization, is an analytical generalization (Plomp, 2006). In answering the question of to what extend design criteria can be generalized from one context to others Plomp referred to Yin (1989) and emphasizes that as in case studies and experimental studies, the findings are only generalizable to theoretical propositions and not to entire populations. Design researchers strive to generalize a particular set of findings to some broader theory, and the theory is in the form of 'design criteria'. Design criteria must be tested, evaluated through replications of the findings in more cases in various contexts with the purpose that the same result should occur. The replications and the iteration cycles in the design process are supportive for the design criteria to be accepted in a larger number of similar contexts. Yet, as Plomp finally warned, contexts may be similar, but each context has unique characteristics and complexities, justified design criteria should be used as heuristics that give direction but cannot guarantee certainties.

2.4 Outcomes

As may be recognized from the discussion about the procedures discussed in the previous section, design research achieves both practical and theoretical outcomes. Based on Lijnse and Klaassen (2004), McKenney et al. (2006), and Plomp (2006), three types of outcomes can be categorized.

2.4.1 Intervention product

The designed intervention is a means of exploring and identifying optimal solutions of an educational problem, which is specific in a domain and based on a certain context. The substantive knowledge in the intervention developed in designing process is also left as a product for the case study sites, and usually can be in the form of materials such as a teacher guide, instructional booklets, and syllabuses and so on.

2.4.2 Professional development

The intervention is collectively designed and tested with careful interaction with practitioners and students. In addition, the design research approach embraces a wide scope of data collection methods. The chances increased are not only for successful implementation also for participants to develop themselves in reflecting how design may contribute to problem solving in their professional contexts, with their classroom constrains. The professional aids for the local schools can also be a working community of motivated stakeholders.

2.4.3 Theoretical outputs

It is useful to distinguish the theoretical contribution of design research according to its different goals. The aim of designing can be validating theories or developing *theoretical criteria* (Nieveen et al., 2006). The goal can also be developing a content-specific educational structure about bout how to teach a domain-specific topic in a context (Lijnse & Klaassen, 2004).

Validation studies aim at validating theories on learning process and classroom settings, a local instruction theory, including instructional activities, sequences, and domain-specific content knowledge (Gravemeijer & Cobb, 2006). The contribution of validation studies lies in validating the theoretical basis of instructional designs. DiSessa and Cobb (2004) already alerted that if the motivation of design research is restricted to producing domain-specific instructional theories, the theoretical value will not progress in the long run (Cited in Nieveen et al., 2006, Plomp, 2006).

Development studies aim at deriving design criteria for developing innovative interventions. To briefly repeat, the design criteria are clustered as a framework, which in the early stage, guides the design researcher for the first prototype. The design criteria are built upon domain theory (Edelson, 2006), heuristics (Linn, Bell, & Davis, 2004; Van den Akker, 1999), lessons learned and examples available (Plomp, 2006; Vanderbilt, 1997). Design criteria must be tested and evaluated through implementation of the intervention. The replications of the findings in more cases in various contexts and the iteration cycles in the design process are supportive for the design criteria to be accepted in larger number of similar contexts.

An *Educational structure* is an outcome where a design research aims at improved adequacy of content-specific interactions of teaching and learning processes, as Lijnse (2000) termed it, unlike validation studies, the contribution of which is to validate the theoretical basis of designing instructional activities, sequences of activities, and domain-specific content knowledge. Lijnse and Klaassen (2004) counted the difficulty of putting general theoretical ideas into adequate practices and argued for *didactical structures* as the theoretical output since it is the consequence of developing the best possible ways of teaching a topic. A group of FIsme researchers adopted a *problem posing approach* to conduct design researches focused on scenario development, to name a few, Klaassen (1995), Kortland (2001), and Westra (2008). The scenario is the body of the preliminary design criteria elaborated in a certain case. An understanding of the case is integrated with the design criteria into a scenario, and validated through the design study, so that the scenario yields an empirically tested *didactical structure,* as a specification and validation of the design criteria about how to teach a specific topic in a context.

2.5 Concluding remark

Design research can be placed within the framework of research approaches as 'narrative research', 'phenomenology', 'grounded theory', 'ethnography', and 'case study research' (Meijer et al., 2008). In educational research there is an urgent need for strengthening the relevance of research for educational practices. We conclude that for practical problems and/or research questions calling for developing an intervention with purpose of identifying optimal applications, design research is an appropriate research approach. We already recognized a mismatch of concepts in terms of theoretical outcomes of design studies and each research trend may receive criticism. Being so, it is not possible to position our study in an exclusive way among different research trends. Neither is our purpose to distinguish interpretations from different research groups. Nevertheless, informed about the design research perspectives, it is useful to launch a design research with specified methodological emphasis, and practical and theoretical contributions. In the next section, we clarify the outline of our design study.

3 Outline of the research design

We outline our study along with the procedures defined by key scholars of design research, and each procedure is presented with data collection and methods for analysis.

3.1 Identifying and analyzing problems

The starting point of our design research study is the rhetoric-practice gap for which no validated solutions are available. It is required as an exploration for routes to optimize intentions into a design and its implementation. The rhetoric-practice gap is the result of complex multi-level conflicts in China's educational system. In the explorative study, the rhetoric-practice gap is carefully identified in collaboration with researchers and practitioners. From a well-informed understanding of the current state of the intended, potentially implemented, and implemented environmental education in China, the purpose is to explore an adequate didactical structure in closing the formalizing and operational gaps for a progressed environmental literacy (see chapter 8). And from the understanding of obstacles and tensions in the current application of environmental education within the curriculum system, a choice is made to intervene at the level of the school curriculum (see chapter 9).

3.2 Formulating criteria to support the design

The design criteria for this study elaborated in a scenario are derived from three theoretical sources: firstly, domain theories of environmental science i.e. sustainable development and ecological modernization to clarify our environmental position, study issue, and content knowledge; secondly, educational theories of teaching-learning approaches i.e. inquiry-based learning and the problem posing approach to make a deliberated plan of procedures; thirdly, educational theories of constructivism to underpin the design intention. An initial set of design criteria is formulated in chapter 11 to guide and structure the design of the scenario. Besides the criteria, the design intentions are also based on the theoretical assumptions of curriculum elements suggested by ideal environmental education (see chapter 3, section 3.1) and the need for improvement identified from the explorative study (see chapter 8). The design intentions are to be embodied in an initial design, i.e. the *ideal curriculum*, and then further tested and revised during the experimental intervention cycles. Generalizable criteria are one of our desired outcomes. To increase the value of the criteria, detailed elaborations are presented in chapter 12 and 13 to provide convincing empirical evidence of the development of the scenario and its implementation. And in chapter 15 a critical reflection is made on how and why the expected learning has happened or not.

3.3 Developing the design

The scenario development also refers to the instrument of curriculum elements i.e. rationale, goal, content, teaching and learning process, teacher's role, students' role, and assessment (see Chapter 2, section 5.3). In chapter 12, the scenario is elaborated in a detailed design process, in the curriculum elements and sequences, together with argued expectations about how it should be functioning. With the understanding of the current three-level curriculum system, a four lesson scenario is planned to make use of the available time in the school curriculum (see chapter 9). The intended scenario is presented by the seven curriculum elements and explained three sources underlining the vision. The design is supported by the initial design criteria. The design vision is also based on theoretical assumptions of curriculum elements that are suggesting ideal environmental education (see chapter 3, section 3.1). In addition, the development of the scenario takes into account the need for improvement identified by the explorative study (see chapter 8). The *formalization* is elaborated in detail along the procedures of motivating, questioning, investigating, applying, and reflecting. In each of the phases, we explain how the intended vision is elaborated in the scenario. Lastly, the potentially implemented scenario i.e. the *formal/written curriculum* is presented in full description, together with its underlying *didactical structure*.

With the intention to optimize the intended environmental education into our design, which implies to include contradicting aspects and engage the students to explore through the entire inquiry process, higher grade students are preferred to participate in the design research. Given the condition that students of grade 6 are tense in preparing for the graduation examinations, grade 5 is chosen, and the scenario is developed purposefully for grade 5 students who normally are at the age of 11-12. As a knowledge preparation, we also referred to the integrated environmental education components in the compulsory textbooks, the domain-specific materials, the Guideline, and the Syllabus. And therefore careful choices are made on the content knowledge, the level of skills, and the complexity of the problematic issue based on an awareness of grade 5 students' pre-knowledge.

3.4 Implementing the design

The scenario presents a conceptual and motivational pathway, including the curriculum elements, steps, and tasks that lead towards environmental literacy. The desired outcome needs to be convincingly backed up with evidence in a real context. For reasons of convenience and available support from local educational administration, four schools in the city of Golmud and Xining, Qinghai province are chosen to participate in the experimental trials. In total, eight cycles of trials are conducted. Each trial as a case study has contributed data for improving the scenario for the next round of trial (see figure 10.1). In chapter 13, we explain to what extent our design intention has been accepted by the participant teachers, what design errors are revealed in the performances, suggesting modifications. The framework of curriculum representations (Goodlad, 1979; Van den Akker, 2003) also provided support to conduct a cross-case analysis of the data to explain: how the vision of the seven curriculum elements is perceived by the participant teachers as shown in their performances, i.e. *the perceived curriculum* and to describe operationally what happened in each lesson considering the problem posing approach, and the errors or obstacles that did reveal, that required modifications, i.e. *the operational curriculum.*

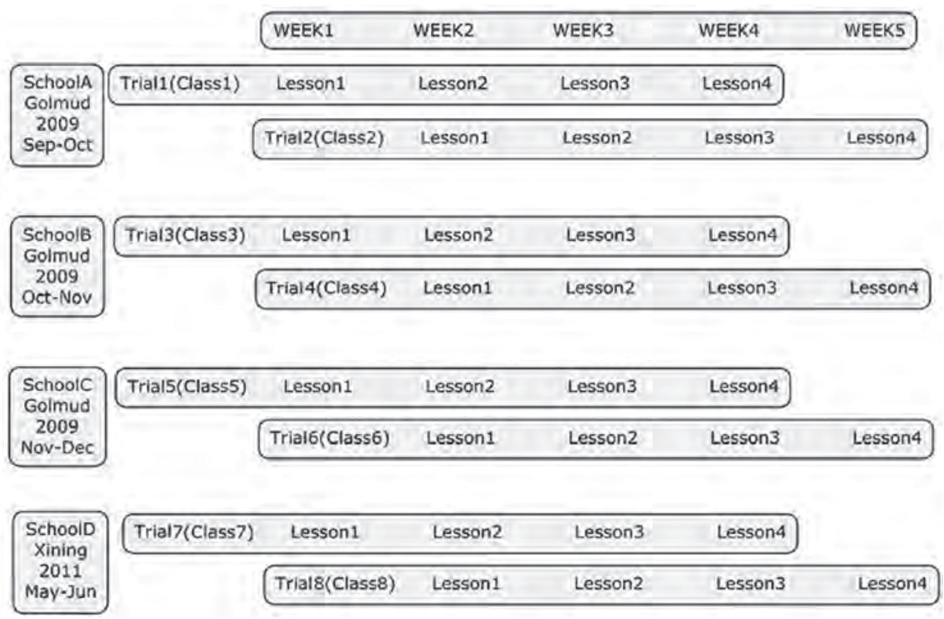


Figure 10.1: Implementation of the scenario

The four schools are recommended by the cities' educational departments for performing well in educational quality and being open to innovations. As, in China, having the permission from educational administrations is the only legitimate way to enter the schools for the experimental trials, with the recommendation letter from the educational administrations, the four schools all accepted the cooperation and showed a high degree of interest. All the schools suggested carrying out the trials in Chinese classes to show that they are highly focused on our research. The reason is that in Chinese schools, every class has a chief teacher who normally is the teacher of the Chinese language course. The chief teachers have a responsibility for the class's general management, such as disciplines, study, safety etc., and therefore are the one most familiar with the students. The chief teachers also have the authority to make flexible use of course time for class meetings. In total, eight chief teachers, two in each school are recommended by the school principals for having good teaching competences. Consequently, 440 students of the eight teachers' classes participated in the implementation of the scenario, as listed in table 10.1.

During the implementation of the scenario the following three data sets were collected:

3.4.1 Interviews

In the preparation, an individual discussion was conducted with every teacher before each lesson. The discussions were to explain and clarify the intention of the design to the teachers, the expected sequences of teaching and learning activities, performances, and desired responses of the students. The teachers were also invited to talk about how they understood the scenario, their confusions, worries, and expectations. And after each lesson, the teachers were interviewed for about 30-45 minutes for their evaluative reflections. The interview themes are listed in appendix VIII. All interviews were audio recorded and coded. In the analysis, we looked for their comments that indicated errors or ambiguities in the design, and their suggestions for improvement. Casual talks were held with the students as an additional source to prove our understanding about the quality of the implementation. The interviews with the teachers were focused on the understanding of *the perceived curriculum*. The coding for analysis of the data is based on the instrument developed in chapter 3 (see appendix VII). The interviews with the teachers and students also supported our analysis of *the operational curriculum* in triangulation with the observations.

Table 10.1: The participant teachers and students

Teacher	Gender	Teaching experience	Teaching subject	Major	Education degree	Participated trial	School	Class	Number of students
Teacher A	Male	12 years	Chinese	Primary education	Secondary vocational school	Trial 1	School A	Class 1	59
Teacher B	Female	15 years	Chinese	Primary education	Secondary vocational school	Trial 2	School A	Class 2	60
Teacher C	Female	14 years	Chinese	Primary education	Secondary vocational school	Trial 3	School B	Class 3	47
Teacher D	Female	9 years	Chinese	Primary education	Secondary vocational school	Trial 4	School B	Class 4	51
Teacher E	Female	12 years	Chinese	Primary education	Secondary vocational school	Trial 5	School C	Class 5	51
Teacher F	Female	15 years	Chinese	Primary education	Secondary vocational school	Trial 6	School C	Class 6	50
Teacher G	Female	9 years	Chinese	Primary education	Secondary vocational school	Trial 7	School D	Class 7	67
Teacher H	Female	6 years	Chinese	Pre-school education	Bachelor degree	Trial 8	School D	Class 8	55

3.4.2 Class observations

A non-participative observation was made of every class of each trial. The data are collected in video recordings of the whole class mode of teaching and learning processes, and audio recordings of group discussions. In addition, the observer-designer also took notes during the classes to support coding the transcriptions. The coding required for analysis focuses on *the operational curriculum* originating from the actual interactions. The observations paid attention to deviations, spontaneous reactions, and innovations occurring during each of the teaching-learning activities. The purpose is to recognize design errors and flaws that caused misunderstandings, and to confirm where and how the design resulted in the expected performances and responses. Learning from these deviations, including misinterpretations and innovations, the scenario was modified for the next trial.

3.4.3 Group discussions

For monitoring the implementation, in all eight trials, the group discussions were recorded to prove whether and how in the students in group work referred to the acquired content knowledge, whether the group work proceeded as desired, and what problems were encountered. After each lesson of the trial, the record of the group discussion was replayed and notes were made for improvements in the next trial.

3.5 Evaluating the design

The results of the evaluation of the attained scenario are presented in chapter 14, focusing on how the four lesson unit has been experienced by the students, i.e. *the experiential curriculum*, and to what extent the four lesson unit has achieved environmental literacy in the students, i.e. *the learned curriculum*. We are aware from the previous literature review that design research is evaluated for improving understanding of the teaching and learning sequences and trade-offs and thus fine-tuned design criteria. As in our study, design research has a domain-specific objective to improve the attained environmental literacy. The quality of the design is judged mainly by the improvements in the participant students' environmental literacy made by the design research as an educational intervention. The improvement is further proved by additional comparative data analysis in evaluating the design research. The following four data sets provided sources for the evaluation:

3.5.1 Individual reflection essays

After each lesson, the participant students were required to write an individual essay to reflect on their learning experiences. In the essays, the students were requested to write about: what they liked most, what was most interesting, and difficult, and what was new for them. Altogether, we were able to collect 1063 essays in the eight classes. To analyze *the experiential curriculum*, we applied a word analysis to see how they referred to the learning experience in general. More specifically, we searched for the students' appreciations by coding and counting the words they use to describe their learning experiences. *The learned curriculum* is analyzed by distinguishing the four strands of environmental literacy, i.e. knowledge, skill, affect, and behavior (Roth, 1992). To measure the attained knowledge, we looked in the essays whether and to what extent the content knowledge was represented. For example, we searched and counted in the essays of lesson 1 to what extent the concepts of 'material flow' and 'waste flow' have been mentioned and how they are understood by the students. To measure the skills and affect, we examined the students' self-reported improvements in the essays. For example, when students mentioned difficulties in working in groups, this information is coded as unachieved skills. To measure the behavior, we tested their verbal commitment to environment actions from the essays. Specifically, in the essay the places where the students made action plans are marked, noted down, and categorized for analysis. So to say, for analyzing the learned curriculum, the coding does not only apply to words, but can be chunks of texts, sentences, or passages as long as they indicate the needed 'theme'.

3.5.2 Group work in lesson 3

In adopting the problem posing approach to carry out our design research, a school curriculum of four lessons is planned as an intervention (see chapter 12). The four lessons were structured accordingly, in the following five interrelated teaching-learning activities: motivation, question, investigation, application, and reflection (see chapter 12). In lesson 3, the students had to apply the learned content knowledge in making environmentally friendly decisions in dealing with the given example of paper notebooks. We expected to see in the group discussions, including the group work results and discussions, an improved environmental literacy in the participant students in application of the content knowledge, and in skills, affect, and behavior. Detailed measurements of the four strands are developed with the reference to environmental literacy defined by Roth (1992) (see chapter 11 and chapter 14).

After the last trial in school D in Xining, an additional comparative evaluation method is applied. In school D, two control classes participated in the evaluation, one with 65 students (control class A) and the other with 57 students (control class B), each in lesson 3 and lesson 4 respectively. The two control classes were also both from grade 5, and each class was divided into six groups by friendship grouping. The control classes had no intervention before they were invited to do the evaluation in lesson 3 and lesson 4.

The lesson 3 application exercise is used and tested in control class A. The comparative data analysis is to measure whether and how the learning of life cycle analysis of paper notebooks has made differences in the students' environmental literacy in applying to find solutions of 3R's principle. Specifically, it is to measure whether and how the participant students differ from their non-participant peers in the application of the content knowledge, in their affect, and if they could demonstrate more desired skills, and behavior. The group discussions, including the group work results and discussions process in lesson 3 were compared between the two experimental (12 groups) and the one control class (6 groups).

3.5.3 Group work in lesson 4

Lesson 4 is designed as an evaluation of the *learned scenario*. Environmental literacy is tested by looking whether the students were able to apply the learned life cycle analysis to a new stationery item other than the studied example of paper notebooks.

In the additional comparative evaluation, the lesson 4 application exercise is used and tested in control class B. The comparative data analysis is to measure whether and how learning the life cycle analysis of the paper notebooks has made differences in the students' environmental literacy in applying what is learned a new example. The group discussions, including the group work results and discussions process were analyzed to measure whether in the life cycle analysis the participant students show the expected improvement in knowledge, skill, and desired affect and behavior. The group discussions in lesson 4 were compared between the two experimental (12 groups) and the control class (6 groups).

3.5.4 Survey

In the three schools of the first six trials, we were able to conduct a survey with the six experimental classes, and with six control classes of the same grade. In total, 607 students participated in the survey. The survey was conducted in their normal class time, therefore all questionnaires of the survey were returned. In each school, after experimental classes have completed the implementation of the scenario, the questionnaire is tested at the same time in the experimental and control classes. The three schools used the same questionnaire, which took about 20 minutes to finish answering.

The questionnaire is designed with the purpose of providing a systematic quantitative measurement on the students' environmental literacy, i.e. *the learned curriculum* and on their learning experiences i.e. *the experiential curriculum*. The 49 item questionnaire (in appendix IX) is developed based on the strands of environmental literacy (Roth, 1992). For the validity, the items for the four strands are designed in close relevance to the scenario. Or to say, we measure the content knowledge, skills, affect, and behavior that is particularly designed into the scenario and expected for the students to develop in their learning processes. The students' knowledge is tested by eight items. The affect is measured by one multiple choice item and eight five-level Likert scale items to test the students' opinion on personal responsibility, internal locus of control, empathy for both nature and society, conflicts of nature and society. The behavior strand had six five-level Likert items to measure the students' verbal commitments of taking actions through persuasion, consumerism, political action, and personal engagement. The Likert scale is used in the measurement to allow a chi-square analysis for comparing the differences between the control and experimental classes. The skills cannot be measured properly by a questionnaire, but had to be observed in the students' group work. Moreover, the questionnaire had 26 items to investigate the students' self-reflection on their learning experiences. The items of the questionnaire were developed in referring to the analytical instrument from chapter 2 (see table 2.5).

3.6 Reflecting to build theory

The intention of the intervention, the scenario, is to collect data for an enriched understanding of the interaction of teaching and learning processes, sequences, elements, trade-offs, and for confirmed formulation of a set of design criteria. The context-bound design study is aimed to explore the opportunities and optimal solutions to close the formalizing and operational gaps for improved environmental literacy. The theoretical value ultimately lies in detailed elaboration of each level of curriculum representations, namely how the intended scenario has been developed into the potentially implemented formal product, and how it is further operated in actual classroom practices and perceived by the teacher, and until it is finally evaluated by assessing the students' learning experiences and outcomes. The intervention produces context-based knowledge about whether, how, and why the scenario may or may not function as a solution to enhance environmental literacy and to close the rhetoric-practice gap.

To launch a design research focusing on validation in various settings goes beyond the time and resources available for this study. However, it is possible to reflect critically on the generalizability of the design criteria for broader impacts in the future. At the most practical level, the contribution is the instructional product, the scenario, the body of worked-out theory for raising environmental literacy, together with its context responsible for a possible application in other settings to consider and interpret. A critical reflection of the approach of the design study will be presented in chapter 15.

Chapter 11 Scenario Criteria

1 Introduction

We begin the design of the scenario by making explicit our basic views on several crucial aspects, i.e. on environmental education, on environmental reform, and on education in general. In this chapter, the value-laden choices will be made to clarify the goals, and the way we aim at with the scenario design guided by a set of design criteria. In a design study, design criteria are deliberately defined from normative beliefs, theoretical notions, perceptions, practice knowledge, and new notions emerging during the construction and intervention process (Boersma & Waarlo, 2009). An initial set of design criteria is formulated in this chapter to lead and structure the design of the scenario. The design criteria should not be read as law-like rules for environmental education. They are to be tested and revised further during the experimental intervention cycles in the later phase as a theoretical reflection on how and why the expected learning has happened. In the domain of environmental education, the theoretical framework is eclectic in nature and embraces different types of theories, i.e. environmental policy, environmental education, and educational science. We have given our attention to sustainable development, ecological modernization, environmental literacy, inquiry-based learning, the problem posing approach, and constructivism. And we are able to develop two categories of design criteria: domain-specific criteria about environmental education, and criteria focusing on structuring and promoting students learning processes.

2 Environmental education and sustainable development

It has been debated whether and how to rename environmental education under the notion of sustainable development. It is necessary to clarify the position taken in this study, especially for making choices for the design of the curriculum scenario after being well informed about Chinese academics' perspectives on the terminology. In China, the terms environmental education and education for sustainable development (ESD) have also been discussed. Tian Q., Yun Y.R., and Yin, P.H., (2007) conducted a large literature review on publications related to environmental education or ESD from 1979 to 2005. The results showed that since the recognition of the importance of ESD with the UN declaration of the *United Nations Decade of Education for Sustainable Development (2005-2014)*, the use of the term ESD over 'environmental education' has dramatically increased in publications.

One opinion is that environmental education is a discipline in its own right, different from ESD (Huang, 2003; Tian, 2004b). Another opinion considers environmental education a part of ESD, namely one of the thematic educations of ESD, such as peace education, development education, etc. (Wang, Wei, & Huo, 2006). However, it is agreed that ESD is rooted in environmental education, but embraces broader dimensions (e.g. equity, peace, poverty, human rights, culture, economy, and society), and represents a reorientation of environmental education (Huang, 2003; Tian, 2004b; Wang et al., 2006). As Wang, Wei, and Huo (2005, 2006) argued, ESD is a development beyond environmental education and has functions that cannot be fulfilled by environmental education. According to the interpretation of Tian (2003, 2004b), ESD in China is a response to the unsatisfactory outcome of traditional environmental education in the past. Traditional environmental education in China held the rationale that our way of production and living is correct and will lead to abundance of life, and that environmental problems are unavoidable byproducts of this development that can be prevented or controlled by technical means. Sometimes ESD is used to name the new version of environmental education, in considering the traditional environmental education has too narrowly focused on the bio-physical environment, on transferring content knowledge about environmental protection, and science-technological solutions. As a response, ESD aims to guide us to a critical rethinking of the practice of environmental education in the past, particularly reorienting environmental education towards economic and social dimensions, and towards a reflection on environmental problems in relation to our lifestyle. In addition, Tian (2004b) also emphasized that ESD is promising in reforming the entire educational system, as it is more in line with the on-going curriculum reform, such as a shift of focus from knowledge to competence, a shift of focus from natural science to social science and humanity, and a shift from standard assessment to multiple assessment. This is a change from traditional environmental education in China which merely extended the knowledge field for education, but contributed little to reforming education in terms of rationale, pedagogy, and assessment; or in other words, traditional environmental education in China is only an additional new knowledge domain within the education system. As Tian (2004b) summarized, the mainstream opinion is that ESD is an advanced stage of environmental education. ESD is not only a necessary reorientation of environmental education, but it also corresponds to the reorientation – or greenization – of general education system that advocates sustainable development. The question to answer now is whether to expand the definition of environmental education, or use ESD to replace the term environmental education.

In 2002, the United Nations Decade of Education for Sustainable Development (2005-2014) was declared. It highlighted the difference between environmental education and ESD. Environmental education is '*a well-established discipline, which focuses on humankind's relationship with the natural environment and on ways to conserve and preserve it and properly steward its resources.*' (UNESCO, 2004, page 16) Education for sustainable development "*encompasses environmental education but sets it in the broader context of socio-cultural factors and the socio-political issues of equity, poverty, democracy and quality of life.*' (UNESCO, 2004, page 16) However, the definition of environmental education and its goals set forth in the Tbilisi conference already included the fundamental notion of sustainable development. Environmental education is a process of recognition of values and classification of concepts, towards the development of skills and modification of attitudes in relation to the environment, to understand and appreciate the interrelations between human beings, their cultures and their biophysical environment; and further with the practice of making decisions and the ethics that lead to a change in quality of life (UNESCO-UNEP, 1978). Sustainable development was defined by the Brundtland Commission in 1987 as *'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'* (WCED, 1987, page 16). Sustainable development has thus been linked with environmental education to promote development models based on a wise use of resources with concern for equity and durability (Sauve, 1996). The United Nations Conference on Environmental Education (UNCED) in Rio de Janeiro, in its Agenda 21 chapter 36, states that education is critical for promoting sustainable development and improving the capacity of people to address sustainable development issues (UNCED, 1992). The interest in a 'new focus' in environmental education resulted in a range of initiatives and publications in favor of shifting the emphasis away from environmental education towards education for sustainability. For this study, we are convinced that environmental education is a discipline in its own right, and sustainable development is an ultimate goal to head for in environmental education, since it was implied in the Tbilisi notion of environmental education. Moreover, when associated with education, the ambiguity of the concept of sustainable development is problematic, in that a variety of educational themes would add more of a burden to the already overloaded curriculum in schools, and in another that it might inhibit the teachers in translating the complexities in the language of sustainability to their teaching practice.

3 Ecological modernization

The link, but also the overlap between environmental education (EE) and education for sustainable development (ESD) has resulted in ample discussion. Some concerns are about the hidden incompatibility of sustainability and development in the term sustainable development. Such hidden incompatibility may impede the growth of countries that are developing (Sachs, 1997). In the world modernization process, it is becoming increasingly impossible for the natural environment to satisfy the demands of mankind. There is persistent inquiry and debate in both academic and policy circles on how to handle scientifically the tension between economic development and environmental degradation. As some authors have pointed out, the core story-line of sustainable development begins with the recognition that the legitimate development aspirations of the world's peoples can not be met by all countries following the growth path already taken by the industrialized countries, for such action would overload the world's ecosystems (Dryzek, 1997). From the Brundtland report *Our Common Future* (WCED, 1987), the following key statements are acknowledged: it is futile and it is an insult to the poor to tell them that they must remain in poverty to protect the environment; the development of knowledge and technology can enhance the carrying capacity of the resource bases; it is possible to reconcile concern for the environment with economic growth (Langhelle, 2000).

Since the 1970s, most industrial countries have aimed at environmental reform and ecological transformation to overcome the environmental crisis. Many typologies of sustainable development have been developed (Baker, Kousis, Richardson, & Young, 1997; Daly, 1996; Dobson, 1996, 1999; McManus, 1996; Pearce, 1993; Turner, 1993). As a reaction to the radical environmental movement of the 1970s, since the 1980s the concept of ecological modernization has been developed by a group of German and Dutch social scientists (Andersen & Massa, 2000; Hajer, 1995; Spaargaren, 1997). This concept denied the validity of the assumptions underlying the pollution control strategies of the 1970s that were based on end-of pipe technologies and resulted in problem displacement rather than problem solving (Weale, 1992, cited in Langhelle, 2000). Arguably, the Brundtland report is seen as the first and foremost expression of ecological modernization and therefore also as a link between ecological modernization and sustainable development (Hajer, 1995; Weale, 1992). Ecological modernization is an attempt to interpret the nature and dynamics of ecological transformation processes that took place in western industrialized countries, such as Germany and the Netherlands. Ecological modernization challenges the assumption of a zero-sum trade-off between economic prosperity and environmental concern (Weale, 1992, cited in Langhelle, 2000). Instead, ecological modernization theory posits that there are core mechanisms by which eco-oriented industrial technology innovation is encouraged by the market-driven economy and market forces are directed towards environmental reform under influence of governmental regulations, NGOs and consumer pressure (Gouldson & Murphy, 1997; Jänicke, Monch, Mol, 1995; Ranneberg, & Simonis, 1989; Simonis, 1989).

Essentially, ecological modernization and sustainable development are both political concepts. Although the two concepts share similarities in some of their key statements, they also show crucial differences in their implications for environmental policy, in terms of scope, goals, and level of ambition of institutional changes (see details in Langhelle, 2000). Ecological modernization is a concept as contested as sustainable development. In our research focus, we do not intend to either prove or disprove the validity of ecological modernization. To evaluate the arguments of proponents and critics for both concepts goes beyond our research scope. The purpose of introducing the concept of ecological modernization is that it illustrates experiences of environmental transformations in industrialized countries such as the Netherlands and Germany. In general, the core mechanisms captured by ecological modernization imply a positive view on the market potential of global environmental needs, when combined with the market logic of modernization and technological innovation (Jänicke, 2008). A major critique that ecological modernization received is that it is not applicable outside its original countries (Fisher, 2001). Research shows, however, that at least part of the processes outlined in this theory are also observable in other countries around the world (Mol & Sonnenfeld, 2000).

China, confronted with accumulating environmental challenges and with lasting economic growth, has a growing concern to have a rational re-evaluation of the relationship between mankind and natural environment that appreciates a harmonious coexistence of humankind and nature. The notion of ecological modernization has been well recognized by Chinese academia and policy circles, as is testified by a report of the Chinese Academy of Sciences (CAS) (China Centre for Modernization Research, 2007). The CAS report categorized three pathways towards ecological modernization are defined for countries which are at different stages of modernization in their economic development. Zhang, Mol, and Sonnenfeld (2007) referred to the CAS report and summarized the three pathways in English. The *comprehensive ecological modernization path* applies to highly developed countries where ecological modernization takes place through dematerialization and ecological rationalities. The *integrated ecological modernization path (also named the Canal strategy)* applies to developmental countries that take a short cut by giving focus to accelerating greening industrialization and economy towards a knowledge society. The *modification classical modernization path* is relevant for developing countries that are undergoing conventional industrialization and urbanization, but modifies these processes according to ecological conditionality. The CAS report observes that around 1998 China has taken off for the canal strategy, as is evident from several key political documents. Zhang et al. (2007) also observe that the attention of the Chinese academic circle for ecological modernization is largely caused by the fact that it gets along well with a set of concepts that are currently highly promoted in Chinese policy discourses, including harmonious society, green Gross Domestic Product, circular economy, reducing energy and emission, and scientific development concepts. Acknowledging this political background in China is elemental before undertaking the design of the scenario, in the sense that the position on environmental reform taken in the scenario design should correspond with current environmental policy discourses.

Design criterion 1

In the scenario, the selected environmental topics should be in correspondence with the current political discourses in China for enabling the implementation, should include both aspects of ecological sustainability and economic development of the country, and should give a role to market logic and technological innovation.

4 Environmental literacy

As Roth (1992) explained, we are still relatively vague about what it is we are trying to accomplish with environmental education. To form an environmentally literate citizenry is the ultimate goal of environmental education (Disinger & Roth, 1992; Hungerford and Peyton, 1976; Roth, 1992; UNESCO, 1980). Environmental literacy is related to the goals and evaluations of environmental education. For the scenario design, the concept of environmental literacy provides support in planning the didactic structure (Lijnse & Klaassen, 2004) and evaluating the scenario. Various researchers in the field of environmental education have defined and operationalized 'environmental literacy', so that it can be used in clarifying the critical steps in education, especially the goals and objectives related to planning and assessment of programs in environmental education (Disinger & Roth, 1992; Hungerford, Peyton, & Wilke, 1980; McBeth & Volk, 2010; Roth, 1992; Simmons,1995; Wilke, 1995).

As is acknowledged in the literature on the concept of environmental literacy, a universally accepted definition of environmental literacy is still lacking. Roth's initial effort in the late 1960s is identified as the earliest emergence of the notion of environmental literacy (Chu et al., 2007; Disinger & Roth, 1992; Hsu & Roth, 1999; McBeth & Volk, 2010; Swanepoel, 2002). The definition provided by Roth in 1992 is widely accepted: environmental literacy involves human discourse about inter-relationships with the environment, and it is considered as our capacity to perceive and interpret the relative health of environmental systems and take appropriate actions to maintain, restore, or improve the health of those systems (Roth, 1992). The concept of environmental literacy has also been linked with sustainable development. In 1989, UNESCO-UNEP offered the following conceptualization of environmental literacy: a basic functional education for all people, which provides them with the elementary knowledge, skills and motives to cope with environmental needs and contribute to sustainable development. Core issues in environmental literacy are the interrelationships between natural and social systems; the unity of humankind with nature; technology and the making of choices; and developmental learning throughout the human life cycle (Roth, 1992).

For the scenario design, the concept of environmental literacy provides insightful perspectives to be considered in planning the didactical structure. The Tbilisi document (UNESCO-UNEP, 1978) recognizes an environmentally literate person as one who has an awareness of and sensitivity to the total environment, a variety of experience in and a basic understanding of environmentally associated problems, acquired a set of values and feelings of concern for the environment and the motivation for active participation in environmental improvement and protection, acquired the skills for identifying and solving environmental problems, and opportunities to be actively involved at all levels, and is working toward resolution of environmental problems. In order to address such concerns in the design of the scenario for primary school students, the didactical structure should provide the students with opportunities to get involved in environmental problems for acquiring experience in and a basic understanding of the problems, and provide them with opportunities to learn and exercise skills of identifying and solving the problems, in order to develop the students' concern and their motivation for participating in environmental improvement.

The environmental literacy framework of Roth (1992) also helps operationalizing the critical steps in measuring the learning outcomes of the programs in environmental education. Environmental literacy draws upon four strands of learning outcomes: knowledge, skills, affect (in the areas of environmental sensitivity, attitudes, and values) and behavior (in the areas of personal investment, responsibility and active involvement). The four strands reflect the Tbilisi declaration of environmental education goals, i.e. awareness, knowledge, attitude, skill, and participation. Moreover, the concept of environmental literacy is not binary (either you are literate or you are not), but it represents a continuum from a zero competency to a very high competency that has been categorized into nominal, functional, and operational level (or degree) of environmental literacy. The four strands described in each of the three environmental literacy levels provide an adequate framework for assessing environmental education programs that aim at fostering environmental literacy. In the design study, the premise is to design and implement the scenario in a real school context in China for the purpose of building the students' environmental literacy, encompassing knowledge, skill, affect and behavior (self-reported and observable). How the framework of environmental literacy is used in developing the evaluation instruments is elaborated in detail in Chapter 12.

Design criterion 2

In the scenario, the desired learning outcomes are aiming to foster environmental literacy in knowledge, skills, affect and behavior, and to cope with the interrelationships between natural and social systems in making choices contributing to sustainable development.

5 Inquiry-based learning and the problem posing approach

Inquiry-based learning and the problem posing approach can be considered as applications of a constructivist perspective in teaching and learning approaches. Inquiry based learning usually implies that the teacher presents a puzzling event in the form of a question or problem, and the students formulate hypotheses to explain the event or to solve the problem, collect data to test the hypotheses, draw conclusions and reflect on the entire process (Lashley, Matczyniski, & Rowley, 2002). Different levels of inquiry-based learning can be categorized by the phases where the students enter the inquiry, i.e. in the question phase, in the inquiry procedure, and in the solution phase (Banchi & Bell, 2008). The concern of the problem posing approach is to focus on evoking motivation when the students enter into an inquiry; students should be provided with a sense of purpose from the learning activities (Klaassen, 1995). The problem posing approach begins with students' already available motives, knowledge, and questions to induce a need, a want for extending their knowledge along a structured sequence of learning activities, so that they themselves come to pose a main problem that they intend to work on, and see the purpose and direction of where the study will lead them to.

5.1 Inquiry-based learning

Inquiry based learning emphasizes that education begins with the natural curiosity of the learner. As Dewey reminded, the importance of inquiry based learning is that students take ownership of the learning process, rather than being presented with ready-made knowledge or subject matter of facts and laws (Dewey, 1997). We could also see that inquiry based learning reflects Piaget's psychological constructivism that highly values learners' own reflection, Vygotsky's social constructivism which further emphasizes the role of the social context and the social interaction in learning, and Freire's critical pedagogical practice that concerns democracy through a dialogue between teacher and learners. We can say that students' active learning is at the core of inquiry-based learning, therefore in assessment, progress is measured by the extent to which students develop their competences rather than by how much knowledge they acquired.

Since Dewey described a basic inquiry format in 1910, many adaptations have been made, but inquiry-based learning usually implies that the teacher presents a puzzling event in the form of question or problem, and the students formulate hypotheses to explain the event or solve the problem, collect data to test the hypotheses, draw conclusions and reflect on the entire process (Lashley et al., 2002). However, such understanding is not sufficient when one uses inquiry-based learning in designing a teaching-learning activity. The question is from where, or to what extent students should conduct their inquiry for themselves. Based on the earlier work of Schwab (1962) and Herron (1971), Banchi and Bell (2008) presented a four-level continuum in classifying the levels of inquiry in teaching-learning activities. The first level is *the confirmation inquiry*, in which students confirm an idea or a principle by following a teacher-prescribed procedure resulting in outcomes that are known in advance. With a confirmation inquiry, the students are provided with the question and procedure, e.g. the method and the results. It is suitable when the goal is to reinforce an idea, to experience conducting investigations according to the confirmed procedures, or to practice an inquiry skill, such as collecting or recording data. The second level is *the structured inquiry*, in which students investigate a teacher-presented question through a teacher-prescribed procedure to generate their own explanation supported by the evidence they collect. The confirmation and structured inquiry are both considered lower-level inquiries, but they are important since they support students to gradually grow with their abilities to conduct more open ended inquiry. At the third level, *the guided inquiry*, students investigate a teacher-presented question using student-designed or -selected procedures to collect evidence and generate their own explanation. The guided inquiry is most successful when students had sufficient opportunities to learn and practice the skills needed such as to plan experiments, and to collect data. At the fourth level, the highest level of inquiry, *the open inquiry*, students investigate questions that are student-formulated through student-designed or -selected procedures to generate their own explanation supported by the evidence they collect. With open inquiry, students have full opportunities for scientist-like inquiry, from deriving questions, designing and carrying out investigations, up to communicating their results and drawing conclusions. It is only appropriate for students to conduct open inquiries once they have demonstrated the required investigative abilities, e.g. collecting and analyzing data, and drawing conclusions.

For environmental education in China, inquiry-based learning is highly promoted in the landmark curriculum document, the '*National Environmental Education Guideline' (the Guideline)* (MoE, 2003b). As defined in the Guideline, the inquiry process includes the following five steps.

Step 1: *Students identify and propose a problem independently or with the guidance of the teacher.*

Step 2: *Students discuss what they know about the problem, and what information is further needed to solve the problem.*

Step 3: *Students collect data from all possible sources, such as library, mass media, internet, experts, officials, NGO members, excursions, interviews, samples of water, plant, soil, daily items, etc.*

Step 4: *Students propose various plans for solving the problem, and evaluate the feasibility of the plans and make a choice.*

Step 5: *Students carry out the plan, are solving the problem, assess and adjust the plan if needed.*

In reference to the inquiry continuum (Banchi & Bell, 2008), inquiry-based learning as recommended by China's '*National Environmental Education Guideline*' is at a relatively higher level, between guided inquiry and open inquiry, since the students derive questions/propose problems either on their own or under the guidance of the teacher, and the students are provided with full opportunities to conduct investigations and to draw conclusions. Banchi and Bell (2008) suggest that in a single curriculum unit, students can be introduced to experience multiple levels of inquiry. For students in the 4^{th} or 5^{th} grade, it is expected they will be able to successfully conduct open inquiries based on their experiences with the first three levels of inquiry.

5.2 The problem posing approach

The problem posing approach is a content-specific didactical strategy frequently adopted in science education design studies at the Freudenthal Institute, for instance in the work of Klaassen (1995), Vollebregt (1998), Kortland (2001), and Westra (2008). The problem posing approach emphasizes that in science learning processes, students draw on their available conceptual resources, experiential base and belief system, and are extending them. When students enter into science terms and theories, it is essential to provide them with a motive, a sense of purpose and direction to extend those. They should always know what they are doing, why they are doing it, and how they are going to proceed, if they are expected to engage meaningfully in the learning processes (Klaassen, 1995; Lijnse & Klaassen, 2004).

The problem posing approach is introduced from a reflection on Donald Davidson's (1980) theory on the relation between mind and body, and also refers to constructivist views and Freudenthal's (1991) view of mathematics education (Klaassen, 1995; Lijnse & Klaassen, 2004). Klaassen (1995) introduced the problem posing approach from a reflection on Davidson's (1980) theory on the relation between mind and body, which basically states that mental concepts cannot be reduced to physical concepts, because of normative characteristics of descriptions in mental terms such as belief, desire and intentional action, and should be understood as non-lawlike, failing to fall under strict laws. Anchored to Davidson, Klaassen inferred that in science learning interpersonal knowledge acquisition cannot do without mental concepts, and our ways of understanding human thought and action are essential to the understanding of science. From this concern, the emphasis of the problem posing approach is on bringing students in such a position that they come to see for themselves the point of extending their existing conceptual knowledge, experiences, and belief system in a certain direction. The problem posing approach is in correspondence to Freudenthal's (1991) view suggesting that mathematics teaching should guide students in 'scientificalizing' their world in a process of guided reinvention, rather than transferring scientific knowledge to them as a ready-made product (Lijnse & Klaassen, 2004). The problem posing approach also draws on constructivism view by suggesting that teaching-learning practices should allow students the freedom to use and make their constructions explicit, by finding a balance between the 'freedom from below' and the 'guidance from above' (Lijnse & Klaassen, 2004).

As Klaassen (1995) reminded, the point of the problem posing approach is not that everything should come out of the pupils themselves. The 'freedom from below' means a problem posing teaching-learning process should start with students' already available motives and knowledge, and questions them to induce a need, a want to extend their knowledge by participating in a sequence of learning and teaching activities. The 'guidance from above' is provided by the teacher and the teaching materials which provide students with a structured sequence of learning activities. As Klaassen (1995) stated, in a traditional setting the teaching materials usually consists of a textbook, in which the students are supposed to follow the main story line presented by the authors. In the problem posing approach the teaching material consists of a collection of tasks with the purpose of helping students composing their own story. The teacher's role in the problem posing approach is to guide from below (students' own motives, knowledge, and question) instead of explaining from above (the story line in textbooks) as in a traditional setting.

According to Klaassen (1995), the problem posing approach does not assume that students stand ready to absorb new knowledge; rather, students are viewed as rational agents. This is to say there is no existing need of students to learn a particular content that one intends to make them learn, if only because they do not yet know the particular content. It is therefore suggested that in the problem posing approach, we need to introduce students to such a need when involving them in a sequence of proceeding activities. It begins with connecting the desired learning outcome with students' existing interests, by providing them with a 'global motive' to begin with, bringing them in a position that they themselves come to pose a main problem that they intend to work on, and see the purpose and direction of where the study will lead them. In a sequence of structured teaching-learning activities, the role of 'global motive' is to enable students to perceive their learning process as internally coherent with a certain direction driven by their own questions. In three studies by Kortland (2001), Vollebregt (1998), and Westbroek (2005), the 'global motive' is expressed as a general steering question to be answered after the completion of learning and teaching. In a sequence of structured teaching-learning activities, the 'global motive' is connected with a series of 'local motives' in every stage of the subsequent learning processes to locally involve students in the preceding learning activities.

As argued by Lijnse and Klaassen (2004), planning a problem posing approach is to provide a structured teaching sequence, a sequence of tasks and teacher interventions in relation to students' reactions. Such a sequence is developed in a design study (see chapter 7), in which a scenario and corresponding teaching-learning materials are designed. A scenario is considered as a hypothetical domain-specific 'didactical theory' that predicts and theoretically justifies in detail the teaching-learning process as it is expected to take place, and why it is expected to happen in that why. After being tested and revised, the final scenario presents an inter-related conceptual and content-specific motivational pathway, including the main steps and tasks to be performed by teacher and students, and is called a 'didactical structure'. The development of a scenario is not just done intuitively, but asks for a mixture of didactical analysis, intuition, the teaching content, the connection between teaching activities, the role of teachers, the possible interpretation of students, as well as theoretical heuristics and reflections (Lijnse & Klaassen, 2004). In selecting a problem, Billett (1996) suggests to start with a routine problem from everyday practices embedded in the context where knowledge is sourced. Next, by engagement in learning processes the learners are expected to put an effort in on non-routine problems that they consider valuable to explore.

For planning a problem posing approach in a design study, Lijnse and Klaassen (2004) identified six phases, and Kortland (2001) proposed five interrelated teaching-learning activities as useful ways of structuring a problem posing approach for environmental topics.

Motivation

Phase 1: orienting and evoking a global interest in and motive for a study of the topic at hand.

Question

Phase 2: narrowing down this global motive to a content-specific need for more knowledge.

Investigation

Phase 3: extending the students' existing knowledge, in view of the global motive and the more specifically formulated need for knowledge.

Application

Phase 4: applying this knowledge in situations that the knowledge was extended for.

Reflection

Phase 5: creating, by reflecting on the developed knowledge (or in viewing of the global motive), a need for a theoretical orientation (or a reflection on the skill involved).

Phase 6: developing within this orientation further theoretical knowledge (or developing a still contextualized metacognitive tool for an improved performance of this skill).

These phases of planning a problem-posing approach will be dealt with more extensively in chapter 12 where the development of the scenario is described.

5.3 The choice of teaching-learning approach

As we can summarize from the reviews above, inquiry-based learning and the problem posing approach share commonalities in several fundamental aspects. Both approaches initiate the teaching-learning process from the student's natural curiosity, existing motives and knowledge; both approaches are grounded in the educational view that students should take an active role in learning rather than being presented with ready-made products; both highly value students' mental reflection throughout the entire learning process; both suggest a teacher's role of guidance in respect of students' already existing knowledge and curiosity. In terms of the design study method we chose, the problem posing approach provided a more reasoned systematic view on carrying out the scenario design, particularly the six phases to structure the teaching-learning activities and to build our initial didactical structure in next chapter. Inquiry-based learning is fruitful as well, especially the four-level continuum gives a useful reference when designing the teaching-learning activities to identify from which particular step and to what extent students are engaged in the inquiry. In addition, being the officially recommended teaching-learning approach for environmental education in China, the inquiry-based learning has precisely suggested steps which will serve as useful tools when we design the subsequent learning and teaching processes, each consisting of a problem posing cycle.

Design criterion 3

In the scenario, the desired teaching-learning approach to support students' open inquiry on the entire learning process is the problem posing approach. The initial didactical structure should begin with students' already available motives, knowledge, and questions to induce a need and a direction in participating in a sequence of learning and teaching activities.

6 Constructivist views on learning

Constructivist views of learning focus on how people are making meaning, on their own and in interaction with others. From an educational constructivist point of view, knowledge is constructed actively by learners, in contrast to the traditional transmission model of education (Prawat & Floden, 1994). Constructivism has been developed into many versions, but with a common belief that the focus in understanding learning is not on an ontological reality, but on a constructed reality (von Glasersfeld, 1997). Our intention in this section is to learn from the core statements of variant versions that emerged in the development of constructivism, and look for key concepts and ideas to be considered in our educational design. Rather than debating the merits of each version, our attention is on their contributions to understanding and improving learning and teaching.

In education, constructivism emphasizes the learner's contribution to learning both through individual and social activities (Bruning, Schraw, & Ronning, 1999). Put another way, one way to organize constructivist views is to talk about two forms of constructivism, cognitive constructivism and social constructivism (Palinscar, 1998; Phillips, 1997) *'Cognitive or individual constructivism'* is concerned with how individuals build up certain elements of their cognitive or emotional apparatus (Philips, 1997). As one of the intellectual roots, Piaget (1937) held that individuals assimilate new knowledge into an already existing framework, and coordinate their own cognition or thoughts from their internal representations of the world, rather than from mapping external reality. *'Social constructivism'* goes a step further in the theory of learning. Vygotskian theory bridges both camps, cognitive constructivism and social constructivism, and helped to bring about a shift in constructivism away from the focus on cognitive processes in individuals to negotiation in social contexts built culturally over time (Leach & Scott, 2003). It is perhaps because of Vygotsky's pivotal role in social constructivism transition that the basic concepts of the Vygotskian School are termed interchangeably as 'social constructivism theory' or 'cultural-historical theory' (Prawat, 1996).

As a basic principle, constructivism highly values learners' autonomy and experience in representing their construction of reality (von Glasersfeld, 1997). Constructivism is also frequently related with instructions promising successful educational design. We focus on several elements from constructivist perspectives recommended for successful educational design by referring to Woolfolk (2005).

1. *Student ownership of learning:* Constructivist theories mostly agreed on putting the students' own understanding at the center of learning, instead of subordinating students to the pre-established practices (Prawat, 1992). Student ownership does not imply that teachers leave responsibility for instruction. As Jaramillo (1996) revealed, the role of teachers is that of learning facilitators forming consciousness for students and teachers themselves, and is for students the linking pin to society. Students may need the support of teachers for instance in helping them find resources, keeping track of their progress, or breaking larger problems down into smaller ones.

2. *Understanding the knowledge construction process:* Constructivist views emphasize making students aware of their own role in constructing knowledge (Cunningham, 1992). Different assumptions and different experiences lead to different knowledge. Therefore, when students are aware of what shapes their thinking, they will be more able to develop, and defend positions in a self-critical way while also respecting the positions of others. The implication for educational design is that the evaluation should show

such respect as well and enable students to develop and defend their different positions.

3. *Multiple perspectives and representation of content:* Understanding knowledge construction processes also has important application in content design. When students encounter only one way of understanding complex content, it often leads to oversimplification. In content design, resources for the class should provide for multiple perspectives and representations of a problem.

4. *Complex learning environments and authentic tasks:* Constructivists believe that students should deal with ill-structured problems in complex learning environments rather than with simplified problems, since the world beyond school presents few simple problems. In complex problems, there are multiple, interacting elements, and multiple solutions are possible. There is no one right way to reach a conclusion and each conclusion can be defended by the students themselves. Complex problems should be embedded in authentic learning tasks that students encounter when applying what they learned to the real world (Needles & Knapp, 1994, Resnick 1987). This concern is in line with situated learning theory in emphasizing that learning should be given in situations where the learning will be applied. Basically, situated learning stresses that much of what is learned is specific to the situation in which it is learned (Anderson, Reder, & Simon, 1996). Situated learning, therefore, suggests that instructors and learners should both engage in authentic activities of their culture for purposeful problem-solving (Brown, Collins, & Duguid, 1989; Collins, Brown, & Newman, 1989). Based on some empirical implications of situated learning, Brill (2001) recommended to immerse learners in an environment that approximates as closely as possible the context in which their new learning will be applied (Schell & Black, 1997), as well as to pay attention to cues, clues and tools that learners make use of from the context to successfully solve problems (Lave, 1988).

5. *Social negotiation:* Many constructivists share Vygotsky's belief that higher mental processes develop through social negotiation and interaction. Symbolic interactionalism is recognized as another expression of social constructivism (Prawat, 1996). Symbolic interactionalism has its distinctive explanation on the diversity of group members' activity in making meaning. Unlike in Vygotsky's scheme, the concern is more on a group's commonality and shared indentity framed cultural-historically. The added dimension of

symbolic interactionalism is that individuals who are engaged in shared social activities do not just internalize the socially constructed meaning, but they also further communicate about the meaning via shared activity, though not necessarily with shared values (Blumer, 1969). The question in education is how a group of individuals interactively constitutes and stabilizes meaning at the classroom level, considering that individuals within a group have their own unique perspective in getting the meaning. In other words, social negotiation or being able to coordinate one's activities with others is of central importance. To achieve this, we must define and interpret one another's actions and get meaning as a social construct in the process of interacting with each other. Therefore, collaboration in learning is recommended. As teaching is to develop students' abilities to establish and defend their own positions while respecting the positions of others, students must talk and listen to each other, working together to negotiate or co-construct meaning.

6. *Artifact-mediated learning:* Vygotsky proposed the key concept of the artifact-mediated learning process in humans. In contrast to lower mental functions, higher mental functions require mediation between stimulus and response. According to Vygotsky's scheme, mediation from social context to mind, from reality to the individual is by means of *artifacts* that are culturally and historically constructed. Vygotsky (1981) emphasized that artifacts (mediators) are symbolic, psychological tools and lie in *sign-mediated activities*, e.g. language, writings, maps, and drawings. Leontiev (1978) stressed that artifacts as *practical activity are* involved in the child's actual relations with reality. An implication for educational design is that curricula should include physical and symbolic tools, and practical activities for students to experience these tools. Meaning is shaped by the artifacts included in curricula and negotiated via interaction with others, situated in a specific social context (Jaramillo, 1996).

7. *Context as social practice:* A *'context'* is differently phrased as a situation, a social structure, a domain of knowledge, and a cognitive structure, but in the concept-context approach a 'context' is defined as a '*social practice*' (Boersma, Eijkelhof & Bulte, 2006). For our study, the concept-context approach is worth introducing as it offers concrete elaboration on selection of concepts and activities in relation to contexts, and it clarifies different conceptions of context. With this definition, the concept-context approach accepts the perspectives of activity theory and situated

learning, emphasizing that '*social practice*' is constituted by one or more cultural-historically defined activities, conceived as providing a shared need for all participants. The valuable insight we gain from this approach is that in designing a curriculum, particularly in a science domain, if we want to foster the relevance of the curriculum to students' context, we need to bring scientific concepts to students with selected appropriate social practices. Boersma et al. (2006) distinguished three types of social activity: life-world practices, professional practices, and scientific practices. For example, in daily life, people think of pure water as safe for drinking, and containing minerals for health; while in laboratory practice, pure water is a substance that does not contain any others (Boersma et al., 2006). The concept-context approach concerns the question of what is the most appropriate meaning of context (social practice) when we intend to use contexts for structuring science curricula. Here, a context (social practice) is not only a mean to improve personal relevance. It is also helpful in connecting scientific knowledge with daily life knowledge in order to promote the acquisition of scientific knowledge.

The above discussed constructivist propositions have together contributed to the development of the following design criteria:

Design criterion 4

In the scenario students should take the initiative of knowledge construction while the teacher takes the supportive role of facilitator and linking pin for students to enter in society.

Design criterion 5

In the scenario the evaluation should respect the knowledge construction process of students, and encourage students to develop and defend their own positions.

Design criterion 6

In the scenario students should be engaged in solving complex problems in which multiple perspectives, and multiple solutions and conclusions are possible.

Design criterion 7

In the scenario students should be engaged in authentic problem solving learning tasks embedded in situations that approximate as closely as possible the context where the learning is applied in the real world.

Design criterion 8

In the scenario students should collaborate in group learning activities to shape socially co-constructed meaning via communication, negotiation, and interaction.

Design criterion 9

In the scenario students should be engaged in practical activities in their actual relation to the reality, using culturally, historically constructed symbolic tools as mediators from reality to the learning activities.

Design criterion 10

In the scenario the domain specific concepts of environmental science should be introduced in relation to the selected social practices that are relevant to students' daily life experience.

It is worth noting that the propositions expressed in the criteria show remarkable agreement with our analytical instrument for ideal environmental education, developed on the basis of Stevenson (1987, 2007) (see chapter 2, section 2.1). Or put another way, the initial design criteria provide for deep theoretical reflection and support for an expected successful didactical design of environmental education. From the theoretical deliberations, the listed ten initial design criteria provide support for designing and evaluating the didactical structure and the scenario.

Chapter 12 Scenario Development

1 Introduction

As we have explained in Chapter 9, in the design study a four-lesson scenario is to be developed as school curriculum. The scenario is developed for grade 5 students and tested in case studies conducted in the cities of Golmud and Xining, Qinghai, China. The aim of the design study is to explore and justify a theory on the 'didactical structure' that is needed to attain the expected level of environmental literacy. In this structure, special attention is paid to reducing the rhetoric-practice gap within the Chinese curriculum system. The scenario presents and explains a conceptual and motivational pathway, including steps and tasks that lead toward environmental literacy. In this chapter, we describe the intended scenario, the formalization from the intended scenario, and the potentially implemented scenario. In presenting the intended scenario, we explain the three basic issues of our educational view on the design of the scenario, namely, the theoretical assumptions on the curriculum elements in the ideal environmental education presented in Chapter 2. In doing so, we take care of the coherence among the elements; the design criteria established in Chapter 11; and the need for improvement revealed by the rhetoric-practice gap. Based on these three theoretical and practical concerns, several basic issues are deliberately discussed, such as the selection of a study issue and the key concepts applied in the design. The formalization of the educational view into a potentially implemented product is elaborated in the five phases of the problem posing approach, i.e. motivation, question, investigation, application, and reflection. In each of the phases, we explain how our educational view is elaborated in the scenario. Finally, the potentially implemented scenario, i.e. the final product, is presented.

2 Intended scenario: the ideal educational view

The scenario is developed on the basis of the theoretical assumptions on curriculum elements, suggesting an ideal form of the environmental education curriculum; the design criteria generated theoretically; and the improvements needed to overcome the obstacles creating the rhetoric-practice gap. In addition to the design of each individual curriculum element, a robust scenario design also implies that curriculum elements are coherent with each other (Mckenney et al., 2006). Therefore, in the design of the scenario attention is paid to the balance and linkages among the curriculum elements.

2.1 Rationale

In reference to the theoretical assumptions, a curriculum rationale is to consider the disciplinarity, the problem focus, the study issue, and the conclusion/solution. To define the rationale of our scenario, we have to select a study issue that is problematic and uncertain about conclusions/solutions, in line with design criterion 6. The study issue focuses on a real, practical, specific environmental problem, conform the design criteria 7 and 9. The study issue can embrace environmental, social and economic aspects of the problem, so that different disciplines may contribute, as indicated in design criterion 1. We also take in account the problems identified in current teaching practices in China. As pointed out by the interviewed environmental educationalists, in line with the on-going curriculum reform, environmental education should reorient itself toward economic and social dimensions, toward a reflection on environmental problem in relation to our lifestyle, as a change from the traditional practices that have focused too narrowly on the natural environmental dimension, on transition of content knowledge of environmental protection, and solutions from science and technology. In respect to criterion 1, the selected study issue should be in correspondence with the current political discourses in China, namely to include both ecological and economic aspects and give a role to market logic and technological innovation. In line with this criterion, we selected the policy of circular economy to underline the study issue, since the policy affirms the notion of ecological modernization and is applied in Qinghai province where we implement our scenario. The policy of circular economy is introduced later in section 2.9. To meet our educational view in reference to the assumptions and the criteria, the selected study issue is solid waste management. Solid waste management is a specific issue and involves students' practice in real life. Solid waste management is problematic in China. Because of this complexity, it has not yet reached a certain solution or conclusion. There are environmental, social, and economic interests involved in solid waste management, so that the scenario will be built from knowledge of various disciplines. Solid waste management is a life-world practice under the circular economy policy. And lastly, as criterion 10 indicates, solid waste management is a life-world practice that has a cultural-historical meaning in China's society. With its relevance to daily life, solid waste management provides an ideal entry to promote students' acquisition of scientific knowledge. The key concepts of solid waste management, i.e. material flow and the 3R principle are discussed in section 2.10; in section 2.11 we elaborate on solid waste management in China.

2.2 Goal

According to the assumption, ideally environmental education is geared to immediate use for a sustainable and emancipated quality of life. In environmental education, knowledge is not merely directed toward action, but rather serves to prepare for inquiry and then taking action in exerting influence on the environment. As also affirmed in design criterion 2, in the design of the scenario, the desired learning outcomes are aimed to foster environmental literacy in terms of knowledge, skills, affect and behavior, to cope with the interrelationships between natural and social systems in making choices contributing to sustainable development. At the core of environmental literacy are the interrelationships between natural and social systems; the unity of humankind with nature; technology and the making of choices; and developmental learning throughout the human life cycle (Roth, 1992). In line with this essential concept of environmental literacy, the human-nature interaction underpins the design of the scenario and is explained in section 2.13.

2.3 Content

According to the assumption, the content of environment education is ideally retrieved from complex and contradicting information resources. The content is very relevant for solving real life-world problems. And most importantly, content arises when students are involved in the environmental problem inquiry so that knowledge is developed actively by students rather than passively passed over. In criterion 4 it is assumed that students can take the initiative in knowledge construction. With the selected complex and uncertain study issue of solid waste management, it is necessary that the content of the scenario is built from multiple perspectives concerning contradicting environmental and socioeconomic interests involved in the issue. As in respect to criterion 3, the scenario adopts a problem posing approach to support students' open inquiry on the environmental problem, which begins with revealing students' prior motives, knowledge, and questions to induce a need and direction in proceeding along the inquiry.

2.4 Process

According to the assumption, the teaching and learning process in environmental education should encourage student's cooperation, active participation, and engagement in dealing with environmental problems. Design criterion 8 also recommended cooperative learning to shape socially co-constructed meaning via communication, negotiation, and interaction. The design of the scenario, working in groups, is conducted in students' learning process. Criteria 3, 6, 7 and 9 confirmed students' engagement and participation in inquiry into environmental problems. Particularly, criterion 9 suggests using cultural-historically constructed symbolic tools to mediate from environmental problems in reality to teaching and learning activities. As indicated in the design of the scenario, we use pictorial devices, such as photos and diagrams to illustrate the elements of the life cycle of solid waste. The analysis of the life cycle is described in more detail in section 2.12.

As stated in criterion 3, the problem posing approach is adopted to structure the teaching and learning process. To support students' open inquiry into authentic environmental problems, we considered first to engage the students into the problem inquiry throughout the entire learning process, namely from finding the problem, inquiring about the problem, solving the problem, up to proposing actions. As we identified in chapter 6, the behavioral strategy is largely adopted in current teaching practices in environmental education, in which the students were too quickly ordered to make behavioral choices without guiding them to understand fully why these would be worthwhile. Keeping this in mind, in the design of the scenario, the teaching and learning process is initiated by considering students' prior observations or experiences of environmental problems that they found unpleasant and wished to resolve. A need is therefore induced in the students to explore along a sequence of activities planned for them to answer the questions proposed by themselves. As Lijnse and Klaassen (2004) pointed out, in the design of the scenario, we should be careful to keep a balance between the 'freedom from below' and the 'guidance from above'. In our scenario the problem posing approach is set up in such a way that everything should come out of the students themselves. It allows students the freedom to make their own construction so that the teaching-learning process begins with students' prior motives to solve the environmental problems related to solid waste management for their own good. In the scenario a structured sequence of learning activities is provided by the teacher to find answers for the students' own questions. The environmental problems that the students want to solve serve as the 'global motive', by which the students see the reason and the direction of why they proceed with the learning tasks. The tasks are planned to address students' questions aimed to understand and solve the environmental problem, therefore evoke a series of 'local motives' in every stage of the teaching and learning process to involve students in the preceding activities. In section

3 we will explain how these intentions have been formalized into the five phases in the problem posing approach.

2.5 Teacher

According to our assumptions, in environmental education, teachers should be amenable to students' autonomous decisions, although teachers are agents with their own view and ideology about education to make their decisions on curriculum and pedagogy. Design criterion 4 also approves that the teacher takes the role of facilitator and linking pin for the students to society to allow students to enter in the zone of proximal development. According to criterion 3, in the scenario, the 'guidance from above' is provided by the teacher, namely, a structured sequence of learning activities. Essentially, in the problem posing approach the teacher's role is guiding from 'below' in respect to the students' own motives, knowledge, and questions, instead of providing a story line in the scenario which the students are supposed to follow, as we observed in current teaching practices implemented in schools.

2.6 Student

According to our assumptions in environmental education, students should ideally be active and critical thinkers, and the generators of knowledge. Design criterion 4 also supports that in the design of the scenario, students should take the initiative in knowledge construction. According to criterion 3, in the scenario, the 'freedom from below' is respected in the sense that the problem posing teaching-learning process starts from students' prior motives, knowledge, and questions to induce in them a need and direction to proceed along a sequence of planned learning tasks. The tasks are planned to address students' own questions aiming to understand and solve the environmental problem found by the students themselves.

2.7 Assessment

According to the assumption, the assessment of environmental education evaluates students' learning processes, the extent to which students develop and defend their own environmental beliefs and choices, as well as their ability to act according to their own choices. Multiple actors, including the students themselves, are invited for a reflective and democratic evaluation, in which teachers' standard assessment no longer takes a major role. As affirmed in criterion 5, the evaluation should respect student's knowledge construction processes and encourage students to develop and defend their different positions. Ultimately, the scenario is aimed at fostering environmental literacy. According to criterion 2, environmental literacy provides support in planning and evaluating the learning outcomes of the scenario. To measure learning outcomes, Roth (1992) operationalized the four strands, i.e. knowledge, skills, affect (in the areas of environmental sensitivity, attitudes, and values) and behavior (in the areas of personal investment, responsibility and active involvement). Specifically, the scenario for primary school students aims to involve students in the environmental problem inquiry for gaining experience and basic understanding of the problems, and to learn and exercise skills for identifying and solving problems, in order to develop the students' concern and motivation to participate in environmental improvement.

Nevertheless, it is crucial to consider how to make the targeted learning outcomes of the scenario realistic in the current setting of educational assessment. As we found in chapter 6, section 8, environmental education when implemented in schools was assessed rather in line with the theoretical assumptions during the classes, but in the final exam, a top-down administrative standard evaluation , which does an end-of-pipe check of the completion of teaching tasks, dominates. Under such administrative pressure, we need to consider how the design of the scenario may survive with the targeted environmental literacy. Fullan (2006) and Fullan and Hargreaves (2012) propose to link educational change with teachers' professional development in turning it to teachers' advantage, by taking into account the teacher's purposes, the teacher as a person, the real world context in which the teacher works, and the culture of collegiality. In the design of the scenario we pay particular attention to motivating the participant teachers by connecting with their need for professional improvement.

2.8 Circular economy

In respect to criterion 1, for enabling the implementation of the scenario, the selection of the environmental topic should be in correspondence with the current political discourses in China. We decided on the policy of circular economy to underpin the study issue, because this policy is applied in the Province of Qinghai where we implemented the scenario, and it affirms the notion of ecological modernization. Ren (2007); Ren, Chen, and Feng (2005); Ren and Zhou (2009) provided a comprehensive introduction of circular economy policy in China. Borrowing from Ren's work, we can clarify that circular economy is to solve environmental and resource problems through restructuring *material flows* between the ecosystem and the socioeconomic system into a balanced state. The concept of circular economy was introduced and has been discussed since the end of the 1990s, and has become a central issue in the policy of the Chinese government, with the Circular Economy Law enacted in 2008. The policy of circular economy is a response to the situation of severe shortages of natural resources and environmental pollution as negative impacts of the dramatic Gross Domestic Product oriented economic development in China. Circular economy can be considered as a practice of the shifted governance philosophy about the country's developmental pattern. Circular economy internalizes the environment as an internal factor in economic growth. In other words, the supply-demand material exchange balance is taken into account to understand economic growth from an angle of eco-efficiency. The balanced material exchange between the ecosystem and the socioeconomic system is controlled by keeping the demands of socioeconomic activities within the supply capacity of the ecosystem, and keeping the pollution from the socioeconomic activities within the self-cleaning capacity of the ecosystem. Compared to the waste-based focus that used to prevail in circular economy-approaches in industrialized countries, in China's practice of circular economy, both production and consumption are critical. Cleaner production, eco-industrial parks and waste management in consumption are central to this circular economy practice. In the Province of Qinghai, a pilot project for an eco-industrial park was established in 2010 by the National Development and Reform Commission of China (NDRC) (2010). Circular economy can open a good dialogue with local administrations and gain sufficient support when we need to carry out our scenario for environmental education in the schools of the Province of Qinghai.

2.9 Material flow and the 3R principle

As introduced by Heck (2006) and Ren (2007), restructuring the material flow is the basis of circular economy. Material flow has two directions i.e. resources flow from the ecosystem to the socioeconomic system, and the waste flows along an opposite route. The effective circular economy is to restructure a linear route of material flow to a circular route, namely, from the resource to the product and to waste (a linear route), and then further turn it into new resources (a circular route). In the meantime, the efficiency of resource utilization is increased and the intensity of the pollution is reduced. The 3R principle i.e. reduce, reuse, and recycle is important in guiding the practice of circular economy. Reduction is for saving resources both in production and in consumption. Reuse is to comprehensively utilize the remaining function of the used products. And recycle is to reprocess the discarded materials into new resources or products. The 3R principle may be new for some Chinese people, although the practices have existed for a long time in society, saving, reusing refillable beverage containers, and scrap selling. In applying the 3R principle into practice, the suggested methods are to conduct material flow analysis or life cycle analysis to guide decision making at the product level (Cunningham & Cunningham, 2008; Heck, 2006; Ren, 2007). The four-lesson scenario is designed for the students to complete a life cycle analysis of solid waste and ultimately attain their understanding of the value and the benefits of the 3R principles in keeping the material flow balanced.

2.10 Solid waste management in China (Golmud and Xining)

Solid waste management is the study issue selected for the scenario, considering that it is an unavoidable issue in applying the 3R principle, and that every student is involved in it in daily life. In schools, textbooks, notebooks, etc. cause the major waste of paper. Therefore, the notebook that all students use and dispose of every day is the product selected for the students to study the material flow to reach their understanding of the 3R principle. An investigation was conducted to have a description of the material flow of paper in the cities of Golmud and Xining, where our participant students reside. In the investigation, basically, the author visited stationary shops, landfills, scrap purchase stations, the garbage transfer station, and interviewed people involved in every stage, i.e. shop owners, landfill workers, scrap purchasers, curbside waste pickers, drivers of garbage trucks, cleaning workers, and the administrators of the Municipal Bureau of City Administration (MBCA), the charging agency for the city's waste management.

The author followed and observed the waste flow in Xining and Golmud with the question of where paper waste goes. When students finish using their notebooks, the disposal methods are various. Students may throw it in garbage bins (inside or outside of the school campus), tear it up and litter the ground, throw it in open dumps, or collect it at home and sell it to a scrap purchaser. It needs to be noted here that street garbage bins in the two cities have two openings, one for recyclable and one for non-recyclable waste, but inside the bins, everything is mixed up together. Littered paper is dumped into garbage bins by cleaners and mixed there with all possible types of trash. The garbage bins are emptied several times a day by the cleaning workers and moved by the city garbage truck to the transfer stations and then moved on to landfills. However, the paper waste can be picked up from the ground, from the unregulated open dumps, and from the garbage bins by people who spend their days searching and sorting the garbage, with only the protection of gloves, for recyclable materials, such as paper, paper board, and PET bottles, to cover their living expenses with the sale of scrap. Sometimes, the cleaning workers even join in this curbside pick-up while doing their cleaning work, to add extra income to their low wages. The retrieved paper waste from curbside pickups and from household collections is sold to scrap purchasers, who run scrap stations, from where the paper waste is sold to recycling companies and becomes a resource for making recycled paper products. When paper waste is thrown into open dumps (only in remote area of the cities), if it is not picked up by scrap pickers, it is left in piles exposed to the air and vermin, and sometimes in smoldering fires for rather a long period of time, until it is cleaned up and transported to landfills or burned in the open air. So, the paper waste flow ends up in landfills or in open burning, or is turned into recycled paper products.

Introduced by the administrators of MBCA of the two cities, the author's visits of the sites were approved; the landfills are all regulated sanitary landfills, located on carefully selected geological foundations, with methane removal standpipes, drainage systems, and an impermeable plastic liner bottom layer enclosing the storage area. Golmud, a city constructed in the middle of a depopulated desert has not yet been confronted with the pressure of running out of landfill space, but in Xining, the capital city of Qinghai, the household solid waste landfill is already running beyond its designed storage load. Before our visits in 2009 and 2010, the landfill methane was vented into the air or flared on the site to avoid dangerous accumulation, but both cities have planned to collect the methane as fuel for the generation of electricity in the foreseeable future. Besides the population of curbside scrap pickers, there are people in both of the cities living on scrap recovery from the landfills where hazardous and toxic materials are crushed and dispersed in tons of mixed garbage. Mostly women, even with their young children, spend every day searching, sorting and carrying the recyclable waste materials from the landfills under poorly protected conditions: simply a cotton mask, a pair of plastic or cotton gloves and a hat for sun or rain. The health risk for the scrap picking population (both curbside pickers and the landfill pickers) is severe. As the administrators of MBCA admitted, in China the scrap pickers are the main force of recycling waste material, a rather grim characteristic of China's solid waste management.

2.11 Life cycle analysis

In the scenario, the main story line is to engage the students in doing a life cycle analysis of the notebook. The students are to understand their role in the material flow by looking at the life cycle of the notebooks they buy, use, and discard in everyday life. With the life cycle analysis, as adapted from Cunningham and Cunningham (2009), the students are to explore issues of five dimensions, addressed in four lessons:

Lesson 1: Where is it coming from? (Its major materials, original source materials, the distance the materials were transported, the business and the stakeholders involved.)

Where is it disposed to? (Its disposal choices, and followed up final results, its reused, recycled products, the business and the stakeholders involved.)

Lesson 2: What are the socioeconomic and environmental impacts? (Energy need, caused pollution, consumed resources, aesthetic loss, health risk to the people involved.)

Lesson 3: What can we do to reduce the unwanted environmental impacts? (Reduce, reuse, and recycle)

Lesson 4: How are other stationery items related with environmental quality? (Applying the 3R principle to analyze the material flow of items other than notebooks and make environmentally friendly choices.)

2.12 Human-environment interaction via commodities

According to design criterion 2 the essence of environmental literacy is to cope with the interrelationships between natural and social systems in making choices contributing to sustainable development. The explorative study on the rhetoric-practice gap in China also revealed a trend in the on-going curriculum reform that environmental education is in a reorientation toward economic and social dimensions, and toward a reflection on environmental problems in relation to our life style, unlike its traditional focus on narrow natural environmental dimension and on science and technology solutions. Kortland (2001) developed a framework as a starting point for investigating the man-environment relationship. In the model, the environment is defined as the whole ecosystem of which man is a part. The environment is significant for man's health, security, and utility functions such as production of goods, recreation etc. Humans intervene in the environment to satisfy needs, for example the extraction of energy, addition of waste, and alteration of the landscape. The interventions may cause environmental problems of depletion, pollution, and affection cost, for instance the aesthetic loss. The negative impact is not only on the environment but also to human living quality. In this design study, the study issue is solid waste management, which is a life-world practice having cultural-historical meaning in the Chinese society. With this study issue, in the design of the scenario, we chose the utility function of the environment to human needs, namely, the commodity, to illustrate the interaction between human and environment. Inspired by Kortland's model, a conceptual framework is schemed and figured below, to design the scenario for students' inquiry into solid waste management for a particular commodity, i.e. their regular use of a notebook:

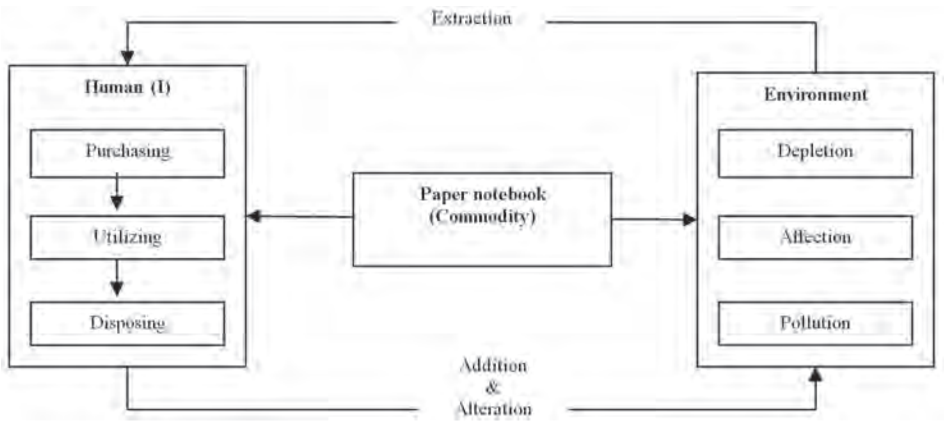


Figure 12.1: Human environment interaction via commodity

As illustrated in the figure, human needs from the environment are specified and personalized to what 'I' (the student) do with 'my' notebook. Because the student needs the notebook, the choices made in purchasing, utilizing, and disposing of it are resulting in an environmental impact. It should be noted here that humans (including me and other people) are part of the environment, therefore the environmental impact caused by 'my' choice with the notebook will in turn affect the life quality, the security, utilization, and health of not only 'myself' but also other people involved in the material flow of the notebook.

3 From intended to potentially implemented scenario: the formalization

3.1 Motivation

In the problem posing approach, most importantly, in the initiation phase, the students should be motivated by developing a sense of purpose and direction for the study topic solid waste management and the learning activities about the life cycle analysis of notebooks. As rational agents, the students are not ready to learn the 3R principle we intend them to learn, since they are not aware of it. In respect of the students' role as active knowledge generators, we begin with the students' prior motive that they want to live in a 'better environment', or in other words, they experienced environmental problems as unpleasant and unwanted. From the students' expressed experiences with these environmental problems, they are then induced by the teacher to realize that the environmental problems are all in relation to our need of commodities for our own living. Therefore, there is a 'global motive' for the students to improve their understanding about our commodities in relation to the environment, since they need and want a pleasant 'better environment'. The 'global motive' can be expressed as a general steering question of what we can do with our daily life commodities for a better environment. The notebook is exemplary for the students' regular every day consumption, and provide the students with a more specific focus, to involve them proceeding with a series of subsequent learning activities, each resulting in a 'local motive' to lead the students to see what and why they need to know more about notebooks to become able to contribute to a 'better environment'. The learning activities following 'local motives' are planned on the basis of questions raised by the students.

The learning objective in the motivation phase is that the students should be able to see the purpose of extending their knowledge about our daily commodities, with the example of the notebook, in relation to the environment.

3.2 Question

From the 'global motive' to improve their understanding about our commodities in relation to the environment, the students are invited to propose their own questions to extend their knowledge about the notebook in its relation to the environment. The students' varied questions would lead to the five directions of life cycle analysis of the notebook, i.e. resource flow, waste flow, exerted impact, choices to make, and application to other commodity items, as listed in section 2.12. In the question phase, the students are induced by the teacher to recognize that knowledge acquisition about material flow (resource flow and waste flow) and about socioeconomic and environmental impacts is necessary for making choices about the notebook, and for making the students clear that such a study (a life cycle analysis) on notebooks can be applied also to any other of our daily commodities. A series of questions formulated by the students is summarized by the teacher into the five directions of a life cycle analysis of the notebook, and addressed in the four lessons respectively. In such a way, the students are enabled to see coherently what they are going to learn in each lesson and why they are learning it. In other words, the study topic is planned bottom-up in every stage from the students' own questions, while the teacher takes a supportive role of facilitator guiding from 'above'.

The learning objective in the question phase is that the students should be able to see that their inquiry questions about the notebook in its relation to the environment are in fact making a life cycle analysis, and a sequence of learning activities is planned based on their own questions.

3.3 Investigation

In the investigation phase, the students' are involved in a sequence of learning activities planned from their proposed questions. With the motive to find answers in every learning task, the students' extended knowledge should become adequate for making choices based on the 3R principle. Under the facilitative supervision of the teacher, the students' investigation takes the form of 1) collecting information individually as homework (e.g. internet searching, interviewing and referring to books); 2) sharing information and exchanging ideas in groups in the class; 3) drawing diagrams of the material flow of the notebook in group learning, with the tool of photo cards, each representing an involved stage or stakeholder; 4) also in group learning, connecting the evoked socioeconomic and environmental impact on the material flow diagram, with the tool of photo cards, each representing a possible impact (e.g. deforestation, energy consumption, biogas, job opportunity and health risk). Particularly, there is a challenge for the students to improve their information sharing skills for collectively completing a learning task. Compared to what the students are used to do, namely, reading literally and sometimes blindly the collected information to each other, in the observed Chinese classes, applying the information to collectively achieve a learning task requires higher skills, such as evaluating the information, making selections, categorizing, summarizing in keeping in mind the information is to solve a problem. As revealed in the trials, training the students with such communicative skills is of interest for our participant teachers, because they found it beneficial for their professional improvement in teaching.

The learning objective of the investigation phase is that the students should be able to know, concerning the specific issue of the notebook, firstly, the resource flow and waste flow, with special attention to the role and place of the student her/himself in the material flow; secondly, the environmental impact caused by the notebook in terms of depletion, pollution, affection loss, and health threats; and thirdly, the socioeconomic impact on stakeholders.

3.4 Application

In the application phase, the students use their extended knowledge, i.e. their understanding of the material flow of the notebook, its stages, stakeholders, impacts, to make their choice about what to do with the notebook, in terms of purchasing, utilizing, and disposing of it. In the application phase, the students' engagement takes the form of a group discussion to make choices collectively, with the purpose of reducing the unwanted negative environmental impact. In the group discussion, the students are to argue their maybe varied point of views, negotiate, and then write down three aspects of their choices on an answer sheet: purchasing, for instance, what notebook to buy, how to buy it; utilization, how to save it in using it; and its disposition, where to throw it away after using it. The students' choices are categorized by the teacher with the 3R principle, namely, 'what are the practices of reducing, reusing, and recycling?'

The learning objective of the application phase is that the students should be able to see that their regular behavior with the notebook of purchasing, using, and disposing is having an environmental and socioeconomic impact. The students should be able to see that their extended knowledge on the material flow is useful in making and justifying their choices in purchasing, using, and disposing of the notebook. And the students should be able to applying the 3R principle tentatively in making their choices, followed by the induction of the term of reduce-reuse-recycle.

3.5 Reflection

In the reflection phase, the students reflect on their learning experiences with the life cycle analysis of the notebook, by inquiring into other stationary commodities they use regularly; the eraser and pen case as being exemplary. In addition to the evaluation made after each of the previous four phases (motivation, question, investigation, and application) to monitor the learning process of the problem proposing approach, the students' learning outcome is measured by the extent to which they apply the extended knowledge and skills to make environmental friendly choices in a life cycle analysis. The students' reflection has several implications. Firstly, by proceeding into a new life cycle analysis, the students will recognize that their acquired knowledge on material flow and the involved impact can bring them forward to make better informed choices with many other daily regular commodities for contributing to a 'better environment'. Secondly, in the new round of problem inquiry, the students' reflection also implies a recognition that the 3R principle leads to environmental friendly choices in that it decrease the negative environmental impact of depletion, pollution, affection cost, and health threats, experienced by them as unpleasant environmental problems. Thirdly, since it is assumed that most of the students' answers can be socially desirably overweighed towards negative environmental impacts, but neglect socioeconomic impacts that can be positive or negative, in the reflection phase, the students are encouraged to take a role as a critical thinker. The students are invited to debate about the conflicts among different impacts and the ideas about ecological solutions that have been generated. And fourthly, in the reflection, there is an opportunity for the teacher to link the students to solid waste disposal habits and traditions in Chinese society, in recalling and comparing reducing, reusing, recycling practices from the past and in the present in view of increasingly affluent lifestyles.

The learning objective of the reflection phase is that the students are able to do a new life cycle analysis on other regularly used stationary items and are able to see that the analysis leads to more deliberated choices contributing to a 'better environment'. In their analysis, the students' point of views can be recognized in taking the 3R principle to defend their own choices aimed at decreasing environmental depletion, pollution, affection cost, and health threats, or even a more complicated consideration of the socio-economical and environmental conflicts.

4 Potentially implemented scenario: the formal product

Through the five phases in the problem posing approach (see section 3), the educational view (see section 2) is formalized into a first version of the scenario. It has been modified several rounds after the classroom trials.

The last version of our design is a result of four cycles of trials in the four participating primary schools. The implementation process is described and analyzed in chapter 13, in which we explain how the final version of the scenario is developed by adopting modifications required to solve the problems and correct the errors revealed by the trials. In this section, we present the last version of the scenario that is the most appropriate scenario to be potentially implemented in the future.

4.1 Prior study: environmental problems and the notebook

The prior study is short, but it is crucial in the scenario, since it fulfills the motivation phase and the question phase in the problem posing approach. The prior study is in whole-class mode, in which the teacher guides the students' discussion, and both the students and the teacher can propose questions.

Activity 1: Introduction

The teacher introduces the scenario in an overview, stating that this is an innovative unit of four lessons about the environment, and that the students are welcome to raise their own questions, and to carry out investigations to find answers to their own questions. In this unit, knowledge is not to be found in the textbook, but through collecting the students' observations from their daily life experiences, from the people around them, and with information collection methods, for instance internet searches.

Activity 2: Motivating

The students are induced to think about a daily commodity in relation to environmental problems in responding to three questions.

1) What is the environment?

The teacher firstly invites the students to give their own definitions of *'environment'*. The students' definitions show their impression of what 'environment' should be. As observed from the trials, we are assured that most of their descriptions deal with the enjoyable aspect of the environment.

2) Have you ever experienced any environmental problems? How did that make you feel?

The teacher then turns the students' attention on environmental problems that they have experienced in person. The students are invited to share their sense of feeling, for example, in a sandstorm, what did it feel like on their eyes and skin; how did it smell etc.

3) Do you like that experience? Do you want to solve the problem? Who should be responsible for solving the problem? Are you playing a role?

Reasonably and logically, the students' experiences with environmental problems were unpleasant and unwanted. Their answers confirmed that the students are motivated to have a 'better environment' through the impetus coming from that experience. Then the discussion comes to the point: who should solve the problem, and how do the students perceive their own role in the problem?

Activity 3: Specifying

In summarizing the students' answers, the teacher guides the students to realize that environmental problems are all in relation to our need for commodities. For example, the garbage before it was dumped was commodities for our use, air pollution from mills is for producing commodities for our use, and deforestation happens because we need timber to make desks, chairs, etc. The students' discussion is concluded to focus on commodities in relation to the environment. Taking a paper notebook as an example of a commodity that is used regularly by the students is then reasonable and understandable.

Activity 4: Questioning

The students are invited to express the questions they needed to ask to understand the notebook in its relation to the environment. As observed from the trials, the students' questions are various but can be all categorized into the five directions of life cycle analysis. For example, the question *'where does the notebook come from?'* can cover questions such as, what is the major material of it, what is the original source of the material, what is the distance the material traveled, what are the businesses and the stakeholders involved. The question of *'what is the evoked impact?'* may embrace the questions such as, what kind of pollution is caused in producing notebooks, what kind of resource is consumed in producing notebooks, and are there people benefiting from notebooks? It is possible that the students' questions go beyond the notebook, and show their wide interests in many other commodities; the teacher needs to steer their attention back to the notebook as an interesting example. The students' questions about other commodities are still affirmed and encouraged, and will be studied at the end of the unit, after the notebook analysis. Therefore, the question of *'how are other commodities related to environmental quality?'* is intended to embrace students' questions that have a wider interest than the notebook.

Activity 5: Summarizing

The outcomes of the prior study are summarized by the teacher through writing a table of content of the unit on the blackboard, for the students to have an overview of the four lessons (see box 12.1). By doing so, most importantly, the students are able to see the questions they are interested in will be addressed in the following lessons, and by the time they complete the unit, they will improve their understanding of the notebook (also applicable to other commodities) in its relation to the environment, and they will know how to contribute to a better environment. The home assignment requires the students to prepare lesson 1, to collect information individually to answer the two questions, by interviewing people, internet searches, etc.

Box 12.1: Lessons list

Lesson 1:	Life cycle of the notebook
	Question: Where does it come from? Where is it disposed of?
Lesson 2:	Impact of the notebook
	Question: What is the impact evoked?
Lesson 3:	My choice
	Question: What should I do to reduce the environmental impact?
Lesson 4:	To be environmentally friendly
	Question: How are other stationery items related with environmental quality?

4.2 Lesson 1: Life cycle of the notebook

Lesson 1 elaborates the investigation phase of the problem posing approach, in which the students investigate the resource and waste flow of the notebook. The analysis of the resource flow is in a teacher-centered whole-class mode; the teacher has to demonstrate to the students how to draw diagrams with reference to the photo cards, each of which represents an involved stage or stakeholder. In the next step, the analysis of the waste flow is conducted in group learning, to share information and exchange ideas and jointly draw the waste flow diagram in referring to the photo cards.

Activity 1: Introduction

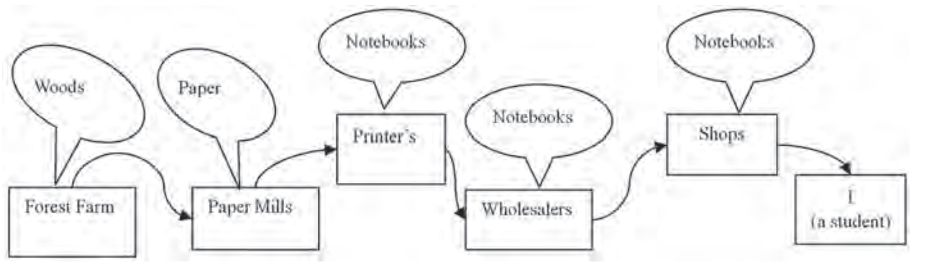
The teacher takes the students to review the 'lessons list' on the Students' Group Work Sheet for them to keep track of what will be learned in the first lesson. Then the students are reminded of their prior study homework, collecting information to answer the two questions: *Where does it come from? Where is it disposed of?* The teacher introduces the learning task: drawing the life cycle diagram of the notebook referring to the photo cards showing every stage or stakeholder involved in the life cycle of the notebook.

Activity 2: Diagram of the resource flow

The teacher demonstrates on the blackboard how to trace where the notebook comes from by handwriting the names of each stage and drawing connection lines referring to the photo cards. The teacher guides the class discussion in a sequence of probing questions:

From where do you get your notebook? —From shops. —From where do the shops get the notebooks? —From wholesalers. —From where do the wholesalers get the notebooks? —From a printer's. —From what material do the printer's make the notebooks? —From paper. —From where do the printer's get the paper? —From paper mills. —From what major material is the paper made? —From wood. —Where is the wood from? —From forest farms.

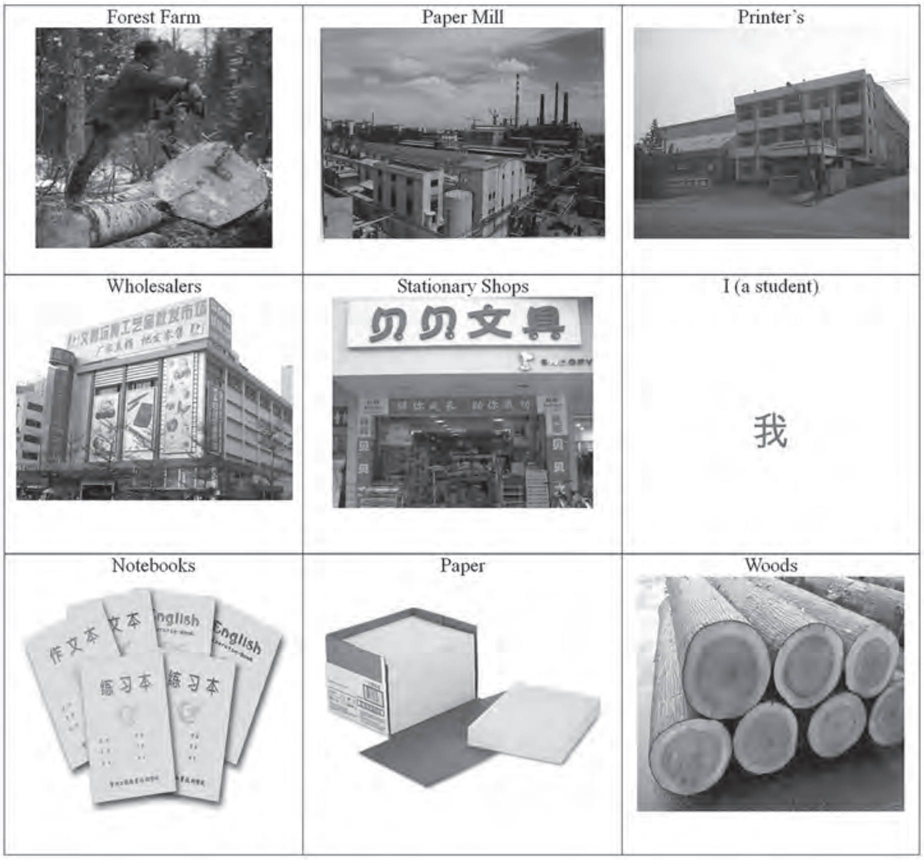
Box 12.2: Resource flow diagram of notebooks



The stages/stakeholders presented in the photo cards do not only serve to visualize and recall the students' daily observations and experiences, but also reduce the complexity of the resource flow of notebooks in reality, which otherwise would be a different diagram when another resource material is included e.g. clothing, straw etc. After the demonstration by the teacher on the blackboard, the completed resource flow diagram is drawn with references to the photo cards of the stages/stakeholders (see box 12.2). The students are required to follow the teacher's demonstration and complete the resource flow on the whole material flow diagram on the Students' Group Work Sheet, as shown in box 12.4; the photo cards are presented in box 12.3.

In the teacher's preparation, he or she should notice that the arrowhead direction is toward 'I', which logically means the resource is coming to 'me' to use. The teacher should be able to differentiate the cards of materials and the cards of stages/stakeholders, but also to see the connections between the two types of cards. This is to say, the material changes its form, wood is coming out of the forest farm, paper is coming out of the paper mill, the notebook is coming out of the printer's and transported via wholesalers, shops, and in the end to me. The teacher should be able to formulate from the diagram the definition of *resource flow* in his/her own words. The challenge for the teacher is to react to unexpected answers from the students, but still keep the discussion focused on the resource flow, for instance, when the students propose resource materials other than wood in making paper, such as waste paper, recycled clothing, and straw.

Box 12.3: Photo cards of the resource flow of the notebook



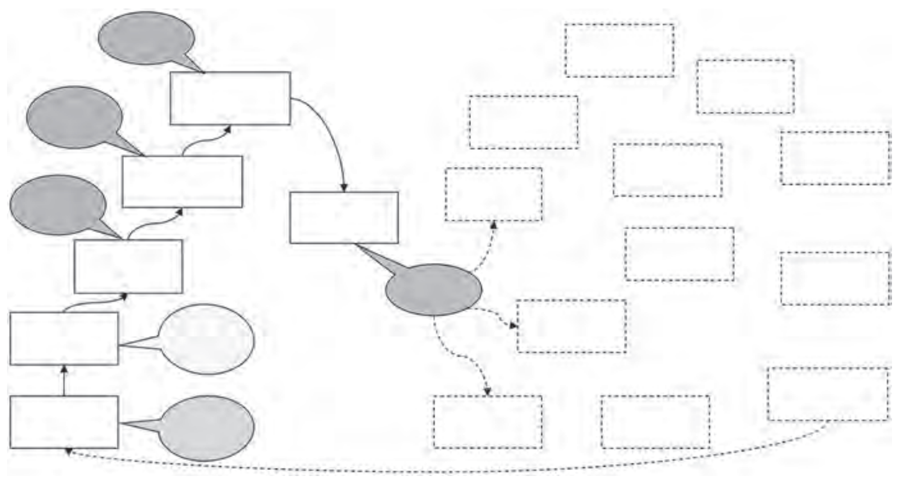
Activity 3: Diagram of the waste flow

The students discuss in groups and trace on the Students' Group Work Sheet where the notebook is disposed of by filling in the blanks in the waste flow on the entire material diagram, as shown in box 12.4, with reference to the photo cards as listed in box 12.5. The teacher should clarify to the students that their task is to select and patch the photo cards according to their place in the journey of disposing of the notebook, and to draw connection lines to show the sequence. The students may or may not use all the photo cards, and they may also make additional cards if they find that some stages are missing in the given cards. Though this section mainly consists of student-centered group learning, it is necessary that the teacher demonstrates the multiple ways of the first step in disposing of the notebook on the blackboard to all the groups, to avoid the students drawing a single-lined diagram in referring to the resource flow diagram on the blackboard. The teacher guides the class discussion by raising the following question:

When you finished using your notebook, where do you throw it away? —Drop it on the ground. —Dump it in the garbage bins. —Collect and sell it to scrap purchasers….

The teacher summarizes the lesson by formulating the definition of *waste flow* in his/her own words from the diagram, and also the related concepts *primary resource, recycled resource, recycled paper*. The home assignment of the first lesson requires the students to prepare lesson 2, to collect information individually to answer the question which environmental and socio-economic environmental impacts are generated in the product's life cycle.

Box 12.4: Material flow diagram



In the teacher preparation, the teacher should become aware that the arrowhead direction is going away from 'I', which logically means the waste is coming from 'me' after using the object. The teacher should be reminded that the waste flow diagram shows how waste disposal actually takes place according to their daily observations and experiences, and not yet about how they think it should be for improving the environment. That question will be addressed in lesson 3. The teacher should be alert on whether the students' answers are realistic and conforming with the students' authenticity, for instance, when students really do burn their notebooks, or dump them into the river. The teacher should be reminded that it is possible in the group discussions that students may merely read their collected information to each other, rather than using the information to place and connect the cards and complete the diagram. A challenge for the students in the group discussion is that compared to reading literally to each other, applying the information to complete a learning task requires higher skills, such as evaluating the information, making selections, categorizing, and summarizing. In other words, students should keep in mind that the information is to solve a problem.

4.3 Lesson 2: The impact of the notebook

The investigation phase of the problem posing approach takes place in lesson 2, in which the students investigate the impacts (environmental and socioeconomic) related to the material flow of the notebook. The lesson begins with a review in a teacher-centered whole-class mode. In reviewing the content in lesson 1, one group is invited to present their waste flow diagram to the class, and the teacher guides the students to review the key concepts related to material flow. In the next step, in group learning, the students show their understanding of what impact might be evoked in referring to the photo cards showing possible impacts during each stage in the material flow.

Activity 1: Introduction

The teacher takes the students to review the 'lessons list' on the Students' Group Work Sheet for them to keep track of what will be learned in the second lesson. Then the students are reminded about their prior homework, collecting information to answer the question: *what is the impact evoked in the material flow*? The teacher introduces the learning task: in group learning, to decide which impact shown on the photo cards is a possible result of which stage in the life cycle, and note it down on the life cycle diagram.

Activity 2: Review

In the review, one group of students is invited to present their group result to the class, i.e. the waste flow diagram drawn in lesson 1. After the presentation,

Box 12.5: Photo cards for the waste flow of notebooks

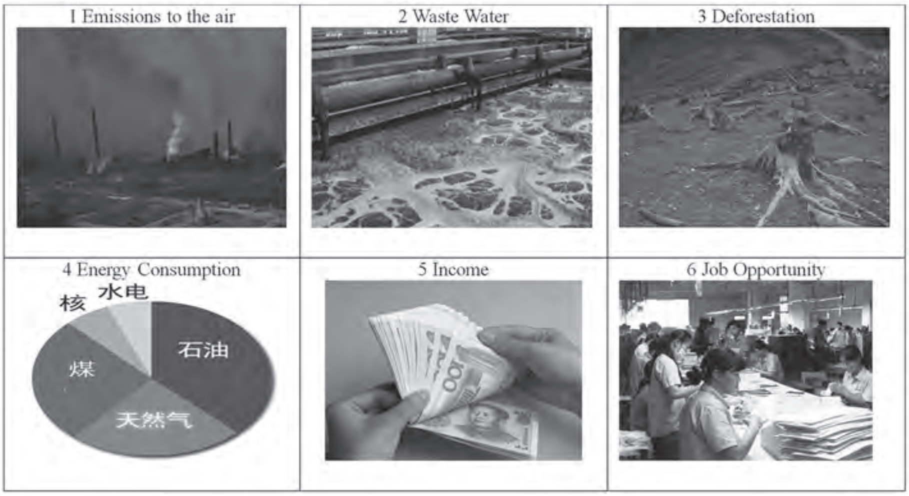
the teacher guides a class discussion to improve the waste flow diagram where necessary. With the completed waste flow diagram, the teacher summarizes again the key concepts *resource flow, waste flow, primary resource, recycled resource, and* *recycled paper*. In the review, it is important that the teacher points out to the students there are three final destinations of the waste paper: landfill, open burning, and recycling. The teacher induces the students to recognize that with the first two ways the waste paper returns to our environment in the air or on land, but with recycling, the waste paper returns into the resource flow in the form of a recycled resource for making paper. The teacher introduces to the students factual information about the landfill in the city (see Box 12.6). The teacher also highlights the place and the role of 'I' for the students, in the sense that the resource flow is originated because I need the notebook; and the waste flow is decided in its first step by what I do in disposing, so to say I am the one in the first place to decide whether the used notebook goes back to the environment in the form of waste or enters into the resource flow in the form of a recycled resource.

Box 12.6: Landfills

Landfill in Golmud: The household waste is stored in a landfill located 16 km southeast of the town. The daily handling capacity is 400 tons. There are dozens of garbage trucks and 450 cleaning workers busy with cleaning and moving the waste to the landfill. Poor people, most of the time women with children, make a living by sorting recyclable scrap in the landfill. Landfill in Xining: The household waste is stored in a landfill located 13 km northeast of the town. The daily handling capacity is 800 tons, but it has been receiving more than 1200 tons per day. Running beyond the handling capacity will demand to open another larger landfill near the city. Poor people, most of the time women with children, make a living by sorting recyclable scrap in the landfill.

In the teacher's preparation, the teacher should be clear that the waste flow diagram shows what the flow actually is according to the students' daily observations and experiences, not yet about how they think it should be for improving the environment. The teacher should also be alert on whether the students' answers are realistic and conform to the students' authenticity. It is crucial that the teacher can understand why to highlight the role of 'I', i.e. resource extraction is originated by people's life needs, waste addition is because of people's rejection of it after use. The challenge for the teacher is to keep an eye on the rather complicated waste flow diagram and to recognize that the three final destinations are landfills, open burning, and recycling.

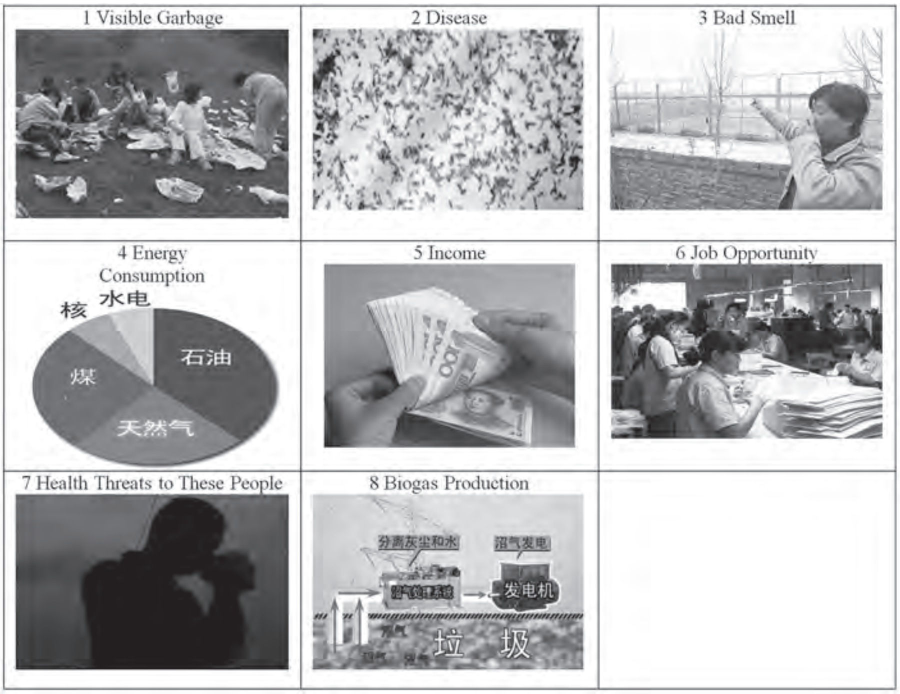
Box 12.7: Photo cards of impact involved in the resource flow of the notebook



Activity 3: Impacts of the notebook

The students discuss in groups and on the life cycle diagram they made on the Students' Group Work Sheets; the students show their understanding of it at every stage of the life cycle, about what impact might be generated. The teacher should clarify to the students that their task is to carefully read the photo cards of impacts, decide which impact might be involved at which stage, then write the card numbers at the stages involved in the entire material flow diagram on the Students' Group Work Sheet, as shown in box 12.4. Box 12.9 illustrates a completed part of the diagram in which the impacts involved are associated with the stages. The students may or may not exhaust all the photo cards, and may also draw additional cards if they find some impact is missing in the cards that were given. The students can note the number of the impact cards at more than one stage, for instance, energy is consumed in more than one stage. Though this section takes place mainly in student-centered group learning, it is necessary that the teacher supervises each group for clarifying the tasks. After the groups complete the task the teacher concludes the lesson by categorizing the environmental impacts (not yet the socioeconomic impacts) into four types: pollution, depletion, aesthetic loss and sanitary & health threats. The home assignment of the second lesson requires the students to prepare lesson 3, to collect information individually to answer the question of what to do to reduce unwanted environmental impacts. Box 12.7 and 12.8 show the photo cards listing possible impacts on the resource flow and the waste flow respectively.

Box 12.8: Photo cards of impact involved in the waste flow of the notebook



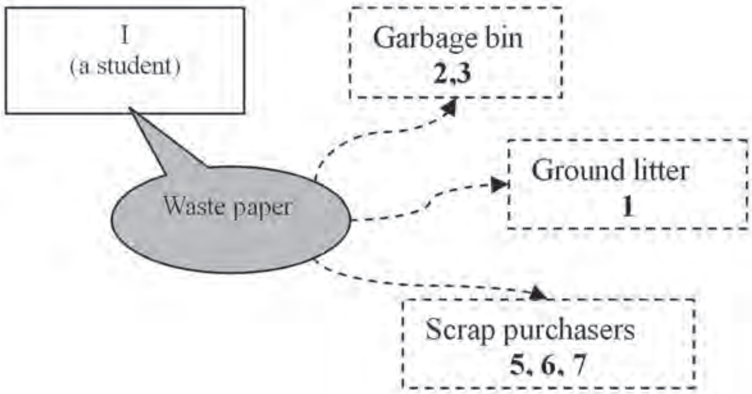
In the teacher's preparation, the teacher should be aware that it is still a challenge for the students to apply the information to complete the diagram rather than merely reading to each other their collected information. And the teacher should be familiar with the environmental impacts shown on the photo cards, and know how to categorize them into the three types.

Box 12.9 illustrates a completed fragment of the diagram in which the involved impact is noted for the stages.

4.4 Lesson 3: my choice

In lesson 3 the application phase of the problem posing approach takes place, in which the students use the knowledge acquired in lesson 1 and 2, i.e. the material flow of the notebook with the involved impacts, to make choices in purchasing, utilizing, and disposing of the notebook. The review of the content in lesson 1 is in a teacher-centered whole-class mode. The teacher guides a class discussion and repeats on the blackboard the work of placing the impact cards on the life cycle diagram. In the next step, in group learning, the students jointly make choices of what to do with the notebook to reduce unwanted environmental impacts.

Box 12.9: An example fragment of the material flow, impact card numbers are added



Activity 1: Introduction

The teacher invites the students to review the 'lessons list' on the Students' Group Work Sheet to keep track of what will be learned in the third lesson. Then the students are reminded about their prior study homework, collecting information to answer the questions: *what to do with the notebook to reduce environmental impacts?* The teacher introduces the learning task: discuss in groups and write down their choices in purchasing, using, and disposing of the notebook.

Activity 2: Review

In the review, the teacher invites every group in turn to report where they placed an impact card, e.g. where group 1 places the cards of 'emissions to the air'. The teacher demonstrates and places the card in the related stages in the life cycle diagram on the blackboard. At the same time, every group is required to modify their listing of impact cards for necessary corrections and completions. With the completed diagram showing all involved impacts, the teacher guides a class discussion to share the students' knowledge about environmental problems that can resulted from the impacts. The teacher guides the class discussion for example by raising the following question:

What environmental problem can be caused by deforestation? —Sandstorm. —landslides…

During the discussion, the students are required to complete an exercise in the Students' Group Work Sheet as shown in box 12.10.

The trials revealed that it is necessary to provide factual knowledge about biogas discharge in landfills and its current operation in the Students' Group Work Sheet; see box 12.11.

Box 12.10: What environmental problems can possibly result from the impact? Please draw lines to connect them.

Impact on the resource flow of the notebook

Deforestation	Landslide
Emissions to air	Sandstorm
Waste water	Global Warming
Energy consumption	Air Pollution
	Water Pollution

Impact on the waste flow of the notebook

Biogas	Global Warming
Emissions to air	Water Pollution
Waste water	Air Pollution
Energy consumption	

In the review, it is important that the teacher guides the students to share their perception about the cleaning workers, scrap pickers, and scrap purchasers, by raising the questions:

What is your impression of the cleaning workers/scrap pickers/scrap purchasers? What is your observation of what they do for a living? Do you have any experiences/communications with them? How do you perceive their roles in the waste flow of your notebooks?

Box 12.11: Biogas in the landfill

In the landfills, after natural fermentation the waste emits biogas, mainly composed of the greenhouse gases methane and carbon dioxide. Breathing in too much biogas makes people feel sick, headache, and even unconscious, and to the worst, a suffocation. Until recently, the landfill methane was vented into air or flared on site to avoid dangerous accumulation. The biogas burning generates greenhouse gases too. However, the collected methane may provide a fuel source for power plants for generation of electricity, which has zero air pollution but still consumes energy.

The teacher encourages the students to express their thoughts about the people freely and honestly at first, and then to summarize from the discussion these people's role in recycling solid waste. An illustrative phrase is given in the Teacher's Manual (see box 12.12).

In the teacher's preparation, the teacher should be able to understand the connections between environmental impacts and environmental problems. The teacher should also be alert that the students may give socially desirable answers about their perceptions of the cleaning and scrap workers, so it is necessary to encourage them to express themselves more freely. The challenge for the teacher is to keep an overview of the rather complicated waste flow diagram and know what impact is related to which stages in the life cycle of the notebook.

Box 12.12: The main force of recycling in China

In our city and most other cities in China, the solid waste sorting system has not yet been established. Even though we sort the garbage, the sorted garbage is dumped in a mix and moved to landfills for eventual storage. However, the garbage on its way from our hand to the landfill is being sorted and selected for recyclable items. And this is done mainly by scrap pickers and scrap purchasers, the people in need of help to cover their living expenses with the sale of scrap. Although they do it for financial reasons, these people's recycling work plays a critical role in turning the waste into resources. As a result, their recycling work slows down primary resource extraction and saves space in landfills. The scrap pickers and scrap purchasers are the main force of recycling in China.

Activity 3: My choice

The students discuss in groups and write down on the Students' Group Work Sheets their collective choices in terms of purchasing, using, and disposing of the notebook, as solutions to reduce the environmental impacts, as shown in box 12.13. The teacher should induce the students to recognize that from the three aspects (purchasing, using, and disposing) their choices of what to do with the notebook will shape the material flow, or to say, change its life cycle. It is crucial that the students' group discussions and decisions are based on their analysis of the changes of the impacts if they choose different methods of disposal. Therefore it is necessary that the teacher supervises each group to remind them to pay attention to the differences each of their disposal choices has on the impacts. The teacher should remind the students to pay attention in particular to the difference in impact between littering by dropping the notebook on the ground and throwing it in the garbage bin. The teacher may guide the group discussion by raising questions such as:

When you choose to dump it in the garbage bin, what will happen to the pollution/depletion/aesthetic loss/health threat cards connected to the followed stages? What will be different on the pollution/depletion/aesthetic loss/health threat cards, if you choose to litter on the ground or if you choose to dump it in the garbage bin

The home assignment of the third lesson requires the students to prepare lesson 4, to collect information individually to answer the question of whether they can now trace the life cycle of other stationery items.

Box 12.13: Making choices for reducing environmental impacts

For reducing the environmental pollution, depletion, aesthetic loss, and health threats, our group chooses to do:
Buy ________________________________
Use ________________________________
Dispose ______________________________

In the teacher's preparation, the teacher should be able to understand that from the three aspects, getting it (purchasing), using it (utilization), and rejecting it (disposing), people's choices may change the life cycle of a commodity. The challenge for the teacher is to reflect critically, together with the students, on what they are mostly used to do in environmental education, persuade or even directly command the students not to litter without giving them the opportunity to see what environmentally, socially, and economically will happen, what it in fact means to the environment, to the students themselves, and to other people involved. From the life cycle analysis, the teacher should be able to see and guide the students to see what exactly changes the environmental and socioeconomic impacts if the waste paper is or is not dropped on the ground. It becomes obvious from the material flow diagram that the littered waste paper will be cleaned by the cleaning workers and dropped in the garbage bin, or to say there is only one step difference, namely, if the waste paper is dropped in the garbage bin by the students themselves or with the help of the cleaning workers, between the students' choice of littering on the ground and dumping it in the garbage bin. The difference in the environmental impacts is mainly an aesthetic loss before the notebook is cleaned up, and socially the students' litter adds to the workload of cleaning workers who are already overworked, or economically on the other hand, the cleaning men may even pick up the waste paper to sell as scrap.

4.5 Lesson 4: The dilemma between economy and environment

Lesson 4 involves the reflection phase in the problem posing approach, in which the students reflect on the life cycle analysis of the notebook through the 3R principle, and inquiring into other stationary items, such as the eraser and pen case, so that the students recognize that they are better informed to make choices with any regularly used daily commodity for improving the environment by conducting a life cycle analysis and by applying the 3R principle. In the fourth lesson, the students participate in four learning activities. The first is a group presentation of the choices made in lesson 3, from which the teacher introduce the 3R principle. The second is a group discussion, in which the students are induced to understand the concept of *'environmentally friendly'* which means to cause less pollution, less depletion, less aesthetic loss, and fewer health threats, and then to compare and order the practices of reducing, reusing, and recycling to the extent of how environmentally friendly it is. The third is a class-wide debate, in which the students are induced to realize there is a dilemma between environmental and socioeconomic impacts and the students are invited to propose solutions for possible mutual benefits. The fifth is a test to be carried out in group discussion, in which the students jointly make an assessment and choose the most environmentally friendly stationery item out of several given items.

Activity 1: Introduction

The teacher invites the students to review the 'lessons list' on the Students' Group Work Sheet for them to keep track of what will be learned in the fourth lesson. Then the students are reminded about their prior study home work. They collected information to answer the question*: how do other stationery items relate to environmental quality?* The teacher introduces the main learning task: receive a test in groups to make an assessment of other stationery items they use regularly to see which is the friendliest to the environment.

Activity 2: Review

In the review, the teacher invites one group to present to the class their choices in purchasing, using, and disposing of the notebook to cause fewer environmental impacts. And in the meantime, the teacher notes the choices on the blackboard, and invites the students to contribute more possible choices. With the completed choice list made on the board, the teacher categorizes the actions using the 3R principle and indicates the categories on the choice list with different marks, as is shown in box 12.14.

In the teacher's preparation, the teacher should plan in advance how to use abbreviations in noting down the choices on the board. It is crucial that the teacher is able to differentiate between reducing, reusing, recycling actions.

Box 12.14: Categorizing choices by the 3R principle

Buy: double-side printed ones▽, made of recycled paper ○, buy less at one time▽, buy plain ones rather than fancy ones▽...
Use: write more carefully and make fewer mistakes to save space▽, do not tear it for fun▽…
Disposal: sale of scrap○, give it to scrap pickers○, use the back side as scratch paper √, make paper crafts √, do not to litter on the ground, dump it to a garbage bin…
Reducing:▽ Reusing : √ Recycling:○

Activity 3: The 3R principle and environmentally friendly actions

In a whole-class mode, the teacher guides the students to reflect on their choices in the categories reducing, reusing, and recycling actions to assess the changes made on the environmental impacts. The teacher may guide class discussion by raising questions such as:

With the reducing/reusing/recycling actions, what happens to the environmental impacts? Are the pollution/depletion/aesthetic loss /health threat reduced?

The teacher then brings in the definition of being *'environmentally friendly'* that it means to minimize pollution, depletion, aesthetic loss, and health threats. It is important for the teacher together with the students to have a critical reflection on the term *'environmental protection'* which they are used to using in referring to the purpose of environmental education. With the understanding of the definition, the students are required to discuss in groups to perform a comparative assessment and rank the reducing, reusing, or recycling actions by environmentally friendly efficiency.

In the teacher's preparation, the teacher should be reminded that there is an opportunity for the teacher to link to the students' solid waste disposal habits, and traditions in society. Reducing and reusing is an equivalent to the Chinese concept of 'saving' or 'economizing', and recycling is similar to what people normally call 'sale of scrap'. In the past, during material shortages, it was normal for every household to save in using, to make full use of refillable containers, and sell recyclable scraps. Now, during times of affluence, only poor people stick to these practices. The teacher can invite the students to share their opinion in this respect. The teacher should be able to reflect critically on *'environmental protection'*, that shows a one-sided authority of humans in protecting the environment. In comparison, *'environmental friendly'* implies a balanced relationship between humans and the environment, a mutual beneficial and mutual protection, 'friendship'. It is crucial that the teacher understands the impact of the differences that reducing, reusing, recycling actions have on the environment in terms of pollution, depletion, aesthetic loss, and health threats.

Activity 4: Debate

After analyzing the environmental impacts, the teacher invites the students to include socioeconomic impacts in reconsidering the 3R principle. When the unwanted environmental impacts are decreased, some wanted socioeconomic impacts also decrease, such as income, and job opportunities. The students are invited to propose solutions to solve this dilemma in a class discussion. The teacher ends the lesson by making a summary of the main story line the students have gone through, using phrases such as:

With the four lessons, we have carried out a life cycle analysis of the notebook, to know that what we do in purchasing, using, and disposing it changes its material flow and the impacts on the environment and on the people involved. Although unwanted environmental impacts can be diminished with the 3R principle, another consequence can be the loss of income or job opportunities for some people involved. It is for us to think further about what to do to improve the quality of the environment as well as helping people in need. Such a way of conscious thinking is to be applied when we deal with any of our daily commodities.

In the teacher's preparation, the teacher should be reminded that the students are very likely to hold a socially desirable opinion that reducing the negative environmental impact is the only important thing, and deny socioeconomic impacts such as income and job opportunities. It is a challenge for the teacher to be able to guide the debate on the rather complicated topic of the conflict. It is crucial that the teacher keeps the class discussion focused on proposing solutions, and to understand that any solution is valid as long as it reduces negative environmental impacts without losing positive socioeconomic impacts, such as eco-energy, planting trees, and technical innovations for control pollution.

Activity 5: Test

The purpose of the test is to see whether the students are able to use life cycle analysis for making a judgment on the environmental efficiency of other commodities. The students complete two exercises on the Student's Group Work Sheet in groups as shown in box 12.15:

In the teacher's preparation, the teacher should be aware firstly that there is no standard answer for the test. The point of the test is to give the students an opportunity to prove that in defending their choices, their argued viewpoints show the extended knowledge and skills of making a life cycle analysis and applying the 3R principle with the aim of minimizing environmental depletion, pollution, aesthetic loss, and health threats, or an even more complicated consideration of possible conflicts between socio-economic benefits and environment.

Box 12.15: Test

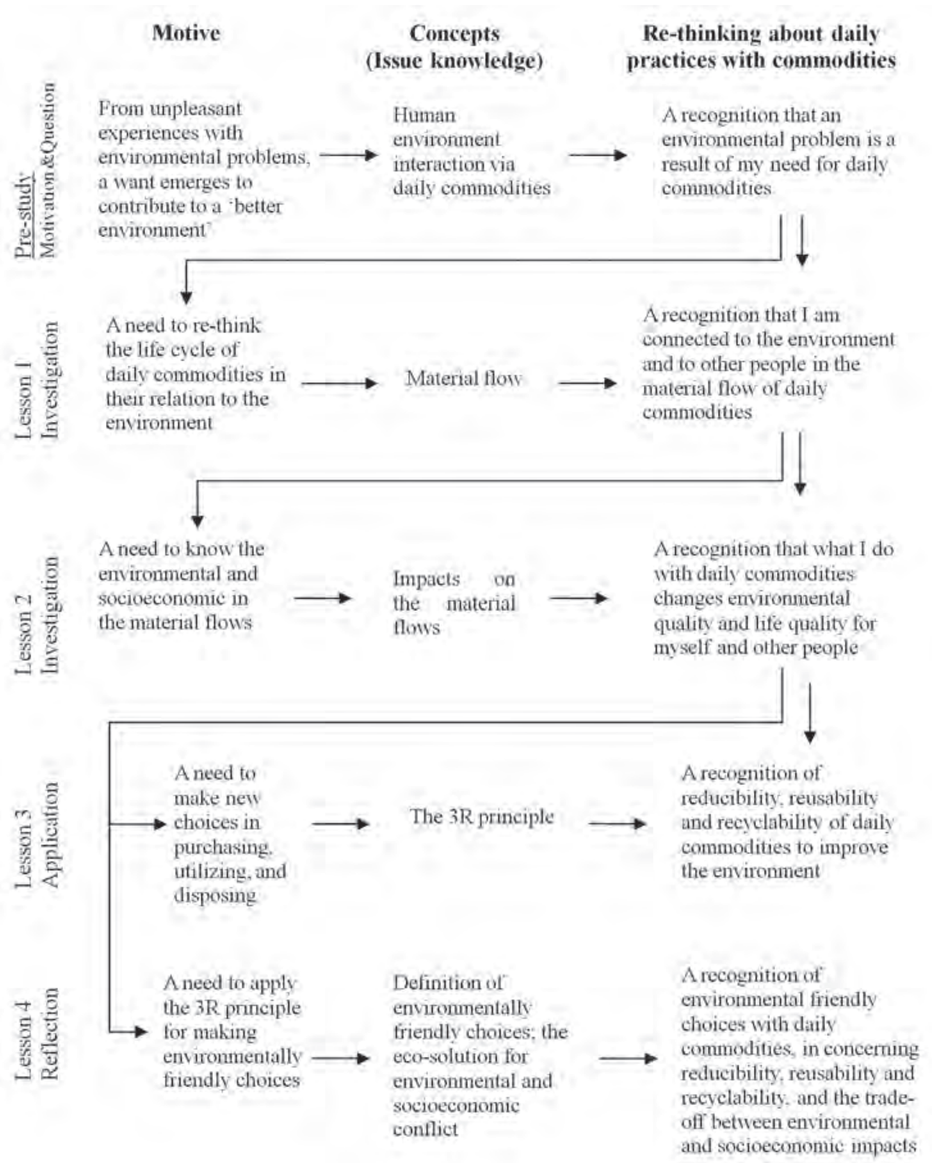
1 Out of the following two types of erasers, which one is more environmentally friendly? (Please name your choice and list your argumentation for your choice. With more argumentation you will gets more points.)
A: Colored eraser with fragrance B: Plain eraser without fragrance

2 Out of the following three types of pen cases, which one is more environmentally friendly? (Please name your choice and list your argumentation for your choice. With more argumentation you will get more points.)
A: Plastic pen case B: Cotton pen case C: Iron pen case

5 Didactical structure

A didactical structure is outlined to give an overall description of the expected motive and knowledge development over the five phases that are carried out in the four lessons. The didactical structure also explains how the four lessons engage the students into the inquiry from their prior motive of the problem posed by themselves, and how the four lessons are coherently connected in succession.

In conclusion, the scenario developed from theoretical assumptions and design criteria is to bring about ideal environmental education practices as much as possible. And most importantly, the scenario is an intended curricular solution for reducing the formalizing gap and the operational gap. Therefore, the design takes into account the obstacles and problems revealed in the study of the rhetoric-practice gap. In the next chapter, we will present the results of whether and how the intended scenario succeeded in classroom implementation.


Motive
Concepts (Issue knowledge)
Re-thinking about daily practices with commodities
Pre-study Motivation &Question
From unpleasant experiences with environmental problems, a want emerges to contribute to a 'better environment'
Human environment interaction via daily commodities
A recognition that an environmental problem is a result of my need for daily commodities
Lesson 1 Investigation
A need to re-think the life cycle of daily commodities in their relation to the environment
Material flow
A recognition that I am connected to the environment and to other people in the material flow of daily commodities
Lesson 2 Investigation
A need to know the environmental and socioeconomic in the material flows
Impacts on the material flows
A recognition that what I do with daily commodities changes environmental quality and life quality for myself and other people
Lesson 3 Application
A need to make new choices in purchasing, utilizing, and disposing
The 3R principle
A recognition of reducibility, reusability and recyclability of daily commodities to improve the environment
Lesson 4 Reflection
A need to apply the 3R principle for making environmentally friendly choices
Definition of environmentally friendly choices; the eco-solution for environmental and socioeconomic conflict
A recognition of environmental friendly choices with daily commodities, in concerning reducibility, reusability and recyclability, and the trade-off between environmental and socioeconomic impacts

Chapter 13 Scenario Process

1 Introduction

In this chapter, the implemented scenario is presented. We explain through actual practices, to what extent the design intention presented in chapter 11 has been accepted by the participant teachers, what design errors are revealed in the performances, suggesting modifications. From the first version to the final written product (as presented in chapter 12), eight cycles of trials are conducted in eight classes of the four participant schools in the cities of Golmud and Xining, Qinghai, China. Each class supported one cycle of experiment and as a case study contributed data for improving the scenario for the next trial. However, a cross-case description and analysis are conducted in presenting the implementation of the scenario. The case studies data of the eight classroom trials are gathered to explain firstly how the visions on the seven curriculum elements are perceived by the participant teachers as shown in their performances, and secondly, to describe operationally what happened in each lesson following the problem posing approach in terms of revealing errors, obstacles and modifications.

2 Implemented scenario: the perceived scenario

In this section, we present how the intended visions on the curriculum elements are received by the teachers as shown in their teaching performances. The results are taken from the classroom observation notes, the classroom audio and video recordings and the interviews with the teachers.

2.1 Rationale

With the reference to theoretical assumptions in chapter 2, design criteria in chapter 11, and problems revealed in the rhetoric-practice study in chapter 8, the scenario is designed as an elaboration of the intended vision on the rationale concerning disciplinarity, focused problem, characteristics of the study issue, and conclusion/solution.

2.1.1 Disciplinarity

Since all participant teachers have experience with cross-disciplinary teaching in their Chinese courses, they were willing to accept that the scenario embraces knowledge from more than one discipline. Nevertheless, all teachers repetitively expressed their feeling of lack of confidence in grasping the environmental science knowledge required for the issue. In the teachers' preparation, what they worried about most was that the included content knowledge of environmental science might go beyond their prior knowledge. Due to the time pressure, we did not succeed in any of the eight trials to get the participant teachers to acquire the content knowledge that they themselves found necessary to improve. As required by the teachers, knowledge cards are added in the teacher's manual. The knowledge card content was expanded in each succeeding round according to the expressed needs or need for change (see section 3). As shown in the classroom teaching, as long as the planned activities were followed, the students were indeed confronted with environmental and socioeconomic aspects, although the quality varied in relation to each teacher's level of understanding. For instance, as long as the students completed the waste flow and resource flow diagram, the students were linked by the photo cards to involved stages, people, economic benefits, social and environmental problems, though some teachers showed better competence in facilitating the group discussion than others.

2.1.2 Characteristics of the study issue

All teachers accepted that the study issue of solid waste management is not predetermined, but open for the students' own understanding. This is to say, the waste flow diagrams can be completely different according to the students' different living habits and observations. The teachers shared a developmental perspective; from their teaching experiences they knew that what students come up with can be very different from what teachers expects from their own experience. However, the teachers held varied opinions about the idea that the study issue of solid waste management is problematic. Five of them could share the designer's standpoint that the current practice of solid waste management is problematic mainly in terms of resource utilization efficiency, the pollution load, and the welfare issue of the poor people doing scrap recycling. One teacher (Teacher D), however, argued that the aesthetic loss, namely, the consequence of litter on the ground should still be the most highlighted problem to the students, since it is the severest observable problem within the students' daily life. *'Are we teaching them litter does not really matter to the environment? We should not leave the students to the idea that litter is not a big deal and does not much harm.'* (Teacher D). And for teacher D the solution for this problem is definitely not to litter and keep the environment clean. While expressing their appreciation of the emphasis on long term environmental impact of resource extraction, pollution, social welfare and health threats, teacher A, B, C, and F also stated that they expect after testing the scenario, they would see at least less waste paper litter in the classrooms.

2.1.3 Focused problem

From the observations of the classroom trials, the teaching and learning were focused on solid waste management. As we explained in chapter 12 (see section 2.1), we chose solid waste management because it is a specific problem and involves students' daily practice in their real life. The intention is fairly achieved, as long as the teachers respect the overall didactic structure of the scenario. In none of the eight trials did the teachers deviate from the didacticAL structure, for instance by giving an abstract introduction on the solid waste management status quo in general without inviting the students to participate in learning activities.

2.1.4 Conclusion/Solution

In respect to the complexity of solid waste management, in each phase of the problem posing approach, the scenario does not require the students to come to a certain solution or conclusion. The students' group learning tasks are based on their life experiences, observations, and prior knowledge. This intention has been achieved by most of the teachers. In teacher D's class, in supervising the students' group work on drawing the waste flow diagram, the teacher took over quickly twice and demonstrated to the students what the diagram 'should' look like, by raising yes-no questions such as *'Shouldn't this card be put here?' 'Isn't this card after that?'*. Most of the time, before the students could say yes or no, teacher D had already finished card placing in order. In that situation, it would be difficult for the students to say no, since they were involved in a new task and trying to figure out what to do properly and the teacher's demonstration could easily be seen as the only correct answer.

2.2 Goal

It was easily accepted by all the teachers that environmental education is for immediate use for improved sustainable life quality. They all expressed a wish that to solve the problems of wasting paper in using the notebooks and of littering the classroom and the campus would be an immediate goal of the scenario. From our design intention, the goal is to build environmental literacy from aspects of knowledge, skills, affect and behavior. Knowledge aims to prepare for inquiry and taking action in exerting influence on the environment, not merely be directed toward action. A critical argumentation was received from teacher D. When asked how she would carry out the scenario in the future without the presence of the designer she proposed to shorten the four lessons to one, in a teacher-centered whole class mode, to tell the main story line to the students, and what to do with the paper notebook. From teacher D's point of view, knowing the correct actions to take is the utmost goal.

Understanding human-nature interaction is at the essence of environmental literacy. As shown in their teaching performances, most of the teachers improved the understanding of the importance to inspire the students to see how both short term aspects (aesthetic loss, and sanitary threats caused by litter) as well as long term aspects (depletion, pollution) are correlated with environmental problems. Nevertheless, teachers A, B, C and H still considered the scenario as a success if the students would become aware why littering is not recommendable, and teacher D expressed the strongest focus on students' behavioral change.

2.3 Content

2.3.1 Information source

The study issue of solid waste management involves contradicting environmental and socioeconomic impacts, so that the students are encouraged to show their multiple perspectives, for instance in lesson 1 and 2 their different understandings of the waste flow and its impacts, and in lesson 3 their different choices in dealing with the notebook. This vision was approved by all the teachers. The students are confronted with complex and contradicting information, as crucially required in lesson 4. The teacher should guide the students to address the conflict between the stakeholders' income, job opportunities and the negative environmental impacts when the 3R principle is applied. To facilitate such a debate was considered a challenge by all the teachers. As revealed in the classroom observation and the interviews, it is relatively easy for them to guide the students to understand that when the negative environmental impacts decrease, there will be in the meantime a loss of income or job opportunity. However, even for the teachers themselves it was difficult to come up with solutions that are valid to solve the dilemma. As a solution, in the teacher's manual some worked out solutions are exemplified for the teachers (see further section 3.4.).

2.3.2 Relevance to students' life world

Solid waste management involves the students' daily life practices in school, at home, and involves stakeholders from the community. The intention is to guarantee the relevance to the students' life world. Judging from their teaching performance, this vision was fairly approved by all the teachers, although teacher D seemed to prefer a non-participative, passive mode of teaching with emphasis on behavioral change. The class room trials showed that as long as the teachers carry out the required tasks, the students are participating in learning activities dealing with daily life practices. Especially in lesson 1 and 2, the teaching is assisted with photo cards visualizing the involved stakeholders or stages, reminding the students to make links with their daily life observations about the notebook's life cycle.

2.3.3 Knowledge development path

As intended, the knowledge should be actively constructed by the students; the scenario adopts a problem posing approach to support students' open inquiry into the life cycle of regularly used stationery, namely the study tools we normally found in the students' pen cases which they use every day. That can be any writing materials, such as paper, envelopes, pens, ink, rulers, etc. Starting from the students' existing motives, the students are engaged along a sequence of learning tasks answering the questions raised by the students. In perception, the majority of teachers appreciated the problem posing approach. Teachers B, C, E and G were especially excited about their experiences in teaching with this approach. Teacher D, however, held an opposite opinion: *'I would basically summarize and read to the students, in whole class mode, the main ideas of the four lessons. The learning outcome would be the same, but this (way of teaching) is much more efficient in time. It can be done in only one lesson.'* However, in the teaching performance, teacher D's teaching performance was faithful to the scenario design, except for her dominant supervision in guiding the students' group discussion.

2.4 Process

2.4.1 Engagement

In the teachers' performances, the students' engagement with the life cycle analysis was well guaranteed. As we observed in our explorative studies, behavioral strategy was largely adopted in current environmental education teaching practices. To avoid this, the scenario emphasized engaging the students with the problem inquiry throughout the entire learning process, namely, from finding the problem in prior study, and inquiring about the problem (in lesson 1 and 2), to solving the problem, and proposing actions to take (in lesson 3 and 4). In the first six trials, the students were motivated to raise questions, but the questions were not categorized in the five directions and presented in a content table form (see chapter 12, box 12.1). This led to confusion among the teachers in fully grasping the coherence among the four lessons. As a solution, the prior study is added (chapter 12, section 4.1), in which the 'global motive' of students' to solve the experienced unpleasant environment is connected to a series of activities answering their questions. This connection is made obvious in the content table for the teachers and the students to remind them about the direction of teaching and learning.

2.4.2 Participation

As envisioned in the design of the scenario, the students' engagement in problem solving is guaranteed when they are enabled to participate actively. Being aware that in the current education practice, there is a lack of visiting, observing, and hands-on activities to stimulate students' participation (see chapter 6, section 5), the scenario places more emphasis on these activities. Lesson 1 and 2 rely to a large extent on the students' daily observations of the notebook's life cycle, and encourage them to visit the stages involved when possible, such as stationery shops, a scrap station, and a garbage transfer station in their communities. Some teachers held a more positive attitude than others concerning the feasibility and necessity. Teacher C contributed the idea to organize an investigation as a prior study, in which the students visit and interview the available stakeholders. Teacher D, however, preferred to transfer the story line within a classroom setting. Other teachers shared a concern that the students may not be very enthusiastic about talking to cleaning workers or scrap pickers as available stakeholders, although it is practicable. *'In our school education, of course, the students know well enough to say, the cleaning workers are hard working and we should respect them. Well, after the class, what they really think of them can be different. I wouldn't be surprise to hear their parents warning them, no, no, keep away from those people.'* (Teacher G) In lesson 1 and 2 the students are invited to participate in hands-on activities of card patching and diagram drawing. In the eight trials, the teachers were satisfied with the technical support provided by the designer (i.e. the printed cards, mark pens, paper sheet etc.). Except for teacher E, who seriously considered preparing the needed tools independent from the designer's help, all others admitted it would otherwise be most inconvenient in their preparation for the scenario and might even hinder the implementation. As a solution, to ease the time strain, the scenario should be modified with the minimum possible time investment for the teachers. The Student's Manual is developed to offer all the needed technical support to make the students' participation easy to organize.

To know how to improve the students' skills in collecting and sharing information is welcomed by most of the teachers. As clarified in chapter 6 section 5, the students are fairly weak in collecting information. The scenario requires the students to complete a group task by applying their collected information. All the teachers could understand, and most among them highly favored the design intention.

2.4.3 Cooperation

The intention of cooperative learning was easily acceptable for all the teachers, though the quality largely depended on the teacher's supervision strategy, as we observed that a few teachers guided the group discussions in a more dominant way than the others. However, in their performances, all the teachers fairly met the requirement to involve the students in cooperative learning in every phase of the problem posing approach. As expected in the scenario, all the teachers could carry out class discussion in finding problems, proposing questions, and organizing group discussions for problem inquiry, solving and reflection.

Grouping was difficult firstly because of the large class size and limited number of audio recorders. A maximum of six groups per class was made, with group size varying from eight to fifteen. Grouping was self-generated in the first six cycles of trials, to make it more comfortable for the students to learn with others. As observed and explained by the teachers, self-generated grouping is either friendship-based or study-competence based. This is to say, grouping among friends passed off easily, while others with no tight relationship preferred to join the groups of 'good students', scoring high in exams. The difficulty in this form of grouping was classroom discipline. In the given large class size from 47 to 61 students, grouping is time consuming and hard to control. The students were running with their benches, calling names to join or leave, and in most cases ended with the finally outraged teacher yelling to get everyone settled. It is strongly recommended by the teachers, to proceed with grouping based on the students' seats in the classroom. As defended by the teachers, the existing seating arrangement was based on a thorough consideration to mix students of different study competences, and also to avoid distraction through personal relationships. The students are already used to work together in their existing groups of four, formed by the two sharing one desk and turn backwards to the other two sitting behind them, with group members sitting next to each other. Therefore, in the last two trials the students are grouped by merging two or three existing groups, making scaffolding with more competent peers possible. In the newly formed bigger groups, the leaders were nominated either by volunteering or group negotiation when the volunteer was not accepted. As indicated in the study of Nguyen (2008) on grouping in Confucian culture, and agreed with by the teachers, an award was given to the groups as an impetus for collective effort rather than to individual members within a group, since that might lead to an unhealthy competitive situation and hinder the cooperation.

2.5 Teacher

In the problem posing approach scenario, the teacher's role is crucial in keeping the balance between 'guiding from above' and 'guiding from below'. As intended, the teacher's role is guiding from 'above', as linking pin for the students to advance their knowledge development, with the structured sequence of learning activities. This vision was accepted by the teachers. And in their performances, all teachers proved to have adequate competence in guiding the learning process via focused 'local' support points on the learning tasks addressing the students' questions. Teachers held contrasting opinions on the vision that the teacher's role is guiding from 'below', from the students' own motives, knowledge, and questions. Teachers C, E and G fully recognized the value of this intention. As teacher G typically interpreted: *'This is answering the very question, why should the students learn, if not only because we want them to learn.'* Teachers A, B and H held a moderate position, in that they could understand this intention and were willing to implement it as the scenario designer expected, but remained suspicious. As teacher A stated: *'Very similar ideas have been promoted around the year 2003, 2004, in the initiation phase of the curriculum reform. We had experimented, but could not go further with it. Everything has fallen back to the traditional way, exam-oriented.'* Teacher D straightforward expressed that providing the story line of the scenario the students should follow would work most efficiently in terms of time and learning outcome. In the teachers' performances, some teachers (teacher C, E, F, G) showed more competence than others in offering supportive facilitation and being amenable to students' autonomous decisions in guiding the class discussions and group discussions.

In the design of the scenario, the teachers are envisioned as agents with their own view and ideology about education, who decide about curriculum and pedagogy. In the implementation, the teachers had freedom to define core concepts in their own words, inspire the students, guide the class discussion in their preferred form, and there was space for more capable teachers to make an extension. It should be noted that this vision does not imply that the teachers should come up with their own designs from their existing views and understanding. As the trials revealed, that would not be possible until the designer and the teachers had fully agreed about the intention of ideal environmental education envisioned from theoretical bases and the implementing obstacles in current settings.

Vos (2010) states that the first phase of implementation is always focused on faithful implementation, as all the teachers emphasized in their implementation; what concerned them most was to carry out the scenario as faithfully as possible to meet the design expectations.

2.6 Student

2.6.1 Critical role

Concerning the students' critical role, the scenario encouraged them to show multiple perspectives and disagreement with the teacher, as typically in lesson 4, debating on conflicting interests involved in the issue. In the classroom trials, as perceived and experienced by the teachers, such a debate was not easy for the students, since in traditional environmental education, the emphasis is on protecting the environment, without further reflection on consequent impacts on social welfare, economic profit, and the conflict between them. The majority of the teachers showed in their performances that students' varied answers and disagreements were welcomed. Teacher D, though favoring a teacher-centered approach, gave a rather open performance in encouraging students' different views in the class discussions.

2.6.2 Active role

The scenario assumes an active role from the students in taking the initiative in knowledge construction. The students are invited to propose questions not merely to show what they are interested in, but the questions create topics in the four lessons for the students to find answers from their own inquiry. In such a way, the students are motivated to extend their knowledge, in seeing why and what information needs to be collected, and why and what action should be taken. These visions received high appreciation among the teachers (teachers C, E, G) who had reflected about the students' initiation for meaningful learning. While others (teacher A, B, F, H) considered that it is still questionable whether the active role is necessary or can be achieved in exam-oriented education, teacher D claimed explicitly that a passive mode of learning is most efficient in the current educational context. Though perceived rather differently, in their teaching performances, all teachers proved their competence in encouraging the students to raise their own questions in the motivation and questioning phase.

2.7 Assessment

Ultimately, the scenario is aimed at fostering environmental literacy. In the design, the teachers measure the learning outcomes from every learning task by observation and evaluating to what extent the students showed the expected competence. Furthermore, the students perform self-evaluation in group negotiations and in whole class discussions.

In the final evaluation, the students have the opportunity to express and defend their own choices. What is counted is not whether the choice is correct, but whether the students' arguments show that they have understood how to apply a life cycle analysis to make environmentally friendly choices. In the teacher's preparation, this vision of assessment was applauded by all the teachers. *'In fact, I can recognize this is what is recommended in the new curriculum standard. When it's released, we have all been trained on it. At least I found the idea very nice, but it is only ideal education, different from what we are asked for in reality.'* (Teacher C) *'This is what we have dreamed of, but the question remains if it is possible?'* (Teacher H) *'If this can apply in our Chinese course, it's going to be marvelous. We will be too happy about it. Every kid becomes lovely by then, and the teacher student relation can only be pleasant.'* (Teacher G) Even teacher D admitted that such assessment largely relieves the teachers' workload and professional pressure, although she proved her competence within the current context as her class ranked highest in standard exams many times.

It can be said that all the teachers proved adequate competence to undertake the developmental, self-reflexive and democratic assessment, for instance, by giving affirmative comments, inviting the students for self-evaluation, clarifying that what matters in the final test are the concerns showed in arguing rather than a single correct choice. However, all the teachers reported that they lacked confidence in making an evaluation of what are valid solutions for the mutual benefit of environmental and socioeconomic impacts. The scenario is therefore modified by adding exemplary solutions with illustrations of the principle of increasing resource supplying capacity and self-cleaning capacity of the environment.

3 From potentially implemented to implemented scenario: the operational scenario

3.1 Motivation and question: prior study

Activity 1: Introduction

In the first version of the introduction, the information stated roughly that this four-lesson unit is about the environment, and that it is an experimental, participative, and innovative lesson unit. In the first two trials, teacher A and B were inclined to add the learning goal of the unit. As they were used to in conventional teaching practices, for the students to foresee the direction of learning, the teachers summarized the didactical purpose in one sentence, as illustrated in teacher A's words:

'We have been producing many commodities for our daily use. On one hand, the products provided us convenience, but on the other hand, it resulted in natural resource depletion and pollution. Nowadays, these problems are getting more and more attention. Today, let's study how we in our daily behavior are affecting the environment directly and indirectly.'

In the problem posing approach, the motivation phase is also intended to induce a direction of learning. However, the learning purpose is foreseeable only in the sense that it is serving the students' existing need of learning. Unlike in the teacher-directed approach, the purpose is not directly concluded by the teacher. After discussions, the two teachers understood and accepted the idea that as a motivation phase, the entire prior study is intended to induce the students to see the purpose via a guided reasoning process, instead of telling them the conclusion already in the first sentence of the lesson. The introduction remained to present the features of the unit, and in particular the features of the inquiry-based learning approach with a focus on the role the students have, and how they are going to learn (see final version in chapter 12).

Activity 2: Motivating

As intended, the motivating is meant for the students to reason about the purpose, the direction of learning as it starts from their own defined problems. The students are guided to reason in such a way in response to the teacher's questions. In the initial plan, the intended 'global motive', a want for a 'better environment' was not yet provided. It was not yet clear whether the students would wish to have a 'better environment' and would be willing to contribute to it. The motivating questions were initially phrased as follows:

1) What is environment? 2) What environmental problems do you know? 3) How are these problems related to you?

From the first four trials, the students' responses to question 1 contributed the following findings. The students' definitions of the environment showed their basic understanding of the coexistence of man and other species in the ecosystem (e.g. the environment is a big family of all kinds of species), the interrelationship between man and the environment (e.g. the environment is the living condition for man; the environment is what we should protect), and most importantly their appreciation of the enjoyable side of the environment as evidenced by all the adjectives they use to describe the environment (e.g. environment includes fresh air, lovely animals; environment is the beautiful scene around us.) The students' definitions proved us that their concept of environment corresponds with the rationale of our design underlying the scenario (see chapter 12, section 2.12). Their definitions also provided first evidence that the 'global motive', a want for a 'better environment' stands. The answers to question 2 revealed the student's very broad prior knowledge on existing environmental problems, however, mess of litter still is mentioned most frequency among the problems. The answers confirmed the need to pay special attention to the student's broader understanding of environmental problems after having an overview of the entire material flow. The students' answer also revealed that the question of *'What environmental problems do you know?'* could not logically guide them to express whether and why they are willing to solve these problems. Therefore, in the fifth and sixth trials, one other question was added, *'In Golmud, what problems did you experience?'* The students' answers to this question indicated that compared to simply listing the environmental problems they know, describing the experienced problems showed their desire for a 'better environment'. With this finding, in the last two trials the second question was rephrased as: *2) What environmental problems did you experience? Can you describe your sensation when it happened to you?* With this modified question 2, the students were invited to describe the experienced problem as a physical or emotional sensation, and the unpleasant experiences logically revealed the students' desire for a 'better environment'.

The students' answers in first six trials showed that the phrasing of question 3 was the most problematic. In answering question 3, the students as expected could hardly relate to their regular use of commodities. In the answers from six classes, only one student could respond as expected: *'When we use a fridge or air conditioner, the Freon is possibly causing ozone depletion.'* All other answers can be clustered into two types: interpreting the relation as the effect environmental problems have on them, for instance, litter may cause the spread of disease and harm their health; and interpreting the relation as a responsibility to take action to solve the problems, but from the design intention, proposing actions before any inquiry was made. In motivating, it is merely to guide the students to realize their own desire, as motivated from unpleasant experiences, for a 'better environment' and to prove their willingness or the recognized responsible role to contribute to solving the problems. Question 3 was therefore modified: *3) Do you like that experience? Are you wishing to solve the problem? Who should be responsible for solving the problem? Are you playing a role?* The last two trials showed that the students' answers to this modified question were clear and affirmative.

The discussions with the teachers also pointed to a need in the scenario for additional support for the teachers to be able to guide the students in relating the environmental problems to our need of daily commodities and how we deal with them. From this concern, the learning activity of *'specifying'* is added in last two trials (see in next section).

Activity 3: Specifying

In specifying, the teacher guides the students to realize that environmental problems evolved mostly because of people's need for commodities, and then helps them to focus on one regular commodity in their daily use, i.e. the paper notebook. The teachers were expected to summarize the students' answers to the three modified questions and guide them to understand that our need for commodities and how we deal with commodities explain most of our relation with the environment. In the classroom trials only one problem mentioned by the students went beyond the relation via commodity, namely, quite a number of students mentioned spitting everywhere as their experienced environmental problem, which cannot be concluded to be in relation to a commodity. From the students' answers evoked in the trials, a paragraph was written, illustrating the teachers how to make such a specification.

For example, the garbage, before it was dumped, was a commodity for our use; air and water pollution from mills evolved in producing commodities for our use, and deforestation is because we need timber to make desks, chairs etc.

The last two trials proved the necessity of adding such an illustration, from where the teachers could easily further specify that this teaching-learning unit will take the paper notebook as an example of the regular use of commodities, from which the students analyze its relation to the environment in detail.

Activity 4: Questioning

Since the first trial, the students reacted as expected in proposing their inquiries about the paper notebook in its relation to the environment. When asked by the teachers the following questions:

In order to understand the paper notebook in its relation to the environment, what do we need to know? On which aspects we need to do investigations?

The students' answers were clearly pointing in five directions: what it is made of, where it is coming from, where it is going to, what the evoked effect is, what to do to reduce the negative environmental effect, and lastly how other commodities are related to the environment since some students might come up with questions showing interests other than the paper notebook. However, in the first four trials, these five directions were not noted in the scenario, but the teachers were implicitly expected to just keep in mind that these questions were the main topics of all four lessons. As a consequence, the didactical structure was not fully understood by the first four participant teachers until they had completed all the four lessons. A crucial modification was made in which the teacher categorized the students' questions based on the five directions and noted them down on the blackboard showing learning tasks in each of the proceeding lessons.

Activity 5: Summarizing

Since the fifth trial, the teachers were required to summarize the questions proposed by the students based on the above five directions to make a preview on the board showing the main content of the lessons (see chapter 12, box 12.1). In the later teachers' performance, they all showed adequate competence in making the summary and giving the review. On the Students' Group Work Sheet, the students are giving spaces to note down 'lessons list', to make the preview of the proceeding learning tasks explicit and accessible.

Under the 'global motive' to improve their understanding about our commodities in relation to the environment, the students are invited to propose their own questions to specifically extend their knowledge about the paper notebook. A series of questions formulated by the students is summarized by the teacher based on the five directions of a life cycle analysis of the paper notebook, and addressed in the four lessons respectively. In such a way, the students are enabled to see coherently what they are going to learn in each lesson and why they have to learn that. In other words, in every stage the study topic is planned from the 'bottom up', the students' own derived questions, while the teacher is taking a supportive role, that of facilitator guiding from 'above'.

The assignment was a modification since the seventh trial, when the prior study was separated from the first lesson. In the first six trials, the teachers suggested the necessity of having such an investigation before the lessons began, but having a separate prior study was not possible due to the available course hours. In the modified prior study, the students received a home assignment preparing for lesson 1, to perform an investigation into the first three directions of questions with commended methods such as internet searches, book references, and interviewing available stakeholders.

3.2 Investigation: lesson 1 life cycle of the paper notebook

Activity 1: Introduction

In the first version of the design, the function of the introduction was to motivate and question, as it is now in the prior study. Since the seventh trial the prior study is separated from lesson 1 with modifications according to the teachers' operations and suggestions. In the last version, therefore the introduction of lesson 1 is merely to review the 'lessons list' and to introduce the main learning activities of the lesson (see chapter 12, section 4.2).

Activity 2: Diagram of the resource flow

In the trial design of the first six cycles, the diagram of the resource flow was drawn by patching and connecting the printed photo cards (see chapter 12, box 12.3). The teachers demonstrated on the blackboard how to construct the diagram, with the help of magnets (see photo A in box 13.1). The observations showed that the resource flow photo cards resulted in a clear understanding by the students. Except for one card, the 'stationery factory', in the students' answers they preferred the concept 'printer's'; therefore the card is renamed to match their concept. In the post interviews, all the teachers shared their appreciation of convenience of the photo cards and magnets, which made their demonstration vivid. However, five out the six teachers denied the possibility of preparing these tools themselves. They reported that such preparation would not be affordable under their workload and time pressure. This will be a simple but crucial obstacle to hinder the future implementation after the design study. Therefore, as a solution, the Students' Group Work Sheet is designed in addition to the Teacher's Manual and applied in the last two cycles. In the work sheet, the students were shown the photo card lists (in box 12.3). The students were asked to fill in the blanks (in box 12.4) when the teacher demonstrated the resource flow diagram, as a result of the collective class discussion. With the aid of the work sheet, in the last two trials the teachers' demonstrations were conducted in handwriting on the blackboard without using the printed cut cards (in box 13.1 photo B).

Regardless of the form of demonstration with cards patching or handwriting, several points for modification were identified on the basis of the teachers' performance. First, the teacher may misunderstand the direction of the arrows in drawing the connection lines, as happened with one teacher during the trials. The modification is an added notice to explain that the arrows in a resource flow should head to 'I', meaning 'I am getting it from', so that in the waste flow the arrows go further ahead to a final destination and facilitate a cycle. Second, an added explanation was that the resource flow answers two questions, 'where it is coming from' and 'what it is made from'; therefore, the photo cards are of two types, materials and stages. The first three teachers either forgot or found it difficult to patch the material cards. Third, the definition of resource flow was removed. In the first two trials, the teachers were worried that their environmental knowledge was not sufficient to grasp fully the new concept of material flow. Therefore, a knowledge card with correct definitions was provided in the teacher's manual. After six trials, the teachers' performance showed that the given definition had kept the teachers from using their own words, since they were merely reading it to the class. In the last two trials, the scenario suggested the teachers to summarize their own interpretation of the resource flow from the diagram; all of them performed fairly well as expected. Finally, time management is crucial; it took 5 to 22 minutes to complete the diagram drawing based on a guided class discussion. It was time consuming, since in the first six trials, only the teachers had the printed photo cards, and the students did not have the reference to know in which scope they were expected to respond the teacher's questions. The varied answers increased the difficulty and time needed for the teachers to link their answers to the given cards. In the last two trials, with the aid of the Student's Group Work Sheet in which the resource flow photo cards were listed in each group, the students' answers were very much focused and simplified the class discussion within a largely reduced amount of time.

Box 13.1: Teacher's demonstration of resource flow diagram on the blackboard

Photo A: with printed cards (in trial 1-6)

Photo B: by handwriting (in trial 7-8)

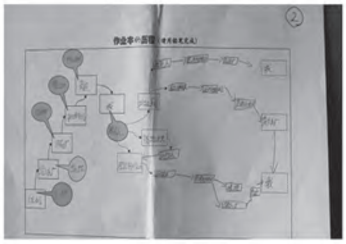
Activity 3: Diagram of the waste flow

In the design trialed in the first six cycles, working in groups, the students drew the diagram of the resource flow by patching and connecting the printed photo cards, with the help of cards, mark pens, glue, and paper sheet (box 13.2, photo A). For applicable reasons, in the last two trials, the activity changed to filling the blanks in referring to listed photo cards (box 13.2, photo B). The observations showed a clear understanding of the cards by the students. The observations suggested several modifications. In the first trial, two of the four groups came up with linear diagrams, from overly following the teachers' demonstrated resource flow, which is a linear diagram with a single line. This finding revealed a need for the teacher to demonstrate possible ways to inspire the students' multidimensional thinking in the first step.

Box 13.2: Students' group work on the waste flow diagram

Photo A: with printed cards (in trial 1-6)

Photo B: with work sheet (in trial 7-8)



Second, the group discussions revealed that some students were still confused that the task was to show how they thought the waste paper should be disposed of. In modification, the teachers were advised to emphasize that the task was to draw the diagram based on what are the actual practices according to their experiences or observation in reality. Third, in the first six trials, a differentiation was made between *'waste flow'* and *'recycling flow'*. The teachers post interview revealed that together with the concept *'resource flow'*, the differentiation may cause confusion. It is more obvious to differentiate only the *'resource flow'* and *'waste flow'*, but it should be noted that in the waste flow, some waste is recycled. Therefore, since the seventh trial, the concept of *'recycling flow'* was skipped. Fourth, the definitions of *waste flow* and the related concepts of *primary resource, recycled resource,* and *recycled paper* were skipped since the seventh trial, but the teachers adequately described these from their own understanding. Fifth, the first four trials proved that grouping is too time consuming and difficult to organize, simply for the reason of class sizes. In the first six trials self-generated groups needed to change their seats and replace their desks to make a circle for everyone to participate in drawing the diagram, which became a chaotic classroom situation. The big group size (12-15) also caused poor participation, as there is no space to make the patching work easily observable for everyone. In a modification since the fifth trial, the group size was reduced to 8-9 students, but six groups were formed in a class which made it no more possible for every group to present their results. In last two trials, convenient and traditional grouping solved the problem of reorganizing the seats. Basically, two existing groups with four students sharing desks in the same row were joining into one new group. At last, concerning the time management within the group learning task, in last two trials, with the aid of the Students' Group Work Sheet the group task has largely reduced the needed time.

3.3 Investigation: lesson 2 impact of the paper notebook

Activity 1: Introduction

In the first six trials, lesson 2 started with an introduction of the main learning activities, i.e. in class discussion review the card patching results of the material flow diagram of lesson 3, and then patch effect cards on the collectively concluded diagram either in group discussion (1-4 trials) or in class discussion (5-6 trials). Since the seventh trials, lesson 2 began with reviewing the lessons list showing the addressed questions (see box 12.1).

Activity 2: Review

For the review, the resource flow diagram was made ready on the blackboard by card patching in the first six trials, or in handwriting in the last two trials (see box 13.3, photos A and B). Here it is the only modification, merely technical, since the Students' Group Work Sheet was made in the last two trials, in which the groups can save their first lesson results and can access the photo card list. With the resource flow diagram on board, the teacher guided the class to review briefly the concept of resource flow and the involved stages.

The review of the waste flow was also conducted in a whole class discussion. The teachers asked the students to state what they thought of each sequential step. When someone raised a hand and gave an answer, the teacher confirmed with the class whether or not they agreed. The students therefore reached a consensus of the waste flow diagram drawn on the blackboard by the teachers in handwriting (see box 13.3, photo C). From the concluded entire material flow diagram, the teachers guided the class to review the concepts of *resource flow*, *waste flow*, *primary resource*, *recycled resource*, and *recycled paper*. The teachers also guided the students to summarize the three final destinations in the waste flow, i.e. landfill, open burning, and recycling. And then a discussion was started to realize the critical role of 'I'.

The classroom trials proved that reviewing the material flow was within the scope of students' prior knowledge. The students could provide answers by relating to their daily life observations, for example: *'Some scrap pickers also pick recyclable waste in landfills or in open dumps; I met some of them in suburbs when I went to my grandmother's house.'* (In trial 7) Shared from each others' life experiences, in the class review, the students extended their knowledge of all possible steps

Box 13.3: Review of material flow diagram on the blackboard

Photo A: resource flow with cards (in trial 1-6)

Photo B: resource flow with handwriting (in trial 7-8)

Photo C: waste flow with handwriting (in trial 1-8)

and in the end collectively reached a conclusion on the waste flow in reality. The teachers' performances varied according to their understandings of the intention of the design. Compared to others, teacher D and F showed a low involvement in preparing the lesson. Teacher D skipped more than half the steps in reviewing the waste flow, though after being reminded she could easily complete all steps. She also forgot to summarize the three final destinations (open burning, landfill, recycling) which was a base to invite the students to discuss the role of 'I'. Teacher F who conducted the trial together with teacher E near the end of the semester, stated many times that she was not in a good condition to test the experimental lessons because of the final exam pressure. Nevertheless, teacher E held the opposite opinion, *'I find it not necessary to be nervous. The students learned what could be learned during the entire semester, not from the last few days' enforcement.'* Teacher F merely read the given definitions in the Teacher's Manual in reviewing the concept of *resource flow, waste flow*, *primary resource, recycled resource, and recycled paper,* since she did not have enough time to digest these concepts herself. While teacher E performed in a more confident and flexible way, she asked the students to share in pairs what they understood about the concepts from the reviewed material flow diagram drawn on the blackboard.

In guiding the students to discuss the role of 'I', most of the teachers could interpret the role in their own words, except teacher F who stopped suddenly and questioned how to guide the students to notice the criticalness of the role of 'I'. After an explanation by the designer, teacher F continued the class but again merely by reading the given explanation in the manual. In comparison, teacher G performed excellently in guiding the students to realize the critical role of 'I'.

Teacher G: Look at the arrows going in and out of 'I'. What do you see? What do you find from the diagram?

Student 1: I see that 'I' am the origin of all the arrows, all the lines.

Student 2: What I understand from the diagram is: if I don't use a notebook, there will be no diagrams like this at all.

Activity 3: Impacts of paper notebook

The form of the students' discussion on the involved impacts has been modified twice. In the first four trials, after the review, the teachers demonstrated the resource flow by patching impact cards to the related stage cards (see box 13.4, photo A). Then the students completed the impact card patching on the waste flow in groups, but they first needed to copy the collectively constructed waste flow diagram on the given plain paper sheet (see box 13.4, photo B), because the group results of the first lesson consisted of patched glued cards and could not be re-edited.

Box 13.4: Discussion on impact in material flow (trial 1-4)

Photo A: Teacher in demonstrating card patching on the resource flow (in trial 1-4)

Photo B: Student's work of card patching on the waste flow (in trial 1-4)

To simplify this group work procedure and for reasons of time management, the solution tried in the fifth and sixth trials was that in the class discussion, every student was assigned one or two impact cards, and would go up to the blackboard to patch the impact cards on the concluded material flow and provide an argument for his or her choice (see box 13.5, photo A). As shown on the photo, the flaw of this method was obvious, namely, the diagram became too full with cards to be easily readable. Finally, in the last two trials, the Students' Group Work Sheet was made, in which the groups could save their results of the material flow diagram and edit it, and could also access the impact card photo lists (as in box 12.7, 12.8, chapter 12). The teachers demonstrated on the blackboard how to note card numbers to mark the stages in the reviewed resource flow. And then the students, on their work sheets, could associate the impact cards with the stage numbers in the reviewed waste flow (see box 13.5, photos B and C).

Box 13.5: Discussion on impacts in material flow (trial 5-8)

Photo A: Class card patching on the entire material (in trial 5-6)	Photo B: Teacher in noting numbers on the resource on flow (in trial 7-8)	Photo C: Students' marked numbers the waste flow (in trial 7-8)
		

Another modification was the change of impact photo cards. In the first six trials the cards of 'air pollution' and 'water pollution' were made in addition to 'discharge' and 'waste water' with an intention to help the students understand that emissions to water and air may lead to water and air pollution. However, the observations showed that students' prior knowledge was sufficient to link the impact to further possible environmental consequences, for instance, discharges may lead to air pollution, and deforestation may result in a sandstorm or a landslide. Therefore, in the final version, the cards of 'air pollution' and 'water pollution' were removed from the list. The card of 'encountered health threat' was renamed to 'health threat to these people', because the latter proved to be misleading in the students' discussion. Most students understood 'encountered health threat' as threat to people in general, but the design intention was to draw the students' attention to the health risks encountered by the cleaning workers, scrap pickers, and scrap purchasers in particular.

The classroom trials proved that discussing the impact of the material flow was within the scope of prior knowledge of most students, but it also gives space for the better informed students to go beyond. Students could already go one step further in mentioning the possible further consequences, for example, the biogas emitted in the landfill is dangerous if it blasts at high temperature, and it is a cause of the greenhouse impact when burned. The students also showed their critical view. In the first four trials when the teachers were demonstrating the impact cards patching on the resource flow, some students were already able to mention not only the environmental impact, but also for instance, the monetary investment and profit and the labor needed, though at that time the teachers had not yet shown these cards to the students. Some students already pointed out that the *recycled resource* is not perfect, since producing *recycled paper* requires energy investment and produces waste too.

The majority of the teachers demonstrated sufficient competence and prior knowledge in guiding the students' discussion on the impact of the material flow. There was space for more capable teachers to make an extension. Teacher A could beautifully relate the impact of 'deforestation' to a Chinese lesson which told a story on the same topic. Teacher B, after reviewing the concepts, extended them with a discussion to compare *primary resource* with *recycled resource*, which was not required in the scenario. However, in teacher F's class, because of the mistake in organizing the students to come up to the board to put up their impact cards, the classroom turned chaotic. There were too many students at once placing cards on the board, and it was too crowded for other students to observe what was going on and give feedback. The resulted card patching had too many overlaps; for instance, the students who had the 'income' cards put all the cards at the 'stationery shop' stage, but in fact there are more stages having income in the diagram. After discussions with the observing designer, teacher F started to guide the card patching correctly. However, after three minutes, she had to quit because the cards were too full and too complicated to sort. The observant designer had to replace teacher F to complete correcting the placement of the remaining cards.

3.4 Application: lesson 3 making choices

Activity 1: Introduction

In the first six trials, lesson 3 started with briefly reviewing what students learned in lessons 1 and 2, and then introducing the main learning activities, i.e. to review in class the impact cards patching results in order to reach a conclusion collectively; and then in group work to make choices about what to do to reduce the unwanted impacts. Since the seventh trials, lesson 3 began with reviewing the lessons lists (see box 12.1, chapter 12).

Activity 2: Review

The main task in the review was to review the impacts in the material flow and the previously discussed concepts, i.e. *resource flow, waste flow, primary resource, recycled resource, recycled paper, and the role of 'I'.* However, the form of reviewing was modified several times. In trials 1, 2, 3, 4, 7 and 8 of lesson 2, the students discussed the impacts in groups. Therefore, in lesson 3, the students were requested to review and modify their group results. The review was based on the material flow diagram collectively constructed in lesson 2. Technically, at end of lesson 2, a photo or a note was taken of the constructed material flow diagram, and before lesson 3 began this was copied in handwriting on a plain paper sheet (in trials 1 to 4) or on the blackboard (in trials 7 and 8) (see box 13.6, photos A and B).

Box 13.6: Recovered conclusion of material flow of lesson 2

Photo A: On paper sheet (in trial 1 to 4)

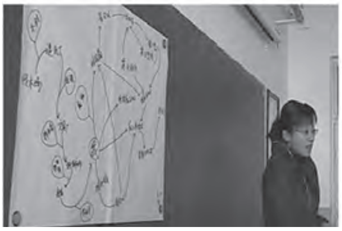


Photo B: On board (in trials 7 and 8)

The review was conducted in a class discussion, in which each student was provided with 1 or 2 impact cards. The teachers organized that the students went up to the blackboard one by one to put up their cards. After each student reported, the class provided the feedback, to affirm or to argue for a change. In the whole class discussion, the students therefore reached a consensus of impacts involved in the material flow (see box 13.7, photos A and B). From the collectively discussed results, the teachers guided the students to review the concepts learned in the previous two lessons, either in the teachers' words (teachers B, D, H) or by asking students to summarize in their own words (teachers A, C, G).

Box 13.7: Class conclusion of the impact in the material flow

Photo A: Card patching on paper sheet (in trial 1 to 4)

Photo B: Marking number on the blackboard (in trial 7,8)

In trials 5 and 6 of lesson 2, the students had discussed the impact in the whole class and had therefore already collectively reached agreement. At the end of lesson 2, the results were saved in photos and copied in handwriting on a plain paper sheet before the start of lesson 3 (see box 13.8, photos A and B). On this basis, the teachers reviewed the concepts in the previous two lessons in their own words.

Box 13.8: Review of the impacts in material flow in trial 5,6

Photo A: Recovered conclusion of material flow of lesson 2

Photo B: Class conclusion of the impacts in material flow

In the review, it is important that the teacher guides the students to share their perception about the cleaning workers, scrap pickers, and scrap purchasers, raising the following questions:

What is your impression of the cleaning workers/scrap pickers/scrap purchasers? What is your observation of what they do for a living? Do you have any experiences/communications with them? How do you perceive their roles in the waste flow of your paper notebooks?

The teacher encourages the students to express freely and honestly their thoughts about the people at first, and then summarized from the discussion about these people's role as the main force of recycling in China's solid waste management. An illustrative phrase is given in the Teacher's Manual (see box 12.12, chapter 12).

In terms of the teachers' performance, after two lessons of teaching, all of them showed more confidence in reviewing the environmental and socio-economic impacts and the previously learned concepts. All the teachers could explain the concepts in their own words. The observations proved that the knowledge about impacts fitted in well with the prior knowledge of most of the students.

Activity 3: Making choices

The group task was to make choices in buying, using, and disposing of notebooks. This task, however, was modified several times in determining for what purpose and at which level of reflection the students made these choices. After the review, in trials 1 to 6, the teachers summarized the impacts in three categories: environmental, including pollution and depletion; economic, including income; and social, including job opportunity and health threats. Then the teacher asked the students for their attitude on each category of impact, whether it was wanted or unwanted, or whether they were uncertain about it. The students' attitudes were rather identical. The wanted impact was income, the unwanted impacts were all types of pollution or depletion and health threats, and the uncertain impact was job opportunity. The explanation was that for scrap pickers, purchasers, and cleaning workers, it is good to have a job but the job is not healthy. In the discussions with the teachers, it was debated whether health threats should be categorized as an environmental or social impact. To most of the teachers' understanding, the health threat is an impact on involved people, so that it is more reasonable to consider it as a social impact. Another debate was on whether the categorization was understandable for the students, since the teachers were worried that the terms 'social' and 'economical' were too abstract for fifth grade students. Nevertheless, differentiating the impact in environmental, economical, and social impact was intended to point out to the students the complex and contradicting nature of the solid waste management. It was expected that noticing the three types of impact, the students may have more awareness and freedom to express critical views and avoid socially desirable answers, namely, just thinking of how to reduce a negative environmental impact. However, in trials 1 to 4 after the teachers asked the students to make choices to reduce unwanted impacts, the students' group discussions were all about how to avoid the unwanted environmental impacts, but ignored the loss of income or job opportunity in consequence. In trials 5 and 6, to encourage the students to make more careful choices and avoid too quickly merely put weight on the environmental impact, a modification was made that the teachers elaborated more thoroughly to the students to understand the conflict among the different types of impact, before the students make choices in groups. As teacher F illustrated by the following examples:

'Before we enter the group task to make your choice, have you noticed this? When the environmental impact is reduced, our wanted other impact is reduced too. For example, we often say, to save paper, but look at the paper mill. When we use less, buy less, the mill has to produce less paper. This means a reduced income, and perhaps even a cut in employment. This is a dilemma. Again, the scrap pickers, many of you said there are health threats for these people, but can they not pick garbage for a living? This is their only way of gaining an income. Here is the contradiction. Now, knowing the contraction, do you have a good solution to solve the problem? Protecting the environment, but at the same time, doing no damage to income and health. Do you have such solutions?'

In the students' group discussions, the students still mainly stated that the environmental loss is unwanted, but few students mentioned they didn't know that the workers in printers' or paper mills could lose their job. And few students showed understanding of the contradiction and tried to figure out win-win solutions, in one example:

Student X: I don't want air pollution, because it can smell bad and harm our health.
Student Y: But it is impossible that we do not use notebooks anymore.
Student Z: We may plant more trees.
Student Y: But they are gone when we cut them all down.

The groups' results on solutions for buying, using, and disposing of notebooks remained focused on reducing environmental impacts only. However, after the teachers' thorough elaborations in trial 5 and 6, in audio-taped group discussions, some stated answers showed concerns about the contradiction among the impacts, as was intended in the design.

The reflection with the teachers revealed structural errors in categorizing the three types of impact. First, the 'social' and 'economical' proved to be too abstract for the students. As in their narrations in group or class discussions, the students could refer rarely to these terms. Second, there was a problem with categorizing social impacts. In social impact there was the uncertain impact of job opportunity and the unwanted impact of health threats. Therefore it was impossible for the students to define which type of impact was unwanted. And it made no sense to develop a black-and-white attitude to the three types of impact. On the one hand, in the students' uncertain attitudes, they could, as expected, be aware of the complex issue of social welfare of the involved people. On the other hand, however, such uncertainty was poorly considered in making choices in buying, using, and disposing of notebooks. In trials 7 and 8, the modification was to skip the environmental-social-economic categorization, but simply ask what specific impact was unwanted. All the unwanted impacts, including health threats, could be more suitably taken as environmental impacts and sorted into pollution, depletion, aesthetic loss and sanitary & health threat, in line with our understanding of human-environment interaction which underlies the design of the scenario (see figure 12.1, chapter 12). Already in lesson 2, after the discussion on impacts, the students may show their attitude to unwanted impacts and sort them into the four types of environmental impacts. After proposing solutions merely to solve environmental problems in lesson 3, finding win-win solutions concerning the balance among environmental, social, economic impacts should be taken as a task at a higher level and to be discussed in lesson 4.

Therefore, in lesson 3 of trials 7 and 8, the categorization was skipped. Instead, a class discussion was held on environmental problems related to the impacts, i.e. deforestation, emissions, waste water, energy consumption, and biogas emission. On the Students Group Work Sheet an exercise was listed accordingly (see box 12.10, chapter 12). As the first six trials revealed that biogas emission was beyond the prior knowledge of most teachers and students, in the last two trials a knowledge card was provided in the teachers' manual and the students' work sheet (see box 12.11, chapter 12). Then the teachers asked the students to discuss in groups how to reduce unwanted environmental impacts.

In terms of the students' group task, in trials 1 to 4 it was intended to reduce the unwanted impact in making choices of buying, using, and disposing of notebooks, and in trials 5 and 6 with an emphasized notice on the contradiction among environmental, social, and economical impacts. In trials 7 and 8 the group task was to making choices merely for reducing the environmental impact.

In terms of the teachers' performances, all showed adequate competence in categorizing impacts, and/or in elaborating the contradictions in impacts. After the mistake in lesson 2, teacher F became willing to spend more time in preparation and performed finely as expected in lesson 3. Teacher G again showed a beautiful example of inducing the student to make choices in buying, using, and disposing.

Teacher : Tell me, how, in which way, your notebook comes to your hand? In one word.
Class: Buying.
Teacher G: What do you do with it? One word.
Class: Using… writing.
Teacher G: After using, then?
Class: Disposing…Throwing away.

3.5 Reflection: lesson 4 environmentally friendly choices

Activity 1: Introduction

In the first six trials, the teachers reviewed the content of the previous three lessons and introduced the main task in lesson 4, i.e. to share the group discussion results of lesson 3 on the choices in buying, using, and disposing of notebooks; and to make a test in groups consisting of assessment on environmental concerns related to other stationery items that are used daily. In the last two trials, the suggestion to start with reviewing the 'lessons list' was included in the teacher's manual.

Activity 2: Review

In the review, the basic task was that the teachers guided the class to review the group results of choices in buying, using, and disposing notebooks and to categorize the choices by the 3R principle. How to make the review and categorization has been tested in several rounds to find the best applicable practices.

In reviewing the group results of lesson 3, the teachers had freedom to do it according to their preferences. Some read the group results to the class (teachers A and E), some preferred to invite each group to report one of their choices (teachers C, D, G and H), or skipped the group presentation, but shared the group results in making a summary on the blackboard (teacher B), or asked one group to present all their result and then the others to complement (teacher F). The observations showed that teacher F's practice was most efficient in time management and at the same time gave space for the students to argue their choices. Therefore this practice is recommended in the final design (as presented in chapter 12, section 4). In sharing the group results, most of the teachers asked the students to present their choices with argumentations. Teacher B and E did not ask for argumentation, and in consequence the next activity, assessing changes in involved impacts through the 3R actions, became more time consuming. Therefore, in the final version, the teachers are recommended to invite the students to report their choices together with explanations of how their choices may contribute to reducing unwanted environmental impacts, in order to help them understand the changed impacts through the 3R actions. In noting the choices on the board, in the first six trials, as the scenario recommended, most of the teachers made the blackboard notes as follows:

Reducing: make fewer mistakes to save space, write till the page is full
Reusing: use the back side as scratch paper, make paper crafts
Recycling: scrap selling, give it to scrap pickers

Teacher C took another form in making notes on the board, in which the choices were listed first by the three aspects buying, using and disposing of, similar to how the students presented their group discussion results, and then recognized and sorted the choices using the 3R principle. The reflection with the teachers reveals that this form of board notes is convenient in that it is more obvious for the students to understand how the 3R principle is applied in sorting their choices, and easier for the teachers to introduce the categories. Therefore, in the final version, the recommended form of board notes is by first listing the choices in buying, using, and disposing of, and then giving different marks to the choices that fit the principles of reducing, reusing, recycling (chapter 12, box 12.14).

In terms of the teachers' performance in reviewing the students' choices, all the teachers were able to probe for specified actions when the answers were vague or general, e.g. to save paper, and not to spoil. Teachers D, E, F and G paid special attention on the practicability of the students' choices. For instance, for the answer to write Chinese characters smaller to save space, teacher G remarked that too small writing is unhealthy for the eyes, and therefore not practicable in reality. The teachers had freedom to categorize the choices in their preferences. Most of the teachers took an inductive approach (except teacher C who took a deductive approach). For instance, in naming several choices such as to buy double-side printed notebooks, to make fewer mistakes in writing, the teachers asked the students what common features they see from the choices, and then to induce the principle of reducing. Only in teacher D's performance, the students were not induced to find common features, but teacher D directly named the choices using the 3R principle. With their prior knowledge, the teachers can make the categorization correct and self-exclusive for most of the students' answers. Only in the class of trial 7, one student proposed to buy notebooks made from materials other than wood, such as straw, for the sake of its shorter growth cycle. Teacher G in trial 7 could not decide how to categorize this choice by the 3R principle, and had to consult the designer during the class. This choice was sorted as reducing, since using alternative materials for paper producing will reduce the consumption of primary wood resource. Moreover, choosing paper from alternative resources implied a valuable consideration of sustainably consuming within the carrying capacity of the plantation as well as a perspective to search ways to enlarge available resources for support of people's needs.

As observed, in presenting their argued choices, the students already showed critical understanding of the changes made on the involved impacts. Some students could already point out that recycling is not a perfect solution, since in making the recycled paper, the pollution or depletion may not necessarily be less than in making paper from primary resources. The proposed solutions already went beyond the 3R and mentioned practices of replacing and recovering. For instance, we may refuse to use paper notebooks and do assignments in digital form on computers, we may write on a small blackboard and erase our writings afterwards; we may buy notebooks made from other materials such as straw, bamboo and clothing; we may use waste paper for fuel. In categorizing the choices using the 3R principle, instead of the recommended term 'xun huan li yong' meaning recycling for utilizing, very frequently the students termed recycling as second time utilizing, 'er ci li yong' in Chinese which is literally confusing with reusing. Knowing this possible misleading terminology, in the last version the recommended 3R translation for future dissemination was: reducing, 'jian liang', literally 'minimisation'; reusing, 'chong fu shi yong', literally meaning 'use more than once in its own form'; recyclem 'zi yuan hui shou', literally meaning 'recycling as a resource'.

In the first six trials, the students' group results on disposing frequently mentioned not to litter. Therefore, in the last version, after the review, the scenario reminded the teachers to guide the students to compare the disposing choices on the changed environmental impacts i.e. pollution, depletion, aesthetic loss and sanitary & health threat. With this modification, the emphasis is placed on realizing the value of disposing choices from a comprehensive view on environmental impacts. With the scenario, after having a systematic view on the involved impacts in the entire material flow, the students should be able to make various choices including 'not litter', unlike the observed common practices in behaviorism style, in which 'not litter' was taken as an only definite choice. In fact from the material flow viewpoint, from 'litter' to 'not litter' there is only one step in difference, i.e.

someone has to pick it up. The impact involved is mainly sanitary threat and aesthetic loss, and no difference is made for pollution in the production stage or on depletion.

Activity 3: 3R principle and environmentally friendly choices

After categorizing the reviewed choices in buying, using, and disposing of notebooks, the teachers guided the students to reflect on their choices in assessing the changes made on environmental impacts, left aside other impacts (the contradiction was to be debated later). Although in the first six trials, the students were encouraged to make choices for any of the three types of impact (social, economic, and environmental), the students' choices were merely aimed at reducing unwanted environmental impacts. In addition, already since lesson 3 of trial 1, the structural error in categorizing the three types of impacts, i.e. social, economical, and environmental, was revealed. It is suggested that win-win solutions should be discussed at a higher level, after the students thoroughly inquired into environmental impacts.

In guiding the students to reflect on their 3R choices in assessing the changes made on environmental impacts, there was difficulty for the teachers in digesting fully how reducing, reusing, and recycling lead to changes in the environmental impacts within the very short time available for teaching preparation (about 20-45 minutes). Therefore the problematic differentiation of 'resource flow', 'waste flow', and 'recycling flow' proved to be confusing for the teachers especially in the first six trials. The problem lies in that 'recycling flow' actually partly overlaps with 'resource flow' and 'waste flow'. As a result, it was rather complicated to conclude what changes there were in the environmental impacts. As in the first six trials, most of the teachers did not feel confident to draw conclusions about the changes in the impacts and asked for written knowledge cards to support them in drawing the conclusions (see box 13.9).

In the first six trials, though they were provided with the knowledge cards, we could not avoid misinterpretations or omissions in teachers' performances. Only two teachers could draw the conclusions completely and precisely. The teachers stated that the conclusions listed in the cards were very confusing and difficult to remember, especially the change of impact in the recycling flow and waste flow. However, they still insisted that the support of the knowledge cards was necessary in boosting their confidence and reducing the time to make notes on the blackboard. The reflection with the teachers suggested a modification to simplify the typology, and recycling flow was skipped from the seventh trial onward. Since the seventh trial, the knowledge cards were skipped to reach conclusions from their own understanding. However, in the last two trials, both teachers forgot to discuss the decreased load to landfills by reducing, reusing, and recycling. The reflection also revealed a need to better prepare teachers to fully understand the changes that happen to the material flow from the incentives of the 3R.

Box 13.9: Knowledge card content, and adding knowledge cards in class

Card 1 Reducing and Reusing (Changed effect in the Resource Flow)
Decreased consumption of primary resource of wood, decreased consumption of energy, decreased pollution
Card 2 Reducing and Reusing (Changed effect in the Waste Flow)
Decreased consumption of energy, decreased pollution, decreased the load to landfills
Card 3 Reducing and Reusing (Changed effect in the Recycling Flow)
Decreased consumption of recycled resource of paper, decreased consumption of energy, decreased pollution
Card 4 Recycling (Changed effect in the Resource Flow)
Decreased consumption of primary resource of wood but replaced by recycled resource of paper, energy consumption and pollution may not be decreased necessarily
Card 5 Recycling (Changed effect in the Waste Flow)
Decreased the load to landfills, decreased consumption of energy, decreased pollution
Card 6 Recycling (Changed effect in the Recycling Flow)
Energy consumption and pollution may not be decreased necessarily

The teachers had freedom in guiding the discussion for the students to understand the 3R principle. Teacher C and D extended the discussion and requested the students to compare reducing, reusing, and recycling. In prioritizing the three principles, the students more clearly realized the differences made on environmental impacts, particularly with an emphasis in noticing that recycling involves pollution and energy consumption possibly equal to or even more than reducing and reusing. As teacher C reminded the students, recycling is still worthwhile in a sense that it releases the pressure on primary wood consumption and decreases the burden to landfill. A modification was made in the last version, in which the teachers were recommended to guide the students to prioritize the three 3R in analyzing the changed environmental impact.

In the first six trials, in lesson 3 the students' sharing their perceptions about the cleaning workers, scrap pickers, and scrap purchasers revealed a need to link the students' disposal choices with traditions in society (see in chapter 12, section 4.5). The students shared the impression that these people are living in poor financial and sanitary conditions, and they recycle only for monetary purpose, because they are not able to do otherwise for a living. In linking to the traditional practices of 'saving', 'economizing', or 'scrap selling' which in the past helped to deal with shortages, the students are to reflect critically on 3R practices in a time of affluence, and for wealthy or more capable people.

Activity 4: Debate

In the first six trials, it became clear that there was a structural design error in lessons 1-3: the differentiation into social, economical, and environmental impacts turned out to be confusing and misleading (see section 3.3, activity 3). In the modification, debating about the contradictions and proposing win-win solutions was seen as a task at a higher level, and therefore planned in lesson 4.

As revealed in observations, in responding to the students' varied answers, an understanding of the ecological balance would improve the teachers' interpretations. For instance, in trial 1, one solution was that when felling the trees, we should not uproot but cut from only the upper half, so that the trees can continue to grow. This solution was rejected by the teacher, because the teacher believed that trees cannot survive when the upper half is cut off, and missed the opportunity to confirm that there was an idea of staying within the carrying capacity in this answer.

The teachers had freedom in inspiring the students to propose win-win solutions. Some good practices were observed. For instance, teacher B invited a student whose mother is a cleaning worker to express his complex feeling that when there is no more ground litter, the job of street cleaning may also be gone. When the students mentioned solar energy, teacher D could refer to a daily life example, domestic solar water heaters. Teacher A's performance showed a science and technology oriented perspective in interpreting the demodernization solutions, e.g. to return to the ancient way of paper production and manpower transportation without pollution.

Student: We may use man power for transportation. It has no pollution.
Teacher A: Well, that's too strenuous. Only in the past, we had carts pulled by horses or oxen. Then we used diesel and gasoline fuel, and nowadays natural gas in Golmud. We shall follow this way of thinking; choosing eco-energy like some of you just mentioned solar energy. What else can you think of?
Student: Wind power.

Teacher: Yes, in Golmud, a fossil fuel power station was shut down because of the heavy pollution and now there is a solar power station.

The observations revealed that proposing win-win solutions for the debated contradictions was a rather difficult task for most of the students; as in every class, each time when the teachers raised a question, there were only three to five students raising hands to share their answers. Though with the limited number of students to respond and a comparatively longer time waiting for them be ready to answer, the proposed win-win solutions have preliminarily reflected on the notion of ecological modernization and the mechanism of circular economy. The proposed solutions show a trust in knowledge and technology, a recognition of the role of government regulations, an understanding of the supply-demand material exchange balance, an intention to enhance the carrying capacity of the resource base, eco-efficiency and cleaner production. For example, the proposed solutions were: in emission treatment to convert into other useful elements such as oxygen through technological innovation, and in waste water treatment to clean and recycle to be used in paper mills; in lumbering, the woodchips can be used to make furniture; decompose the garbage into other substance e.g. useful minerals; use waste paper as fuel; and use waste water from the paper mill for an electrical power plant; more plantations; not to cut down young trees; pursue eco-energy like solar and wind power; the government should make a polity to enhance employment in environmentally friendly industries such like forestation in barren mountain areas. The proposed solutions also showed a realistic concern about recycling in Chinese society, namely, sorting the waste paper and giving it to scrap pickers, so that they don't have to pick from mixed garbage or landfills and can avoid sanitary health threats, since in most cities in China, garbage sorting systems have not yet been established officially.

Activity 5: Test

The final test received modifications twice. Before being implemented in the classrooms, the initial design showed only a basic idea that the students should be able to show in their argued choices the applied life cycle analysis with respect to the supply-demand balance. Initially, the final test would consist of two exercises. One was to recognize the most environmentally friendly items from their regular use, such as a cloth pen case, a leather pen case, a plastic pen case, a metal pen case, a pencil, auto pencil, correction gel and an eraser. It was not to make an exact choice, but to write down the questions that students had to answer in order to make the selection. The other was a reading exercise in which information is given about some of the most common school items (not yet decided at that time) about materials, pollution, and depletion in their life cycle. And the students were required to make a choice for the most environmentally friendly item based on the given information. In the first trial, the two exercises could not be made due to time limitations. Nevertheless, the trials of the first three lessons and the reflection with teacher A contributed to a structural modification. The final test had to be simplified first to be applicable. Without denying the design intention, from trial 2-6, the two initially planned exercises were merged into one in which the students were to list questions that need to be answered for choosing the most environmentally friendly items out of the three types of pen cases, cotton, iron, and plastic. The observations of the students' group discussions showed that instead of raising questions, more often the discussion went about arguing for an exact choice. Their arguments also could reveal what they are able to apply from the learned life cycle analysis from the example of the paper notebook. Therefore, in the last two trials, the students were to name an exact choice and give arguments. The group gained the point not from the choice, since there is no standard correct choice, but from the listed arguments. Moreover, in the last two trials, one more exercise was added in which the students make the environmentally friendly choice from two erasers, a plain eraser without a scent and a colorful, scented eraser. The intention of this addition was to remind the students to think about the supply-demand balance in the material flow before they continue with the more complicated exercise of pen cases selection.

In terms of the teacher's performances, all the teachers were able to understand and explain clearly that the matter of the test was not to give a correct, exact choice but to list questions that needed to be answered for making the choices (in trial 2-6), or the arguments for the choices (trial 7-8). Teacher E and G performed beautifully by reminding the students to refer to the case of the paper notebook analysis. However, it was also possible that the teachers may overemphasize to the students that they should think of making another round of life cycle analysis. For example, teacher B repeatedly pointed out to the students that there are several directions of questions that should be addressed, what the material is, where it is coming from, etc. But in fact, these directions of thinking were expected to emerge from the students' own reflective discussions. At last, since the students' group results are the major proof of the attained environmental literacy, the results will be analyzed in the next chapter.

Chapter 14 Design Study Evaluation

1 Introduction

This chapter analyzes the attained curriculum of the design study from two aspects, how the scenario has been experienced by the students, and to what extent the scenario has contributed to the students' environmental literacy. The students' appreciation of the scenario is understood from their reflection essays written after each lesson was implemented, and from the questionnaire. Environmental literacy is measured from four strands, i.e. knowledge, skill, affect, and behavior (see chapter 11). As introduced in chapter 10, the learning outcomes are measured from four data sources, the individual self-reflection essays after each lesson, the lesson 3 group work results and group discussions, the lesson 4 group work results and group discussion, and the survey (see full items in appendix IX). For each strand of environmental literacy, the results are presented by the data sets, and then conclusions are drawn in triangulation.

2 Students' appreciation of the course

To evaluate the students' learning experiences, their reflection essays were inductively coded to see what the students liked and were interested in. The questionnaire had 26 items to investigate the students' self-reflection of their learning experience (see appendix IX).

2.1 Data analysis: essay

In the students' descriptions of their learning experiences the most frequently appearing expressions were: fun, participative, vivid, brave, open, shared, exciting, emotional, hot, happy, active, nervous, and expressive. The students most enjoyed drawing the material flow diagram, the group discussions, the opportunity to express their thoughts freely and the openness in the class to exchange opinions, getting feedback from others, and the free grouping in which they could leave their seats and work with friends. The students found placing the colorful photo cards in the material flow strikingly new and interesting. Most of the students appreciated the group work in that it gave them the opportunity to see how others study. The students also showed concern about whether their group results would receive a positive assessment from the teacher. This affirmed the design of intergroup assessment. As confirmed with the teachers, students who normally do not speak out, or have a low score in exams were especially active during the learning process. In their essays, these students also shared their feeling of pride, and being excited and nervous to speak out in front of the class, and contribute to the group tasks.

In the essays, the students also pointed out several difficulties they encountered. Some students reported that drawing the waste flow diagram was difficult since they realized a lack of daily life observations about waste disposal. The most mentioned difficulty pointed to a lack of training on communication skills in cooperative learning, i.e. to share different opinions, to reach a collective decision, to complete a study task, and to make representations. Few students reported a feeling of stress that in this experimental course the accepted methods and conclusions were multiple, and the teacher did not show the correct standard answers. And a few students also pointed out that they were not used to the chaotic situation during the group work, unlike the highly disciplined conventional classes. Lastly, the essays also showed the students' active involvement. The feedback and suggestions provided in the essays were taken into account in modifying the scenario.

2.2 Data analysis: survey

The survey conducted with participant students included 26 items for them to evaluate their learning experience. Each question was answered on a 5-point Likert scale ranging from 'fully disagree' to 'fully agree'. Table 14.1 describes the means and standard deviation of the answers to every item.

Table 14.1: Descriptive analysis for appreciation

Item	Mean	Std. D	Item	Mean	Std. D
46 enjoy	4.41	.851	33 various activity	4.02	1.095
49 daily life topic	4.32	.886	34 express opinion	4.31	.814
45 concerned issue	3.97	1.072	35 student share opinion	4.31	.824
47 negotiate goal	4.01	1.074	39 inspire think	4.16	.903
48 achieve goal	3.66	1.229	43 abstract thinking	3.57	1.214
37 useful info	3.98	1.042	27 different opinion	4.00	1.016
38 helpful example	3.58	1.279	36 find answer	3.89	1.114
24 opinion debate	4.09	1.020	42 explore concept	3.77	1.134
25 original opinion	3.96	1.017	41 motivate	4.12	1.023
26 teacher student share	4.25	.877	44 learn more knowledge	4.47	.741
28 various opinion	3.87	.976	29 difficult question	2.46	1.138
40 multiple angle thinking	4.33	.806	30 difficult multiple opinion	3.09	1.274
32 interaction	4.16	1.064	31 conflict concept	3.11	1.309

The survey results show that most of the students highly scored the items that measure positive experiences. Generally, the students enjoyed learning (item 46). While learning, the students recognized the study issue is relevant for their life experience (item 49), and the study issue is their concern (item 45). The students largely agreed that they had the chance to negotiate learning objectives (item 47), and found the learning materials helpful to achieve their learning goals (item 48). The students also affirmed that the learning materials provided them with useful information and helpful examples (item 37, 38). The students appreciated that the lessons were open for various and original opinions, and inspired them to think from different perspectives (item 24, 25, 26, 28, 40). The students also appreciated the various participative and interactive activities (item 32, 33), and the opportunity to express and share opinions (item 34, 35).

Most of the students reported their improved competence of thinking, especially abstract thinking, and creative thinking (item 39, 43, 27), looking for appropriate answers (item 36), learning the concepts from investigations (item 42). And the students were motivated by what they learned to further extend their environmental knowledge (item 41, 44).

In the survey, there were three other items to measure negative attitudes (items 29, 30 and 31). The results show that most of the students did not find the study issue too difficult (item 29). Contrasting results were found with items 30 and 31, with more or less equal numbers of students agreeing or disagreeing that the multiple perspectives were confusing, and similarly on whether they found the conflicting concepts confusing.

2.3 Conclusion

To conclude, two data sets supported our investigation about the students' learning experiences. Jointly, we are rather certain that in general, the participant students were optimistic towards what they learned. And we have proved that the intention of the design has been largely recognized and affirmed by the students, in terms of the relevance of the study issue, students' study initiatives, participative and practical learning activities, interactive teacher-student communication, multiple perspectives and solutions. Importantly, the students largely found their competence in thinking and inquiry was improved, and they were motivated to extend their knowledge. The students' feedbacks also pointed out that it was challenging for them to encounter multiple perspectives and uncertain conclusions, and to deal with conflicting concepts. The study revealed a lack of daily observations as a source of knowledge, and communication skills to work cooperatively. Lastly, grouping is awkward with the large class sizes in China's schools.

3 Environmental literacy: knowledge

For the attained knowledge, the students' essays were inductively coded to see how the included content knowledge was taken up by the students. The questionnaire includes eight items to test the students' knowledge gained from the scenario. The group discussions in lesson 3 by the experimental and the control classes were compared to prove whether the content knowledge learned has made a difference in the students' decision making in buying, using, and disposing paper notebooks. The group discussions in lesson 4 of the experimental and the control classes were compared to prove whether the content knowledge learned has made difference for the students in choosing environmentally friendly stationery items.

3.1 Data analysis: essay

In the reflection essays, the majority of the students highlighted the concepts of resource flow and waste flow, and showed a solid understanding of the effects in the life cycle of paper notebook. The students' essay also very frequently mentioned 3R principles. Most students reported that they improved their understanding about recycling and economizing (reducing and reusing). As one student illustrated *'…not to litter does not necessarily lead to environmental protection. The cleaning men's work is very tedious, litter adds to their work load, but only saving paper can decrease the lumbering, and save the forest.'* Most crucially, the students could show in their texts a recognition of their role in the life cycle of the paper notebook, and a preliminary idea of circular economy. For example, *'I came to know, to protect the environment, we need to save paper, but not only this. We also need to really think about a lot of commodities around us, what they are made of, where they come from, for example, desks, chairs, pencils, and paper. These are all directly related to us. This is my deepened understanding…'*, and *'I learned the notebooks are made from natural resources around us, water, trees, energy, and so on. Before, I thought litter is not a big deal, it is just one piece of waste paper on the ground, but after this course, I realized the waste paper should be recycled, to save resources.'* Lastly, the students also showed a willingness to extend their knowledge about details of the notebook's life cycle, as they mentioned how exactly the paper is produced in the paper mill, how the technique of making recycled paper differs from making paper from primary woods, how the recycling companies are run, what alternative resources are possible for paper making, what happens in garbage transfer stations, and what are other daily life commodities' life cycles. Some students also showed a willingness to extend their knowledge not only from books, but more directly from daily life observations.

3.2 Data analysis: survey

The survey includes eight items to test the students' content knowledge related to solid waste management. The analysis was to compare the data from the experimental and the control classes. For all eight items, the experimental classes received higher scores than the control classes (one item scores one point if the answer is correct). The one-way ANOVA results show that for seven of the items the students of experimental classes received significantly higher scores than the students of control classes. See table 14.2.

Table 14.2: One-way ANOVA of content knowledge

		Item1 energy	Item 2 primary resource	Item 3 recycled resource	Item 4 transport	Item 5 cotton clothes	Item 6 recycling aim	Item 7 disposal pollution	Item 8 disposal depletion
Mean	exp	2.65	2.55	2.39	.95	.69	2.60	2.70	2.37
	con	2.09	2.19	2.32	.88	.51	2.28	2.46	2.13
S.D	exp	.529	.684	.631	.214	.464	.719	.603	1.087
	con	.420	.592	.603	.320	.501	.663	.594	.984
F		206.959	48.419	1.542	9.485	21.489	33.791	24.201	7.583
Sig.		.000	.000	.215	.002	.000	.000	.000	.006

All differences were significant except for item 3, which asked the students to identify recyclable objects. This may be explained by the fact that the item included two options, i.e. battery and television that were too complicated for students in both the experimental and the control classes.

3.3 Data analysis: lesson 3 result comparison

When merely the listed choices about buying, using, and disposing paper notebooks are compared, very similar choices were made by the groups from the experimental and the control classes. However, the coding analysis showed that the group discussions differ in their argumentation. The group discussions of the experimental class provided more evidence that the students could apply a systematic life cycle analysis in making their choices. The majority of the participant students could refer to the basic concepts in analyzing the life cycle i.e. material flow, waste flow, pollution, depletion, health threat, sanitary and aesthetic loss, and the 3R principle. In analyzing the material flow and waste flow, the participant students discussed the stages and people involved in more detail. In comparison, in the group discussions of control classes, only a few students showed an intuitive concern to make choices from analyzing the material flow, its procedure, and the pollution and depletion involved, while most of the arguments emphasized fragmented aspects of pollution, sanitary and aesthetic loss. To exemplify, almost every group proposed recycling as one of the disposing choices. However, compared to the control groups, the experimental groups provided more reasoned arguments such as: *'We can choose to send material to the recycling company directly, but recycling paper has still so many stages and consumes energy still'. 'It can cut fewer trees though'.* A typical argumentation in the experimental groups was: *'We should send the notebooks to scrap stations, so that we can protect more trees'.* The experimental groups discussed environmental impacts in more details, such as biogas, CO2 emission, energy use, air pollution etc., while the control groups mostly talked in general terms, for example, to protect the environment, to reduce pollution, to save trees.

3.4 Data analysis: lesson 4 result comparison

In lesson 4, the students participated in two exercises as a final assessment. In exercise one, the students compared a scented, colored eraser with a scentless, colorless eraser, and explained their reasoned argumentation in selecting more environmentally friendly items. In exercise two, the students make similar comparative evaluation of plastic, cotton, and metal pen cases.

In exercise 1, the experimental groups more clearly recognized the scented and colored eraser was not recommendable because it involves a more complicated producing process, and its contaminants are harmful for students. As in one example, *'If the colored ones must have one more process or step in producing, then more consumption of resources, energy, more waste.'* The control groups discussed more heavily about health threats than about negative environmental impacts, and mentioned them in general and abstract terms, such as *'The colorless and scentless ones are better, the colored and scented ones do no good for our health and for the environment.'*

In exercise 2, the experimental groups more clearly used a life cycle analysis in comparing the three pen cases. Every student of the experimental groups applied to some extent the concepts of material flow, waste flow, and the 3R's principles in predicting negative environmental consequences. For example:

'I believe the cotton pen case is better, the tissue is made of plants. It costs fewer natural resources, less energy, unlike metal ones.' 'I don't choose the plastic one. Plastic is the worst to dispose of, and when it is burned, it makes a lot of black smoke, very toxic, pollutes the air…And if disposed of to the landfill, very difficult to degrade.' 'Cotton pen cases last long. We can wash it and use it like a new one. But the plastics ones, when they fall on the floor they break easily. And… we maybe then throw it away and buy another one. That is again a consuming of resources…and energy.' 'Cotton ones can be recycled. We can make toys of the cloth… Metal can also be recycled, smelted to other products.' The control groups also intuitively applied life cycle analysis. But compared to the experimental groups, the control groups showed only a preliminary understanding of the related concepts, and discussed in more general terms, for example: *'Cotton pen cases are better… the producing process of plastic or metal ones is too complicated, wastes resource.' 'The plastic pen case is the worst…the most difficult to dispose of.'* Moreover, compared to the experimental groups, the control groups discussed more frequently about practicability and convenience, such as the metal pen case does not contain much and makes annoying tinkling noises.

3.5 Conclusion

Supported by the above four data sets, we demonstrated that the lessons have improved the participant students' content knowledge. This is proven in that the basic concepts of life cycle analysis on waste management were remembered and applied in proposing actions in coping with the example of paper notebooks and in conducting a new life cycle analysis of another stationery item. Especially, the experimental groups developed a more systematic understanding of material flow, waste flow, and recycling. Compared to the experimental groups, the control groups put more weight on societal impacts, such as health, practicability, and convenience.

4 Environmental literacy: skills

Concerning the attained skills, we inductively examined the students' essays to see the students' self-reported improvements. The questionnaire was not considered appropriate to test skills directly. Rather, the students' command of skills was best observed from their group discussions. The students' discussions in the application phase (lesson 3) and assessment phase (lesson 4) from the experimental and the control classes were compared, to prove whether the participant students could demonstrate more desired skills than the students who did not participate. With reference to the skill strand proposed by Roth (1992), we expect that after the lessons the environmental literate students are more skilled in working cooperatively, applying ecological concepts to predicting probable ecological consequences, thinking critically and creatively, thinking in terms of systems.

4.1 Data analysis: essay

Although the majority of the students mentioned group work as what they appreciated most of the lessons, many of them pointed to the difficult side of working cooperatively, especially a lack of communication skills, i.e. to share different opinions, to make representations, to lead the group members, to reach a decision and to complete a study task collectively. Some students mentioned conflicts in their group discussions, such as quarrels, fights, and even dropping the group, as one student described *'In the group, everyone thinks he is right, then a quarrel can easily happen. Nobody was convinced by me. So, I knew if I stayed, there would perhaps even be a fight. So, I changed group.'* The students' descriptions also revealed that it is a challenge for them to analyze environmental issues from various perspectives and to be open for alternative solutions, as some students illustrated: *'It was troublesome that in the group discussion about waste flow, some say to put the cards here, while others say there, there was no consensus, we did not know what to do.'* And *'In patching the cards of waste flow, there were many possibilities. This is very confusing, unlike in our normal courses, the correct answer is only one. We did not know where to start. There were too many methods.'*

4.2 Data analysis: lesson 3 result comparison

The coding analysis of the group discussions revealed several differences. Foremost, very obviously, in the control classes, every group copied the form of an ordered discussion exactly as we observed them in the conventional Chinese classes. Namely, the group leader acted as a host, posing questions, naming a student to answer, and then asking for comments from others, e.g.: *'Now let's move to the second question, how to use notebooks for the good of the environment. Let's give answers one by one. Liu, you first… Anyone wants to add something?... Do we all agree?'*. In comparison, the experimental groups discussed more spontaneously. The group leader acted more like a facilitator, reminded the group to cover the required topics, and in some groups it was not easy to recognize the leader from the utterance. Being aware of the current practices of group learning from our previous observations, we may not conclude that the experimental groups were less organized in their discussion, but rather that the participant students were more relaxed, and democratically active in the discussions.

Secondly, the students in the experimental groups showed more critical thinking, especially when practicing systems thinking, namely, making choices in considering the entire life cycle. This is shown in the following fragment of discussion:

Student A: 'We should not litter.'
Student B: 'There is then still a need to cut trees.'
Student C: 'Litter is a waste of resources. We can recycle, to make papers again.'
Student B: '…Hum…sending it back to the paper mill still pollutes, and consumes energy.'
Student D: 'At least, we should refuse imported paper notebooks from foreign countries, that is a very long way to transport something.'

The above discussion also revealed that the proposed choice of 'not to litter' and 'recycle' was criticized when the students thought of the entire material flow and waste flow. In comparison, 'recycle' and 'not to litter' were proposed by all the control groups as the disposing choice without any question.

4.3 Data analysis: lesson 4 result comparison

First and foremost, in terms of the skill of working cooperatively, just as in lesson 3, a highly disciplined discussion was observed in the control groups, and the experimental groups discussed in a more spontaneous way. Secondly, the experimental groups demonstrated more clearly the skill of systems thinking with the content knowledge learned in the life cycle analysis. This is evidenced in exercise 1, where the students in the experimental groups mostly compared the production process of the two types of erasers, while the discussions in the control groups focused on health threats.

4.4 Conclusion

In terms of the skill of working cooperatively, the observations show that the experimental groups developed a more democratic and active way of discussion, while the control groups adopted the conventional ordered form of discussion. However, in the self-reflection essays, the participant students reported their frustration caused by a lack of communication skills to accomplish the task collectively, especially because of the need to confront various perspectives, to avoid or solve conflicts. Although the participant students reported that having an uncertain conclusion or solution was a challenge for them, they showed a more systematic and critical understanding of the potential contradiction among different disposal options. The participant students especially demonstrated a greater practical skill in analyzing detailed processing stages of the material and waste flow.

5 Environmental literacy: affect

For the students' environmental affect, we also examined the students' essays to see their self-reported improvements. The questionnaire included nine items to measure the affect strand. The experimental groups' discussions in lesson 3 and lesson 4 were comparatively analyzed to prove whether what was learned influenced the students' environmental affections. With reference to the affect strand proposed by Roth (1992), the environmental affect is expected to show in the students' expressed empathy and feeling of concern for both nature and society, perceptions of points of conflict between nature and society, improved understanding from isolated phenomena to interacting systems, willingness to curtail some individual short-term privileges for long range public good, internal locus of control, and personal responsibility.

5.1 Data analysis: essay

In the essays, most students expressed an empathy and feeling of concern not only for the environmental crisis, but also for the vulnerable people involved in the material flow, i.e. the scrap pickers, scrap purchasers, cleaning men, and factory workers, their hardship and their health. For instance, one student expressed *'I used to find the scrap purchasers very unpleasant, filthy, stinky, and talking in dialects not in Mandarin, but now I changed my opinion; their work has a big impact on our environment.'* However, there were still quite a number of essays that showed a one-sided emphasis merely on environmental protection. In some essays, we could see the students' elemental perceptions of conflict between nature and society, for instance: *'If we do not yield waste paper, the world is tidy, but then what are the scrap pickers going to live on?'* And *'I am getting interested in the business men involved, for the consequence of reducing paper consumption, they might be no more able to survive with the notebook business, they should look for an alternative way of living.'*

From coding the essays, it is a prominent finding that the debate of lesson 4 on conflicting environmental, social and economic impacts was a difficult and abstract task for most of the students. As one student shared the observation, *'In lesson 4, the debate had no hands-on activity, only brainstorm, it's boring. Not many could answer the teacher's question, some talked nonsense.'*

In the essays, however, the students showed an improved understanding from isolated phenomena to interacting systems. For example, some students were able to recognize that the action of not littering is only valid for sanitary aspects, but that reducing, reusing, and recycling have ecological consequences that include depletion and pollution.

The majority of the students' essays showed a strong willingness to curtail some individual short-term privileges for long-range public good, from the recognition of the impacts of personal behavior. This is illustrated by the following quote: *'Except notebooks, other commodities also deplete resources, for example, cotton pen case depletes cotton, water, and iron for the zipper, and so on, so please be economized in using them.' 'Everything in nature is closely connected to us; TV, cars, pencils all of these will lead to pollution and depletion.'* And, *'Before purchasing, it is needed to take into account that this commodity may bring harm to nature. What is the harm to people? What problems may occur after disposing of it? What is the harm to natural resources and ecology? You may find this way of shopping is inconvenient, but we may all learn to use knowledge and then can save time for it (environmental decision making).'* Quite a number of students inclined to summarize the essay with a slogan, with the most frequent one *'To protect the environment, a responsibility for everyone!'* Being aware of the behaviorism education mode that is dominant in current school practices, we need to be careful to say that this shows the students' acceptance of a personal responsibility or locus of control.

5.2 Data analysis: survey

In the survey, the items of the affect strand were intended to measure whether the students have empathy for nature and society, their perceptions of conflicts between nature and society, internal locus of control, and personal responsibility.

Item 11 and 12 measured sensitivity and empathy for both nature and society. The Chi-Square test results show that there is a significant relationship between participating in the experiment and the degree of the sensitivity, for item 11, χ^2 (4, N = 607) = 30.9, $p < .01$ and for item 12, χ^2 (3, N = 606) = 14.5, $p < .01$. Given the dilemma of decreasing lumbering and its consequence of job losses, the participant students were more inclined to show a balanced concern for both natural and social impacts (33.2% of the students of the experimental groups and 20.4% of the students of the control groups chose 'feel uncertain'). Given the choices to value the importance of environment and economy, the participant students were more inclined to show a balanced concern of both environment and economy (28.8% of the students of the experimental groups and 20.1% of the students of the control groups chose feel uncertain).

Item 9 and 10 measured the perceived personal responsibility, the responsibility of the government and others. The Chi-Square test results show that there is a significant relationship between participating in the experiment and the perceived personal responsibility. For item 9, χ^2 (4, N = 607) = 14.3, $p < .01$. More of the participant students most strongly expressed their will of taking personal responsibility (52.1%) than the non-participant (43.5%). There is no significant relationship between participating in the experiment and the perceived responsibility of the government, for item 10, χ^2 (4, N = 607) = 4.7, $p > .05$. The students had very similar perceptions about the government's responsibility, most of them agreed with its importance (74.4% of participants and 75.8% of non-participant chose affirmatively).

Item 16 and 17 measured the students' internal locus of control. The results of the Chi-Square test show that there is a significant relationship between participating in the experiment and the perceived internal locus of control, for item 16, χ^2 (4, N = 606) = 10.5, $p < .05$. More of the participant students most strongly expressed their internal locus of control in recycling (51.0%) than the non-participant students (39.8%). For item 17, χ^2 (4, N = 606) = 13.4, $p < .01$, more of the participant students saw the possibility to find solutions to help the scrap pickers (65.8%) than the non-participant students (54.3%).

Item 13, 14 and 15 measured the perceptions of conflict between nature and society. The results of the Chi-Square test show that there is a significant relationship between participating in the experiment and the sensitivity for conflict between nature and society, for item 13, X2 (4, N = 601) = 11.3, $p < .05$. More of the participant students most strongly expressed their disagreement that the country's resource is unlimited (53.5%) than the non-participants (40.5%). There is no significant relationship between participating in the experiment and the perceived role of science and technology as a solution, for item 14, X2 (4, N = 605) = 2.9, $p > .05$. The students had very similar perception about the role of science and technology; about one third of them agreed with its importance in solving the conflict, one third disagree, and the remaining 1/3 feel uncertain. And there is no significant relationship between participating in the experiment and the perception of the demodernization solution. For item 15, X2 (4, N = 604) = 2.9, $p > .05$, the students had very similar perception about the pre-industrial way of living; nearly half of the students disagree that going back is a valid solution for the shortage of natural resources.

5.3 Data analysis: lesson 3 result comparison

In comparing the results from the group discussion of lesson 3, both experimental and control groups could predict probable ecological consequences in making choices for buying, using, and disposing of paper notebooks. Their choices showed a willingness to curtail individual short-term privileges for long range public good, and a willingness to take personal responsibility to help to correct or avoid negative impacts. To name a few actions that were commonly mentioned, buy double-sided, write smaller characters to save space, scrap sale after using. However, in group discussions, the reasoned arguments differ in three aspects. Firstly, the experimental groups' discussions showed an improved understanding from isolated phenomena to interacting systems, in applying the concepts of material flow and waste flow. Secondly, the experimental groups showed a more balanced sensitivity and empathy for both nature and society. For instance, throwing the notebook in the garbage bin was proposed commonly in both experimental and control groups, but some experimental groups extended the discussion about the role of scrap pickers in sorting and recycling waste paper from the garbage bin.

5.4 Data analysis: lesson 4 result comparison

As in the two exercises, the group discussions in experimental class and control class all showed an acceptance of personal responsibility for probable impacts. In comparison, the experimental groups' discussion demonstrated a more balanced appreciation for both nature and humanity, while the control groups' discussion considered health threats to humans more.

5.5 Conclusion

From the data triangulation, we conclude the following learning outcomes:

1. The lessons have developed the students' sensitivity of the conflicting environmental, social, and economic impact, although most of the students reported that to debate about the conflicts was a difficult and abstract task.

2. The students showed improved systems thinking in conducing life cycle analyses.

3. Through the lessons, the students also enhanced their perceived internal locus of control in their actual practices, for instance, more of the participant students saw possible solutions to help the scrap pickers.

4. The lessons strengthened the participant students' already existing willingness to take personal responsibility for probable negative environmental impacts.

5. And we found that in the lessons the students developed a more balanced sensitivity and empathy for nature, economy, and humanity. For instance, in making environmentally friendly choices, they expressed a concern for environmental crisis, for the vulnerable people involved, and also for the debatable tension between ecological and economic impact. For the non-participant students, in making actual choices in their daily stationery items, health threats, economic and practical concerns received more attention. Nevertheless, we also observed in self-reports that a number of them had a one-sided emphasis, mostly in a slogan form, on environmental protection. Therefore, we should be aware of the difficulty to change the students' expressive habit built in the behaviorism tradition of environmental education practices.

Nevertheless, the students from the experimental and control classes had very similar perceptions of the importance of the government's responsibility, the role of science and technology, and the disfavor for the demodernization solution. One explanation is that the Chinese students are rather firmly prepared with these perceptions from formal education and/or mass media that are corresponding with the government's environmental policies. Lastly, it should be noted that the assessment data were collected during and shortly after the implementation of the scenario, so that we need to be cautious with any claims about the long-term impacts on the students' environmental affect.

6 Environmental literacy: behavior

The participant students' behavioral change was tested by their verbal commitment to environmental actions as stated in the essays. The survey had six items to measure their commitment of persuasion, consumerism, political action, and personal engagement. We also comparatively analyzed the group discussions in lesson 3 and 4, to prove whether and how the participant students differed from the non-participant students in making choices in buying, using, and disposing of the paper notebooks and in evaluating environmentally friendly actions about the erasers and the pen cases.

6.1 Data analysis: essay

In the essays, almost all students expressed verbal commitment to taking actions for environment protection. The proposed actions showed a concern of maintenance of environmental quality by the 3R principle. The proposed actions were mostly through consumerism and political action, such as economize in using, writing letters to the municipality, etc. Nevertheless, not to litter, not to spit carelessly, keep clean, maintain a tidy environment were still reaffirmed in about 15% of the essays. A few students even named this experimental course *'environmental sanitation education'* instead of *'environmental education'*. In the essays, the commitments usually refer to an unspecified collective identification of 'we' instead of the individual pronoun 'I'; this may imply that students usually do not personalize the behaviors described.

6.2 Data analysis: survey

In the survey, the behavior strand had six items to measure whether the students made verbal commitments to taking action through persuasion, consumerism, political action, and personal engagement.

Item 20 and 23 measured the students' willingness to persuade others. The Chi-Square test proved a significant relationship between participating in the experiment and the willingness to distribute leaflets, for item 20, χ^2 (4, N = 606) = 11.2, $p < .05$. More of the participant students most strongly expressed their willingness to distribute leaflets (52.9%) than the non-participant students (46.6%). There is no significant relationship between participating in the experiment and the willingness to persuade others to recycle, for item 23, χ^2 (4, N = 603) = 4.9, $p > .05$. For both the experimental and the control classes, the majority of the students expressed willingness to persuade others to recycle.

Item 19 measured the students' consuming behavior. The Chi-Square test shows that there is a significant relationship between participating in the experiment and the will to reject stationery because of pollution, for item 19, χ^2 (4, N = 606) = 18.3, $p < .01$. Fewer participants agreed to reject (30.1%) than non-participants (45.0%), and more of the participant students disagreed to reject (40.6%) than the non-participant students (27.7%). This may mean that the non-participant students weight the environmental benefits while the participant students are more cautious about socio-economic costs as well.

Item 21 measured the students' willingness to take political action. The Chi-Square test shows that there is no significant relationship between participating in the experiment and the will to take political action, for item 21, χ^2 (4, N = 605) = 6.4, p > .05. For both experimental and control classes, the majority of the students expressed willingness to write to the mayor about enhancing environmental protection.

Item 18 and 22 measured the students' willingness for personal engagement. There is a significant relationship between participating in the experiment and the willingness to donate, for item 18, χ^2 (4, N = 606) = 16.9, p < .01. More of the participant students most strongly expressed their willingness to donate (63.3%) than the non-participant students (52.9%). And there is no significant relationship between participating in the experiment and the will to recycle, for item 22, χ^2 (4, N = 604) = 7.5, p > .05. For both experimental and control classes, the majority of the students expressed willingness to recycle. It can be that the participant students are more aware from the life cycle analysis that recycling is something one cannot do individually.

6.3 Data analysis: lesson 3 result comparison

Merely comparing the listed choices in buying, using, and disposing of the paper notebooks showed that the control groups and the experimental groups had many choices in common. However, the experimental groups mostly proposed buying choices in predicting ecological consequences, while the control groups had more choices aimed at economic aspects. In terms of the choices of using, a small difference was found between the two types of groups, the experimental groups proposed more detailed practices for saving paper, while the control groups made more mention of general choices. In making disposing choices, the experimental groups obviously differed from the control groups in that they proposed the disposals in more details, showing better understanding of the waste flow than the control groups. The choices have been listed in box 14.1.

6.4 Data analysis: lesson 4 result comparison

The two exercises in lesson 4 were not intended for collecting data about the students' verbal commitment to action, but mainly to test whether the students were able to apply life cycle analysis to other objects than paper notebooks. Nevertheless, the group discussions included evaluating actions, in this case the producing and disposal actions related to the life cycle of erasers and pen cases. In their evaluations, the experimental groups were more inclined to take balanced positions in respect to quality of life and the environment, while in the control groups' position, life quality e.g. health, convenience, practicability were relatively emphasized more.

Box 14.1: Group work results: choices in buying, using, and disposing

Buying:
Experimental Groups' Choices: buy double-side printed paper, buy the recycled paper, buy good quality ones that can last long, buy the amount for your actual need, buy less at one time, go to the shops by foot, buy plain ones, buy practical ones, buy at standard shops or supermarkets for guaranteed quality, buy the ones made from other materials like straw and cloth.
Control Groups' Choices: buy double-side printed paper, buy the recycled paper, buy good quality ones that can last long, buy plain ones, buy branded ones for guaranteed quality, buy at standard shops or supermarkets for guaranteed quality, use polite language in talking to the shop assistants, buy good quality for a small price.
Using:
Experimental Groups' Choices: write smaller characters, make fewer mistakes in writing to save space for correction, use back side for scratch, do not make paper airplanes, do not tear the paper for fun.
Control Groups' Choices: write neatly, write in saving spaces, write smaller characters, make fewer mistakes in writing to save space for correction, use back side for scratch.
Disposing:
Experimental Groups' Choices: send the used notebook for scratch, make paper crafts, do not litter, sell to scrap purchasers, take the waste paper to the scrap station on foot, collect the waste paper and directly send it to a recycling company.
Control Groups' Choices: send the used notebook for scrap, make paper crafts, recycle, do not litter.

6.5 Conclusion

The data triangulation yielded mixed findings. It confirmed that the lessons have developed in the participant students a more rational consuming behavior preference. The participant students' preferred behavior is based on an improved environmental concern. Triangulation resulted in the following conclusions:

1. In the control groups' behavioral choices in notebooks, quality of life (e.g. health), convenience, and practicability were chosen more frequently than in the experimental groups.

2. More importantly, the participant students were more cautious in taking environmental actions. In the survey, the participant students less strongly

rejected stationery that produced pollution, while the non-participant students chose more frequently to take action against pollution. This may mean that the participant students inclined to be more rational and realistic consumers in being aware of the potential conflicts between ecological and social-economic impacts, e.g. a possible consequence that many people lose their jobs.

3. The participant students were more willing to take some actions, for instance, to distribute leaflets, and to donate, but for recycling they did not differ from their non-participant peers, namely the majority of the students expressed willingness to recycle and to persuade others to recycle. As revealed in the group discussions, the experimental groups were able to propose more detailed practices for recycling, in knowing the more detailed procedures and the involved vulnerable people's life conditions.

However, the students from the experimental and control class also showed similarities in their commitment to environmental action. The participant and non-participant students did not differ in their willingness to take political action, e.g. to write to the mayor. And the issue of sanitation received considerable attention from the students in both the experimental and the control classes. 'Not to litter', 'not to spit carelessly', 'keep clean', and 'maintain a tidy environment' were repeatedly mentioned in the essays and in the group discussions. We shall be reminded that for Chinese students sanitary conditions, particularly for public areas, had high importance and may sometimes even replace their understanding of environment quality. Lastly, most of the participant students' essays still showed a preference for the unidentifiable collective pronoun 'we' instead of the individual pronoun 'I'. We should be careful to say that, with a collectivistic cultural background, the four-lesson unit may result in a personal action perspective for the students in coping with environmental problems.

Chapter 15 Design Study Reflection

1 Introduction

In this chapter, we reflect on the contributions of our design study. First, students' learning outcomes as one of the contributions are briefly summarized from the previous chapter. Then we describe the difficulties encountered during the implementation of the scenario and their implications for the teachers' preparation to secure the implementation, and for future teacher trainings for their long-run professional development to become curriculum developers. At the most practical level, the contribution of the design study is the intervention product, disseminated to our participating schools as their school curriculum teaching materials. Finally, we present our view on the theoretical output, in design criteria in the didactical structure or in the educational structure. In design research, the ultimate value is in gaining and sharing experiences in exploring optimal solutions for complex problems, as for our study, the rhetoric-practice gap that discourages the improvement of environmental literacy.

2 Students' learning outcomes

As we presented in chapter 14, students' learning outcomes are measured along the four strands of environmental literacy, knowledge, skill, affect, and behavior. In addition, the appreciation of the participant students for the learning experiences is also included in the evaluation of the attained curriculum in our design study. As our data reveal, in general, the participant students enjoyed learning in the four lessons. And the most crucial is that the students when engaging in the series of learning activities, can largely recognize and appreciate taking study initiatives, and are motivated to extend their knowledge at the end of the four lessons. So to say, the design study did fairly succeed in inducing in the students a motive, a sense of purpose and direction of learning, as inherent in the problem posing approach. The attained curriculum is measured as improved environmental literacy. The data triangulation supported positive conclusions. Participation in the design study improved the students' content knowledge of solid waste management and their ability to apply the acquired knowledge in conducting a life cycle analysis. The participant students also improved the skill of critical thinking, systems thinking, the skill of more detailed life cycle analysis, and the skill of more flexible and democratic discussion in cooperative learning. In the affect strand, the design of the sequences of lessons did improve the students' sensitivity of conflicting environmental, social, and economic impact, the locus of control, and the willingness to take personal responsibility. And with regard to behavior, the participant students are more conscious in making green choices in their daily use of stationery items, compared to their peer students who did not receive the intervention of our design, and showed a more balanced sensitivity for the complexity of conflicting social, economic, and environmental impact. The participant students are also more willing to take action and know more practical details to carry out the action.

However, we are aware of the limitations of the attained learning outcomes. Still quite a number of students expressed a one-sided opinion to merely protect the environment in a slogan form. This can be a continued impact from the behaviorism tradition of environmental education practices that the students are used to, or can be an impact of being observed and wanting to give socially desirable answers. Another striking result is that the sanitary condition in public areas gains a high level of attention from the students, as 'not to litter', 'not to spit careless', 'keep clean' were repeatedly emphasized by quite a number of students. For several among them, the concept of environmental quality was equivalent to sanitary quality in their understanding. Moreover, since the learning outcomes are evaluated shortly after the lessons, we are cautious to draw conclusions about the long-term impact. The data analyses in chapter 14 also revealed that our design study posed some challenges to the students participating in the four lessons, such as to deal with multiple perspectives, to accomplish a task in cooperation, and to develop solutions to solve conflicts. The implementation pointed to the need for teachers' professional development to better take the intended role as the linking pin to guide the students to improve the needed competences.

3 Teachers' professional development

3.1 Teacher trainings needed in the future

The four-lesson unit is carefully tested in interaction with the teachers and students. The teachers' performances proved that the scenario is a robust design. As long as the teachers carry out the planned activities, the students were indeed engaged in the inquiry process and yielded the learning outcome fairly as expected. However, as we learned from the implementation (presented in chapter 13), the teachers lacked the confidence to grasp the content knowledge of environmental sciences, and especially to develop solutions for ecological and economic dilemmas. Some teachers still preferred a definite and immediate goal of behavioral change, such as 'do not litter' and 'keep the public area clean'. One teacher explicitly doubted the knowledge developmental path advocated in the problem posing approach and held an opposite educational view. The teachers have different levels of competence in guiding the group discussion adequately without overly leading the students. And the teachers need especially to guide the students to improve skills of cooperative learning, not only by exchanging information but also in accomplishing a task. We consider these findings as potential risks of keeping an operational gap.

For the teachers to ultimately grow to be curriculum developers as intended in the current curriculum reform, whether or not the teachers hold an entirely opposite educational ideology, would need a well-planned training to be able to either realize the inadequacy of the traditional strategy based on behaviorism, or know how to carry out the affirmed ideal visions into a coherent and robust design. Therefore, from the classroom trials, the teachers contributed not only with the suggested modifications, but also expressed a need for systematic teacher training in the future.

Firstly, the training should focus on the basic concepts of solid waste management to carry out the scenario according to the teachers' prior knowledge and to create confidence and ability in responding to various students' answers. Secondly, a systematic training on the concept of sustainable development is needed, especially for the concepts of carrying capacity and self-cleaning capacity, to improve the teachers' understanding of the incentives of the 3Rs, to be more competent in interpreting the changes in environmental impacts, for instance, to understand that recycling slows down the depletion of primary resource and decreases the burden to landfills. Thirdly, the training should also focus on teachers' educational view on exam-oriented or quality-oriented approaches. The case of teacher D, who adheres to a teacher-centered approach, indicated the possibility that in future implementation some teachers may ignore the problem posing approach and the didactical structure. Whether the problem posing approach can be proved to be successful within the current standard assessment system is however a question beyond the scope of this research. Nevertheless, we are alert that an operational gap might emerge if the teachers do not see the value of a constructivist educational view as adopted in the scenario. Fourthly, the training shall include how to guide students to improve their cooperative learning skills. The audio recorded group discussions showed that the students needed help to improve communication skills in sharing information, exchanging ideas, and negotiation aimed to complete a task, other than merely sharing information. Fifthly, the training should invite not only the teachers of the intra-curricular course, but also YPD teachers who are the designers and practitioners of extra-curricular activities of environmental education. Sixthly, though the teachers are free to make their own decisions on content and pedagogy, there is a need of training on instructional designs to ensure that teachers select an appropriate instructional approach, such as to avoid threatening examples. Lastly, the teacher training itself should take a problem posing approach so that the teachers come to understand the approach by experiencing the entire inquiry process. This finding also confirms the suggestions from the environmental educationalists that we have interviewed (see chapter 9, section 4.3). As we may infer from the teachers' preparations, there was a tension between the lack of teacher's motivation at the start and lack of time throughout the implementation. This is illustrated by the case of teacher F who was impatient and inadequately prepared the lessons and had to quit halfway during the class in lesson 2 (see chapter 13, section 3.2). We should also consider the context, the culture of collegiality, and the teachers' commitment to the background of assessment, and take them as persons. Therefore, the teachers' training should be planned with an understanding of what teachers look for from professional development.

3.2 Realistic professional development

The above identified needs for teaching training can only be fulfilled when they are realistic in the current setting of educational assessment. For the scenario to survive after the design study, the teacher's professional development should be planned so that the teachers who are working under such administrative evaluation pressure are motivated to implement the scenario, seeing it is interesting and worthwhile. We already kept in mind in developing the design intentions (see chapter 12, section 2.7) the suggestion from Fullan (2006) and Fullan and Hargreaves (2012), to link educational change with teachers' professional development in turning it to their advantage by taking into account the teacher's purposes, the teacher as a person, the real world context in which the teachers work, and the culture of collegiality. Therefore, in the classroom trials, we paid particular attention to motivating the participating teachers by appealing to their need for professional improvement.

For the teachers, the real world context of work puts a high value on rankings in standard exams. All the teacher interviews revealed that the standard final exam and excessive work load are considered as the most crucial obstacles. As we know from chapter 9, the evaluation of teachers results in monetary rewards for teachers whose class students ranked high in the final standard exams, and by administrative pressure on the teachers of low scoring students (summoned by the school principal or director to self-reflect on the unsatisfactory exam result). In all the four participating schools, very often teachers receive unexpectedly administratively assigned extra-curricular activities, like training for an art festival or sport competition. These activities intruded heavily on what was considered as ordinary teaching by the teachers, since they took time from the teachers to spend on teaching or reflecting on teaching. The students are summoned to attend many tasks that have been administratively arranged top-down. Against this background, when at first the teachers were invited to participate in the design study, as most of them frankly expressed, it was taken as another extra work load among all other administrative tasks. For the teachers, the length of four lessons was considered as most optimal to implement within limited teaching hours.

Resulting from high time pressure, administrative pressure, and monetary impetus, the culture of collegiality is competitive. It is observed in all the four participating schools that professional communication proceeds by attending and observing each other's class teaching, and giving feedback or advice. The teachers consider this as another important opportunity besides final exams to demonstrate their teaching competences to their colleagues. It was observed that the teachers were willing to invest much time and energy in a careful preparation of a lecture that was going to be observed by their colleagues and even sacrifice personal time after work. As one teacher illustrated *'This is not only about accomplishing an assigned task. All people are watching at what you do, how you raise questions, how you guide the students. You earn face or you lose face. Everyone is taking it seriously. From observing others' we sometime also learn innovative practices.'* Acknowledging this culture of collegiality, space is found for the teachers to improve their professional competence via innovation. As proved in the trials, via the problem posing approach, the teachers came to know how to initiate from the student's existing want to learn, plan learning activities according to the students' own questions, and training the students' skills of collecting, sharing, and applying information. What matters for the teachers is that when applied in their regular lessons, these performances distinguish them from their colleagues. For example, in all observed classes of the Chinese lesson *'The City of Water: Venice'*, the teachers generally invited the students to collect information about the city of Venice, and the result was that the students used very similar key words in internet searching, e.g. 'Venice' 'the city of water' and found almost the same information from Baidu Baike (the Chinese version of Wikipedia). That is a general introduction to the city's location, population, industry etc. without students having the opportunity to show what their interests really were. By contrast, teacher G participating in the design study, started by inviting the students to ask questions from their interest before they do internet searches, by asking questions like *'What do you want to know about Venice?' 'What about the city are you curious about?'* The students could easily come up with very specific questions such as *'I want to know how students go to school, are there cars or buses in Venice?' 'I want to know why the houses built in the water don't collapse.'* The information is therefore collected very differently, since it was aimed at answering the questions coming from their varied interests, particularly considering that students' skill in information collection is one of the learning goals of the Chinese course. Teacher G's innovative performance received very positive feedback from her colleagues. To conclude, under the pressure of time and standard assessment, there is still room in peer evaluation for the teachers to improve their competence in educational innovation. The teachers held different opinions on whether their improved competence may be useful or not to guide the students in achieving a high score in standard based exams. Whether the teacher's motivation for the professional development is only to make a distinction between peer evaluation and standard exams is mostly related to the teacher's personal commitment. Teachers held various views in valuing their professional satisfaction gained from the teaching and learning process. As became evident from the design study, the teachers who were more committed to the practice of teaching itself showed more appreciation of the problem posing approach as a way of professional development than teachers who were mainly concerned with success.

3.3 Curriculum implementation perspectives and empowering teachers

With the understanding of administrative pressure, assessment pressure, and culture of collegiality, we also come to a reflection on the implementation of curriculum innovations. A curriculum can be implemented from different perspectives, from a dominant top-down way to a very flexible experiential way. The curriculum implementation can be defined by a fidelity perspective, a mutual adaptation perspective, and an enactment perspective (Snyder et al., 1992). In the fidelity perspective, the main concern is on measuring the degree to which a particular innovative curriculum is implemented as intended. In the mutual adaptation perspective, the concern is on how the planned curriculum is shaped by practitioners in the situated context. This suggests a process of adjustment made jointly by curriculum designers and those who actually use it at the school or classroom level. The enactment perspective considers the externally created curriculum as a tool for the teachers and students to construct jointly the educational experiences enacted in the situated context. However, Snyder et al. (1992) also suggest taking a pluralistic view on the three perspectives. That implies that the actual implementation should be defined on a continuum rather than by one of the exclusive perspectives, or that the implementation at a certain point fits the fidelity perspective and that at other points it fits mutual adaptation or enactment.

Nevertheless, the curriculum enactment perspective was defined by design researchers as a cornerstone of their vision of educational design research (McKenney et al., 2006). Our experiences in implementing the scenario show that this vision does not apply to our design study: the implementation should be situated in a zone between fidelity and mutual adaptation, but not as enactment. As we described in chapter 10 section 3.4, teachers' preparations were carried out in individual discussions with every teacher, before each lesson. In the discussions, the designer explained and clarified to the teachers the expected sequences of teaching and learning activities, performances, and desired responses of the students. The teachers were also invited to talk about how they understood the scenario, their confusions, worries, and expectations. All the teachers emphasized in the preparation discussions that their main concern was to carry out the scenario as faithfully as possible to meet the design expectations. The observations in the classroom trials and the after-class reflections with the teachers were meant to confirm the closeness of the implemented with the intended scenario, and to recognize together with the teachers the needed adaptations, which then were used in revising the scenario. So to say, our design study mainly concerned a fidelity perspective, although it was open for the teachers' adjustments or inputs that would improve the efficiency and practicability of the design, as long as it was in agreement with the aims of the design. In our experience, the design study can only survive in use after the completion of this design study when we respect the teachers' problem of tight time pressure. In our design study, every teacher participated in only one trial. Therefore, time simply does not allow our design study to empower the teachers to the extent, as the enactment perspective suggested, that they can be curriculum developers. Moreover, in our implementation, the before-class lesson preparations, the classroom observations, and the after-class reflections with the teachers have shown that the teaching unit cannot be carried out as smoothly as intended unless the teachers implement it with adequate understanding of the design intentions. Therefore, sufficient training, support, and monitoring are necessary. Otherwise, an operational gap may very easily occur as the teachers may simply continue their conventional way of teaching and run the risk of behavioral instruction or inappropriate instruction such as using threatening examples. Most importantly, our experience brings to mind that we need to be careful not to apply the enactment implementation perspective as compulsory in design studies. We propose to articulate besides the pluralistic view, a developmental view on implementation and empowering teachers in implementation. We mean that participating in the design studies shall be considered as the first phase of the teachers' further professional development. Then, very likely, participating in teacher training as identified in the design studies is the second phase, until the teachers grow to be curriculum developers and know how to build an enacted curriculum during the ongoing implementation jointly with their students. The full autonomy of the teachers is aspired to in the decentralization reform, but when the teachers are required to act with too much autonomy too soon, we may run the risk of overloading them with an innovation task that cannot yet be accomplished by them independently. It did already happen in China's current curriculum reform that teachers are expected to perform as school curriculum developers, but without sufficient support and monitoring, and this resulted in the emergence of formalizing and operational gaps.

4 Intervention product and dissemination

At the most practical level, the contribution of the design study is the instructional product, the scenario, the body of worked-out theory for raising environmental literacy, together with its context responsible for a possible application in other settings to consider and interpret. In our design study, the intervention was not merely a mean for identifying optimal solutions of enclosing the rhetoric-practice gap with improved environmental literacy. The curriculum product tested and verified in the intervention process is also left for the participant schools of our case study sites. The finally modified products are a teacher guide and a booklet of students' group work sheets as their school curriculum textbook for environmental education. The materials are in Chinese. The printed books are sent to the three schools in Golmud and the school in Xining. All the schools favorably accepted the books as one of the most important gains from partcipating in the design study. As one of the school principals commented, the experience of developing a school curriculum with outsider specialists, allows the school to better show their quality in comparison to their peer schools, and the books provided a good starting point for the school to undertake innovative environmental education.

5 Theoretical output

5.1 Reflection on the design criteria

Our design research, by means of developing the scenario as the outline of intervention, aims at identifying optimal solutions to enclose the rhetoric-practice gap with improved environmental literacy. The intervention is based upon theoretical propositions, the cluster of design criteria (chapter 11), which are evaluated, and sharpened via the implementation. By doing so, the study has generated knowledge about how such an intervention is developed, guided by the design criteria (chapter 12), and whether and why such intervention works in the context (chapter 13). Our initial design criteria are deliberately defined on the basis of domain-specific and educational theories. All criteria were successfully elaborated in the design of our scenario. The implemented scenario has yielded fairly satisfying learning outcomes for the students. We can say that, from elaborating into the scenario to operationalizing into the implementation, the design criteria all stood up and proved to be necessary for a robust design. However, this was only possible thanks to the verifications and validations of the scenario through all eight rounds of trials. By the implementations, the scenario based on the design criteria is evaluated critically, and then is further verified to overcome the difficulties that occurred in the classroom trials.

With our experience in generating the criteria, designing the scenario by the criteria, and implementing it, we come to several insights about the design criteria. Although our design study has proved the necessity and at least the internal validity of the design criteria, confusion arises when we tried to formulate our criteria from the abundant available ones for all possible levels of environmental education, e.g. the Tbilisi principles, the national guideline of China, the NAAEE guideline, and the guidelines proposed in various teacher training programs. The confusion arises because there are too many criteria, and they are too similar and too abstract. The development of the design criteria would not have been possible if we did not begin with choosing our positions from the theories (in chapter 11). Our experiences in elaborating the criteria into the scenario showed that it is crucial to be aware of the policy discourse background, to be explicit about the attained outcomes of environmental education, and to make a choice for a teaching-learning approach based on an educational view on learning. The design criteria are mostly represented in the selection of the study issues and the social practices. The difficulties that occurred during the implementations have pointed to the need for teacher training, as proposed in the previous section.

The remaining question now is whether our design criteria, even though they are validated in our study, would be useful for future design research. With design criteria design researchers strive to generalize a particular set of findings to a broader design theory. In a discussion on to what extent design criteria can be generalized from one context to others, Plomp referred to Yin (2003) in stating that as in case studies and experimental studies, the findings are only generalizable to theoretical propositions and not to populations or universes. The context-bound nature of design research makes it a valuable approach in striving to practical relevance. The theoretical yield of design research, in contrast to statistical generalization, is an analytical generalization (Plomp, 2006). It is expected that the replications and the iteration cycles in the design process are supportive for the design criteria to be accepted in larger number of similar contexts. Yet, as Plomp warned, contexts may be similar, but each context has unique characteristics, which justifies that design criteria should be used as heuristics that gives directions but not certainties. Our experiences showed that it is insufficient for the researchers to select and convert the criteria into a curriculum product. Therefore, the design criteria cannot provide empirical support for an adequate design about how to improve Chinese students' environmental literacy in solid waste management in general. However, our design research yields another theoretical output, a content-specific educational structure.

5.2 Reflection on the didactical structure

The scenario yields another theoretical output, an empirically tested educational structure, or in Lijnse's (2000) term, *didactical structure*, as a specification of the design criteria on how to teach a specific topic in a context. As we outlined in chapter 12, the didactical structure gives a procedural specification on the topic of solid waste management, how the five phrases of problem posing are developed into the scenario, and how a life cycle analysis is performed by content-related steps. The structure resonates well with the design criteria. At the core of the didactical structure is human interaction with the environment via commodities. It begins with the students' desire to contribute to an improved environmental quality from their unpleasant experiences of environmental problems. Therefore, it initiates a global motive to engage in the open inquiry process of the life cycle analysis. Each phase of inquiry begins with a need, a local motive that the students come to realize from the issue knowledge extended in an earlier phase of inquiry. So to say, in each phase of inquiry, the issue knowledge developed is crucially depending on having knowledge acquired in a previous phase. As from our experiences in this design study, the structure outlines a pathway of how the study issue of solid waste management as specified from design criteria is formalized into a concrete scenario in adopting a problem posing approach. The structure is validated through the classroom trials, and proved to be a necessary support for the teachers to understand the design intention, but it is debatable, however, if it can be generalized to a content-independent structure. Especially, for future teacher developers, it is questionable how far the education structure validated in this study can guide them to design their own lessons on the topic of solid waste management. Furthermore, it is uncertain in how far this topic-specific structure may give hints to teachers to develop lessons on other topics in environmental education, for example, biodiversity. In our design study, we did draw inspiration from the didactical structure developed by Kortland (2001), which was elaborated for developing decision making skills on the waste issue. When Kortland's didactical structure is formulated in content-independent terms, the idea occurred to us that it is a more generally distinguished didactical function based on the five phases of problem posing approach. Starting from that idea, we established the didactical structure, as in chapter 12 that clarifies the procedural issue of knowledge development, the maintenance of the global motive in the local motives generalized from enhanced environmental literacy on the issue of solid waste management. However, we came to the point of being able to fully understand the value of having a didactical structure after a long route of generating intended criteria, elaborated in the scenario, and implemented into practices. Therefore, it is more sensible to admit that it deserves new research to find out how a design study may bring about a need for teachers' professional development to the extent that they themselves become curriculum developers and know how to use productively the available design criteria or structure to align with their own interests.

5.3 Reflection on the debate about theoretical outputs

As we already recognized in chapter 10 the debate about the theoretical value of design studies is especially concerned with its generalizability. The locally validated instruction theory, as Gravemeijer and Cobb (2006) termed it, or the didactical structure, as Lijnse and Klaassen (2004) may argue, is not merely meant to validate the theoretical basis, but an inter-related motivational pathway. They both include structured sequences, activities, and issue knowledge in a specific domain. Despite the mismatch of terms used to differentiate design research trends, as it is not our research focus, we are more concerned to reflect on the theoretical output as achieved in this design study. This context-bound design study is aimed at exploring optimal solutions in addressing the complex problem, i.e. the rhetoric-practice gap that discourages the improvement of environmental literacy. The intervention produces context-based knowledge about whether, how, and why the scenario may or may not function as a solution to enhance environmental literacy and to close the rhetoric-practice gap. The theoretical value ultimately lies in detailed elaboration of each level of curriculum representations, namely, how the intended scenario has been developed into the potentially implemented formal product, and how it is further elaborated in actual classroom practices and perceived by the teacher, and until it is finally evaluated by assessing the students' learning experiences and outcomes. As we indicated already in chapter 10, design study in its initiation is considered as critical response to the over-ambitious goals and the lack of relevance in educational research, and we must bring to mind here that content-independent, and context-free design criteria may turn out to be no more than a slogan for teacher designers. The design criteria and the didactical structure did fulfill the potential to show expected directions in the very early stage in formalizing the scenario and in teacher preparation. However, we need to be critically cautious about the generalizable design criteria for broader impact. As in this design study, the theoretical value for future designer researchers still lies in the detailed elaboration of how and why the scenario is developed, that is to say whether, how, and why it functioned as a solution to enhance environmental literacy by narrowing the rhetoric-practice gap in China. And especially for the future teacher designers, the theoretical value is neither in knowing the criteria nor the structure, but has to be worked out in experiencing their own design studies aimed at improving practice and professional development.

Chapter 16 Conclusions and Discussion

1 Introduction

To draw a conclusion in connecting the two studies, the explorative study and the design study, we answer the research question: *What has the scenario accomplished as a curricular solution in closing the rhetoric-practice gap?* In the explorative research phase, we found the evidence of the rhetoric-practice gap in China, characterized the nature of the gap, and identified the tensions that create the gap. We therefore contributed to a Chinese perspective on how environmental education is engaged in challenges and opportunities in schooling. In the design study phase, we developed an exemplary curriculum unit and validated it in the selected locality. With the design study, we tried to transform the worked-out school curriculum into a teaching-learning strategy for enhancing environmental literacy of pupils in China. Evaluating the quality of the design study is also based on an understanding of how and whether it enabled to close the gap. On the basis of our exploration of the occurrence of the rhetoric-practice gap and the experiences in closing the gap with the design study, we may also contribute with our confirmed view about how to boost the application of environmental education into the school agenda to meet the existing challenges. In this last chapter, we briefly summarize the key findings from previous chapters and draw conclusions.

2 The design study in closing the rhetoric-practice gap

The rhetoric-practice gap, according to the analysis presented in the explorative study, can be decomposed in more specific gaps across the curriculum development of environmental and general education. The two most important gaps investigated in this study are: 1) the formalizing gap that in most of the curriculum elements, the assumed ideal features for environmental education are well supported in the rhetoric, but are inadequately adopted in the integrated and the domain-specific materials; or the few assumed features that are not supported in the rhetoric are further disapproved in the practices; and 2) the operational gap that the potentially implemented teaching materials have adopted the intended features, but the implemented teaching practices largely ignored them; or mostly the operational gap occurs because the teaching materials of both modes are designed disregarding the intended features or even fail to give any information in defining the curriculum elements.

2.1 The design study in closing the formalizing gap

The formalizing gap is identified by the seven elements rationale, goal, content, process, teacher, students, and assessment (see chapter 8, section 3). To close the gap, the intended scenario was developed (chapter 12, section 2.1-2.7), in reference to the theoretical assumptions (see chapter 3, section 3.1) and the design criteria (see chapter 11). With the special attention to overcome the inadequacies that created the gap, the intentions are characterized into the formal scenario (chapter 12, section 4) to be potentially implemented. The formalization follows the five phases of the problem posing approach (see chapter 12, section 3.1-3.5).

2.1.1 Rationale

The formalizing gap is evident for the rationale. Since all the assumed ideal features – holistic, interdisciplinary, real, practical and specific problems focus, and problematic study issues that open for flexible solution or conclusion – are affirmed in the rhetoric, but most of the integrated teaching materials are not yet developed to introduce problematic issues for the students to inquire, or to give them the chance to develop their own conclusions or solutions. To overcome the inadequacy in the existing materials, in our design study, the desired ideal features are characterized in the selection of solid waste management as the study issue, guided by the assumed rationale and the design criteria developed. The consideration was that solid waste management is problematic in China, and has not yet reached a certain solution or conclusion. It is a life-world practice under the current policy of circular economy, and involves environmental, social, and economical interests. Therefore, with the choice of this study issue, we provided the students with an ideal entry to inquire about solid waste management and to develop their own conclusions or solutions. In formalizing the scenario, we considered not only how to optimally characterize the intended features in the scenario, but more importantly also to already foresee and avoid the risk of leaving an operational gap in the implementation of the next step. Directed by the problem posing approach, we are especially concerned that the students need to develop a sense of purpose in taking this inquiry and not only because we intended them to. With the problem posing approach, the intended rationale is formalized into the motivation phase, in which the students begin with their experienced real environmental problems and hence develop a 'global motive' to contribute to an improved environment.

2.1.2 Goal

The formalizing gap for the goal is evident because in the rhetoric the assumed goal – knowledge is for immediate use for sustainable and emancipated quality of life and to prepare for inquiry and taking action in exerting influence on the environment – is fully confirmed, but the majority of the integrated teaching materials is developed unaware of it. Taking into account the gap, the assumption, as well as the criterion developed, the intended goal of our design study is explicitly defined to foster environmental literacy based on knowledge, skill, affect, and behavior, four strands, rather than being merely directed towards action. At the heart of environmental literacy is the understanding of the human-nature interrelationships. In the formalization of the scenario, the intended goal has to be connected to the study issue of solid waste management. It is expected that the teacher guides the students to realize that environmental problems are all related to people's need for commodities for living. So that in the motivation phase, the 'global motive' is further expressed as a steering question of what we can do with our daily life commodities; the paper notebook is an example for improving the environment.

2.1.3 Content

In terms of content, the formalizing gap exists because the assumed ideal features – content built from complex and contradicting information resources, with a high relevance for the real life world, and knowledge is developed by students – are well reflected in the rhetoric, but are not characterized in most of the materials in both modes, i.e. the content is not developed from complex sources, and factual knowledge is not developed by students' inquiry. To close the gap, the scenario reflected the assumption and the design criteria developed, and characterized them in the choice of solid waste management as the study issues and in the choice for the problem posing approach. Solid waste management is a relevant social practice in students' life world that involves various contradicting interest. Therefore, with this study issue, the content of the scenario is selected from multiple perspectives concerning the complexity of environmental and social-economical tradeoffs. With the problem posing approach, the scenario supports the students to take initiatives in seeing a direction of the knowledge development path. In the question phase, the students have freedom to propose their own questions, the 'local motive', which would lead to the sub-topics that formed the four lessons respectively.

2.1.4 Process

The formalizing gap exists in the teaching-learning process, because the assumed features – cooperative learning, participative learning, and students' engagement – are fully supported in the rhetoric but are ineffectively adopted in the two modes of materials, the integrated and the domain-specific materials. Particularly, the students had very limited opportunity to engage in the entire inquiry process. And the choices for participative and cooperative activities were narrowed down to only collecting information or express thoughts. Keeping this in mind, and guided by the assumptions and the criteria developed, the teaching-learning process in the scenario is structured by the problem posing approach. In the process, from their wish to improve the environment, the students are motivated to engage in the entire process, from finding a problem (motivation phase) and inquiring about the problem (investigation phase) to solving the problem (application phase) until another round of problem analysis (reflection phase) starts. The whole engagement offered the students opportunities for more diversified participative activities, and a higher level of cooperative learning, such as observing, visiting stakeholders, describing life, and hands-on activities in using the symbolic tools. In these cooperative learning activities, the students need to collectively find solutions to complete the group tasks, so that they have to develop a higher level of skills than merely collecting information and exchanging information. Instead of that they have to evaluate, categorize, summarize, compare and select information to solve the problems. In the investigation phase, the students participate, in a cooperative form, in a sequence of activities, in which they acquire the knowledge and skills expected for doing a life cycle analysis of the commodity, and to develop the desired environmental affect. In the application phase, the students make their choices about what they do with the exemplary paper notebook in purchasing, utilization, and disposition, based on their acquired knowledge, skills, and the developed affect.

2.1.5 Teacher

The formalizing gap is created because of the absence of any information about the role of teachers in the two modes of materials, although the assumed ideal role – to be amenable to students' autonomous decisions and as agents to shape curriculum and pedagogy – is reflected in the rhetoric. Together, in reference to the assumption of the ideal teachers' role, and the developed criteria, we tried to meet the need by presenting a detailed indication about the expected performances in the teacher's manual, and by making it clear in the teachers' preparation that their role is guiding from 'below', i.e. be amenable to students' autonomous decisions, as well as guiding from 'above', i.e. keeping in mind the structured sequences of learning activities that are initiated from the students' own interests. It is most crucial in the motivation phase that the teachers act as the linking pin for the students to be aware of the need to contribute to a better environment, and to realize the relation between humans and nature via daily life commodities. In the reflection phase, the teachers act as the linking pin for the students to historically understand the 3R practices in Chinese society and to critically debate about the tradeoffs in economical and ecological impacts. In the question and application phases, the teachers mainly act as facilitators to support students' own inquiry.

2.1.6 Student

The formalizing gap exists because the assumed students' role – active and critical thinkers, and the generators of knowledge – is identified clearly in the rhetoric but is poorly recognizable in both modes of teaching materials. The inadequacy lies especially in that the students are limited to study predefined topics, to respond to questions proposed by the teacher, to receive standard answers for the predefined questions, and to take suggested actions. Guided by the assumption and the criteria developed, the scenario tried to overcome this inadequacy by giving students the opportunity to take the initiative in learning, and by engaging them in the open inquiry. In the motivation phase, the initiation is based on the students' interest in having a better environment that is grounded on their unpleasant experiences with environmental problems. In the question phase, the four lessons are planned to address questions proposed by the students themselves and to explore their own action plans or solutions. In the application and reflection phase, the students develop and defend their own choices.

2.1.7 Assessment

The formalizing gap in assessment exists in that the assumed assessment emphases – process of inquiry, the extent to which students develop and defend their own environmental beliefs and choices, and the ability to act according to their choices – are fairly confirmed in the rhetoric, except for a preference of end-of-pipe standard assessment for extra-curricular activities, but it is undefined in most of the teaching materials of both modes. In the limited number of materials that have information about assessment, the formalizing gap is evident in that only a minimal proportion adopted the intended assessment approaches, and also the materials for extra-curricular activities have continued to show the preference of end-of-pipe standard assessment. Under the guidance of the assumption and the criteria developed, the assessment in the scenario is therefore included in every phase of learning, measured from the students' own reflection, and is executed by the designer-researcher, the teachers, and the students themselves. In the application phase, the students argue and negotiate in groups to propose their own behavioral choices in purchasing, utilizing and disposing of the paper notebook. In the reflection phase, the groups recognize more environmentally friendly stationery items by applying a new life cycle analysis. In the assessment there is no standard answer, but an emphasis on the extent to which the students show in their argumentation and reasoning in group discussions the extended knowledge, skills, and developed environmental affect.

2.1.8 Conclusion

The development of the scenario was based on the assumptions and the design criteria, and with special attention to the inadequacies in the existing material designs. Being so, the intentions of the design have been optimally formalized into the scenario, therefore avoided the formalizing gap that occurred in existing materials. From our experience, in the formalization, it is first crucial to select a study issue, in our case solid waste management, which represents most of the intentions; or to say, the intentions should serve as guidance to evaluate whether the selected study issue is good enough to optimally characterize the ideal features. Secondly, it is a key to select a teaching-learning approach, in our case the problem posing approach, which structures the teaching-learning path and organizes the lessons. Or to say, the problem posing approach in our design study served as a track along which the intended features are characterized into five study phases. The problem posing approach also especially contributed to defining the role of the teacher and students, so that the students' study initiative is already guaranteed in the formal scenario, the teachers and the students can have a sense of purpose for accepting this inquiry, and consequently to avoid the risk of leaving an operational gap in the next step.

2.2 The design study in closing the operational gap

The operational gap is created mostly because of the inadequacies in the actual practices, no matter if the intended features have been formalized into the materials. An operational gap can be avoided, when the teaching practice is performed well in line with the ideal features. Keeping this in mind, we further examined the quality of our scenario in closing the operational gap, from its acceptance in the teachers' perceptions and from the actual classroom practices. The findings also improved our understanding of why the operational gap occurred previously in environmental education in China, and how further efforts are needed to avoid it in the future.

2.2.1 Rationale

The operational gap exists for rationale in that the majority of the materials failed to give the students the possibility to present their own conclusions or solutions, and this is also missing in both intra- and extra-curricular practices. The gap also lies in that the domain-specific materials are largely focused on problematic study issues for the students to inquire into, but the contrary was found in the domain-specific extra-curricular activities. Such evidence reminds us that it is possible to create gaps if the practices are not selected in respect to the formalized intentions. In our design, we tried to implement the scenario as faithfully as possible. During the implementation, all the teachers readily accepted that the scenario embraces multi-disciplinary knowledge, but did not feel confident to grasp the issue knowledge and requested the designer to add knowledge cards to the teacher's manual. The majority of the teachers agreed that solid waste management is problematic in terms of efficiency of resource utilization. One teacher disagreed, but emphasized that the problem is the aesthetic loss caused by littering. All the teachers accepted that the scenario is focused on a real, specific, and practical problem. Although the teacher's manual encourages the students to develop their own solution or conclusion, during the classroom trials, one teacher dominated the students' group discussion several times by giving them the answers she thought were correct.

2.2.2 Goal

In current practices of environmental education, as observed in the explorative study, a possible formalizing gap for goal is enclosed. The goal perceived in the integrated intra-curricular teaching practices fairly confirms the intended goal for environmental education, although the majority of the integrated teaching materials is developed without awareness of it. However, there is still a preference in both intra- and extra-curricular practices that knowledge merely concerns behavioral change. In our design study, all the teachers agreed the intended goal is an improved sustainable life quality, but they suggest that not to litter is the immediate goal to achieve. One teacher argued that among the four strands of environmental literacy, knowing the correct actions is the utmost goal. Most of the teachers have developed an awareness that besides aesthetic loss and sanitary threats caused by litter, depletion and pollution have another impact in the long term. Some of them still emphasized that for the students to understand why litter is not recommendable is an important goal to achieve. We should only tentatively conclude that the intended goal is understood and accepted by most of the teachers, but some of them put their emphases on behavioral change in general and on not to litter in particular. After the design study it was concluded that an operational gap is likely to occur when the teachers are not provided with a more systematic training (as discussed in chapter 15, section 3.1), to be more convinced of the advantages of the intended goal, to prepare for more deliberate actions, and to get a more systematic understanding of consequences besides short term aesthetic loss by littering.

2.2.3 Content

A possible operational gap is avoided since in the actual teaching practices of both modes, the content is introduced in line with the intended approaches, although the intentions are largely missing in the two modes of materials. Therefore, the practitioners have shown a competence to develop content in accordance with what is desired in environmental education. This competence can be understood as a fruit of current curriculum reform, in which the institutionalized intentions for general school education have many characteristics in common with the ideal environmental education. In our design study, the classroom trials have proved that as long as the teachers carry out the planned tasks, the students are indeed engaged into the life cycle analysis of the paper notebook which is highly relevant to their life experience, and requires information from different sources to understand the complexity of the environmental impacts. Nevertheless, as perceived by the teachers, it is very difficult to facilitate the students to debate about the trade-offs in ecological and economic impacts and to propose win-win solutions. This finding has led to an adaptation in the scenario, namely the addition of knowledge cards to exemplify some worked out eco-solutions. Even so, one teacher still preferred a conventional top-down knowledge transition approach and disapproved the problem posing approach, for the reason of efficiency in making behavioral changes. To avoid the operational gap in the long run, systematic training for the teachers is necessary to fully understand the value of the knowledge development path encouraged by the problem posing approach, and to improve their understanding of the complexity of environmental and socio-economic impacts (chapter 15, section 3.1).

2.2.4 Process

The formalizing gap is found in teaching-learning processes in both modes of practices, because the intended engagement into the entire inquiry process, and intended opportunities in participative and cooperative learning that are inadequately presented in the two modes of materials continued to miss the two modes of practices. In our design study, the students' engagement is guaranteed by the teachers' performances, though in the perception of one of the teachers, such a full engagement throughout the process is not necessary. The scenario invited the students to participate in various activities. As in lesson 1 and 2, the students were invited to observe, to visit the stages or stakeholders in their communities, e.g. a scrap station or a scrap picker. They were also invited to participate in hands-on card patching or diagram drawing with the help of the symbolic tools. The teachers worried about the inconvenience of preparing the tools without the support from this design study. Therefore, an additional group work sheet was provided, in which more card patching is simplified into drawing diagrams from the printed photo cards. Observing and visiting raised the teachers' concern of safety and social pressure, because these are out of campus activities, and suggest a contact with lower class people. In terms of cooperative learning, all the teachers were familiar with guiding the class-wide discussions and performed as intended in welcoming the students to freely express any of their views. In group work, the students were requested to complete learning tasks cooperatively, which is different from the merely exchanging collected information that they are used to. As the classroom trials proved, this style of cooperative learning was new for the teachers and the students. Some teachers acted rather dominantly in facilitating the group discussions, and some groups encountered large or small difficulties. Therefore, we can foresee there will be an operational gap when the teachers become detached from the design study, if they are not fully convinced by the design intention, and if they are not well trained to facilitate and help the students improve their cooperative learning skills. Except the technical adaptation to reduce the teachers' work load, teacher training is especially needed for them to understand and agree with the constructivist view, and the necessity of the students' full engagement (see chapter 15, section 3.1). Outdoor participative activities are still problematic and hard to implement in Chinese schools. Grouping is another difficulty to overcome in the large sized classes in China. In the future, solutions to these problems need to be deliberately found together with the teachers by involving them into a subsequent phase of the design study from a mutual adaptation or enactment perspective that targets teachers' professional development (chapter 15, section 3.2, 3.3).

2.2.5 Teacher

For the teacher's role, there is an operational gap in domain-specific environmental education. The domain-specific materials failed to define the teacher's role in detail. In the extra-curricular practices, merely knowing that they have the freedom to adapt content and knowledge is far from sufficient, and the teachers struggled with making an appropriate design that would avoid top-down dominant teaching, and offering change to more average students as well, rather than to only a few elite students. In integrated environmental education, a possible operational gap is closed because the teachers performed mostly in line with the intended role for environmental education, although the integrated materials did not include any indications. This can also be considered as a result of the current curriculum reform. In our design study, the teachers all agreed and showed adequate competence in guiding from 'above', but they held contrasting opinions about their role in guiding from 'below'. There is suspicion about the pressure of exam-orientation that is still valid in current school practices, so that one teacher insistently argued for the effectiveness of teacher-centered top-down teaching. Although the intended scenario supports the teachers as agents to adapt content and pedagogy, at the stage of this design study, the teachers' preparation has the fidelity perspective (see chapter 15, section 3.3) as a starting point to guarantee that the ideally formalized scenario is implemented as faithfully as possible. When detached from the designer, there is likely to be an operational gap if the teachers hesitate again about the value of constructivist views, and if the problem of feeling pressure from the exam-orientated evaluation is not solved. This may be solved in the next stage of the design study that allows more mutual adaptation and enactment, with a focus on the teachers' professional development (see chapter 15, section 3.2, 3.3).

2.2.6 Student

For the students' role, there is also an operational gap in domain-specific environmental education. In the domain-specific materials the intended students' role is not recognizable, and in the extra-curricular practices, the majority of the students were considered as passive recipients. In integrated environmental education, a possible operational gap is closed, since the students in the class were respected as generators of knowledge and critical thinkers, although this is not described in the integrated materials. In our design study, the students are supposed to take an active role in initiating knowledge development. In the implemented motivation and question phase, all the teachers were competent in encouraging the students to raise their own questions, even though they perceived this rather differently. Most of the teachers were suspicious of whether the student-centered approach is feasible or effective in the exam-oriented school practices. In lesson 4, the students were encouraged to debate critically about the tradeoffs in environmental and social-economical impacts. Such debates turned out to be too difficult for most of the students, and to a large extent this was due to the lack of confidence in the guidance from the teachers who themselves had not yet seriously thought about the contrasting impacts before. Although most of the time, the teachers in the design study were capable of supporting the intended students' role, although their concern about exam-oriented pressure shows a risk of an operational gap in the future.

2.2.7 Assessment

The operational gap is evidenced in that the intended assessment is ignored in the majority of the materials of both modes, and is also inadequately implemented in both modes of practices. In domain-specific environmental education, however, the undesired standard-based end-of-pipe assessment is accepted in the materials, and further put into practice in a top-down administrative way. And in integrated environmental education, the performed assessment during the class was mostly in line with the intended approach, but the unintended standard evaluation applied in the final exams. In our design study, the intended evaluation approaches were welcomed by all teachers. Even the teacher who insisted on the teacher-centered dominant approach admitted that such a way of assessment would finally relieve the teachers from being overloaded with work and from professional pressure. And in implementation, all the teachers showed their competence to undertake the indented developmental, self-reflexive, and democratic evaluation, such as in recognizing the students' improved knowledge, skill, affect, and behavior during the learning process, to guide the students in performing a self-evaluation, to encourage the students to elaborate and defend any of their own choices. We can see that the intended assessment is sincerely appreciated by all the teachers, or is seen as an innovation that they look forward to. In the future, the operational gap for assessment can be avoided since the intended approaches are also desired by the teachers, and they are competent to carry it out as expected. Yet it is another issue whether such an assessment will be welcomed and will survive under the pressure of exam-orientation. This issue will be discussed in the next section.

2.2.8 Conclusion

The scenario is robust in the sense that the students are indeed engaged in an entire life cycle analysis that was initiated from their own interests. At the stage of our design study, the implementation is ensured from the fidelity perspective to avoid the operational gap. The teachers are prepared to carry out the planned activities as faithfully as possible. During the implementation, most of the time the teachers could carry out the activities as planned, though they might also perceive the intended elements in different ways. As perceived by some of the teachers, aesthetic loss by littering should be emphasized along with all other environmental impacts. Some teachers were worried about the feasibility of a student-centered learning approach, and were skeptical whether it would be effective to get a high mark in standard-based evaluation. For this reason, one teacher insistently argued in favor of the efficiency of teacher-centered knowledge transition from the top down, and rejected the value of the problem posing approach. Seemingly contradictory, all the teachers applauded the intended developmental, self-reflexive, and democratic assessment approach. For the teachers, the pressure of their workload and professional development comes from the exam-orientated practices, which have remained in current schooling. To conclude, the operational gap is not yet completely closed in our classroom trials, as is evident from some inadequate teaching performances, such as in over-leading the group discussion and in having difficulties to guide the students to debate about the trade-offs. Other evidence lies in the difficulties with outdoor activities and grouping. Moreover, the students also encountered problems in achieving the intended cooperative learning. And most importantly, not yet all the teachers are fully convinced of the value of the intended design. Being so, when detached from the design study, the operational gap will very likely also occur in future. Looking ahead, at the least a more systematic in-service teacher training will be needed to improve their content knowledge and to fully recognize the value of the problem posing approach. In the future, perhaps a new design study with a focus on the teachers' professional development will find better solutions to improve the teachers' commitment, and ultimately have them grow to be curriculum developers themselves. In such a design study the scenario has to be implemented from the perspective of mutual adaptation or enactment.

3 Application of environmental education in the curriculum system of China

After the design study, we are also able to reflect on the optimal application of environmental education in confronting various obstacles and tensions in the current curriculum system in China. By going through the findings from chapter 9, we present in this section our improved insights.

3.1 Reappraisal of the rhetoric-practice gap

The study of the rhetoric-practice gap is proposed to help reveal the resistances that environmental education received in school practice in the 1980s. Nonetheless, as in our study, the evidence of the resistances is still found in China. In fact, the rhetoric-practice gap has been an ongoing concern in the environmental education research, as can be observed by a number of authors in their recent studies elsewhere. According to the review of Gruenewald and Manteaw (2007), several texts were published since Stevenson's essay from 1987. The reader is referred to the work of Orr (1992, 1994), Bowers (1993, 1997), Fien (1993), Huckle and Sterling (1996), Hart (1997), O'Sullivan (1999), and Smith and Williams (1999). These research efforts converged into a comprehensive critique on the structural, ideological, pedagogical and curricular practices of the dominant schooling that continues to work against the goals of environmental education. The world-wide evidence from these studies also provides a critical reappraisal of Stevenson's description of the rhetoric-practice gap.

As we found in our design study, the exam-orientation had a remarkable influence on the teachers' perception about the value of innovation in teaching. Similarly, Barrett's (2007) observation in Canada problematizes the assumption that teachers who are highly committed, creative and competent in environmental education have the agency to overcome the barriers. Barrett revealed that teachers' ability to act upon environmental education may be constrained by resistant discourses about what counts as legitimate. Consequently a significant gap may still exist between the teachers' concern on the one hand and their practice in class on the other hand.

Very similar to China's curricular rhetoric reform, in South Africa, the discourse of environmental education is built into the national curriculum statement. Lotz-Sisikta and Schudel (2007) examined the South African National Curriculum Statement closely for its adequacy in classroom practices. The analysis is drawn from case studies in which teachers plan lessons based on the national curriculum statement and implement them in classes. The study reported some inaccuracies in factual information, superficial and skewed interpretation of issues, and problems related to the quality of the teacher's knowledge in the lessons planned and taught by the teachers. As well as in Latin-America (González-Gaudiano, 2007), a context where a depleted conventional school curriculum showed a growing inability to respond to the present complex challenges, the placement of environmental education in schools still faces many of the constraints as characterized by Stevenson. Environmental education in schools also showed a dominant biologist-naturalist emphasis, and teachers encounter difficulties and tend to oversimplify, which reinforces an environmental education stereotype that is removed from its vision. Lotz-Sisikta and Schudel (2007) noted in their study that a high practical adequacy of the national curriculum statement requires a strong partnership between school, municipality and local authorities and better quality teaching and learning support materials. The materials should allow for informed deliberations on contextual issues, with the strengthened teachers' knowledge and epistemology to support their existing beliefs and concerns.

As we found in our design study, having solid material that is deliberately context-bound is not yet sufficient to fill the gap completely. A partnership can be strongly stated only in the rhetoric and remain dominant in providing top-down administrative evaluation to schools, as we find in extra-curricular environmental education activities in China. And teachers' development of knowledge and epistemology cannot yet be fully fostered when in the first stage of design study the implementation focuses on fidelity.

The insufficiency of fidelity in implementation of educational innovation is also demonstrated in the study of Hacking et al. (2007). The authors identified that the rhetoric-practice gap is still evident in schools in the UK, but they looked at a project – Listening to Children – for possibilities to move closer to Stevenson's terms of environmental education. The project involved children in a curriculum initiative, paid attention to children's local knowledge, and expressed children's desire in the curriculum. By the end of the project questions were asked about continuity and expansion when the enabling conditions that support the project are no longer available. The project is described as a successful example to reduce the gap, but its enabling conditions, such as the stakeholders' collaboration and the confines of the existing curriculum are relaxed, etc. seemed a repetition of what environmental education expects from schooling.

In the United States, the No Child Left Behind project showed that legislation with its emphasis on accountability and narrowly defined achievements fundamentally works against the aims of environmental education (Gruenewald & Manteaw, 2007; Ernst, 2009). As Gruenewald and Manteaw (2007) noted, under the pressure of accountability and standardized outcome measurement, environmental education responded in two ways. One is to accommodate and to prove that environmental education may also help to foster students' achievements in the measured content area, so that the goal is deviated from achieving a more sustainable society toward reinforcing the standard measurement. The other response is to resist such a distortion. Rather than squeezing environmental education to survive in schools, it promotes demonstrating a different way of practicing accountability to rethink the rules of what needs to be accounted for. The hope is set on students' participatory inquiry of local political democracy and community problem solving, taking place-based education as an example (Gruenewald & Manteaw, 2007; Smith, 2007). However, we see a risk that such a democratic participation itself might have to overcome as many constraints as environmental education. We will further elaborate our view on how best to apply environmental education in the school agenda, taking the context of China.

To conclude, the explanations of the rhetoric-practice gap still hold for the frustrated implementation of environmental education. Also the studies that were conducted worldwide tried to build on deliberation with conventional schooling. In acknowledging the occurrence of the rhetoric-practice gap in China, and in experiencing the tensions and the barriers to narrow the gap, we are now more cautious about claiming additional supportive conditions, such as a democratic partnership, or attaching environmental education to an innovative educational approach, such as place-based education or community-based education. Any solution to build such deliberation should be context-bound, and validated on its adequacy in actual practices. In the context of China, if not to sacrifice the true aim of environmental education to satisfy the standard measurement, an improved application of environmental education into the school agenda should begin with a top-down and not with a bottom-up reform.

3.2 Macro-level reform and micro-level innovation

Exploring the rhetoric-practice gap improved our understanding of the tensions and barriers that dissuade school level practitioners to commit themselves to environmental education. From our experiences working in the schools in the design study, we further confirm that to foster environmental education cannot be the mission at the micro level by the school level practitioners.

As we found in implementing the scenario, the teachers welcomed the intended assessment but suspected other intended elements to various extents. This seeming paradox points to the source of pressure, the evaluation system dominating the current schooling. The teachers truly appreciate the reformed intention in the new curriculum standards. And the participant teachers in the design study could easily recognize that the intention of the scenario has many features in common with it. However, when the professional evaluation is applied to teachers, it puts weight on the students' average score in the teacher's class. This resulted in contrasting teaching performances during the classes and in the final exams. And it also led to the consequence that on the one hand teachers are looking forward to undertake the developmental, reflexive, and democratic assessment of the students, but on the other hand hesitate to fully accept the design intentions from the scenario that are in coherence with the expected assessment. We can conclude that even though at the micro level, the teachers have a desire for innovation, there is a problem with accountability in the standard evaluation, which is established administratively top-down.

Besides the assessment barrier, the school level practitioners are not yet fully prepared to develop their own school curriculum. In its current application, environmental education is encouraged as a topic to develop a school-based curriculum for. However, simply leaving the freedom to do so to the teachers would also mean leaving them alone to become curriculum developers. Our design study proves that although the teachers have the basic competences to perform innovative teaching, they need to be further trained to improve their issue knowledge, to improve the understanding of true aim of environmental education, and the essence of environmental literacy. And the teachers, the YPD directors, and school principals need to be further supported by experts or experienced designers about what design intentions are expected for the ideal environmental education and how to optimally elaborate them into a product. As we have already seen, without support during the design process, the operational gap did occur easily, through inadequate teaching such as a superficial, fragmented interpretation, or through direct commands for behavioral changes.

Therefore, we conclude that the mission to foster environmental education should not weigh primarily on school level practitioners. One reason is that the barrier of assessment is set up from the top and cannot be removed by the practitioner at the bottom level. The other reason is that school level practitioners are not yet equipped as curriculum developers to make the most of the school curriculum. What would be feasible is to systematically plan the application of environmental education into the school agenda from the macro level, by gaining more attention from educational administrations. From our exploration of the occurrence of the rhetoric-practice gap and our experiences in closing the gap with the design study, we may contribute with some advice about how to promote the application in the three modes of environmental education.

3.3 Three modes and three levels of environmental education

Considering the competition in the labor market and the social-historical culture in China, the standard assessment cannot be replaced in the near future, although it has been discouraged in the rhetoric of educational policy. To accommodate a standardized outcome measurement is considered as a sacrifice of the true aim of environmental education. Rather than modify environmental education to survive in schools, it is more productive and promising to advance the ongoing curriculum reform so that it raises hope for a further greening of the curriculum. However, we should be aware that it is not realistic for environmental education to be the top priority on the school agenda, since others may easily argue for the same necessity to prioritize any other educational topic, such as ethics education, health education, tax education, or national security education. By fostering environmental education, we mean to advance its quality in the already established three modes of application. As has been explained in chapter 9, in the current curriculum system in China environmental education is applied in three different modes (see table 16.1).

Table 16.1: Application of environmental education in China

	National curriculum	Local curriculum	School curriculum	Extra-curricular activities
Multi-disciplinary integration	*			
Cross-disciplinary topic	*			*
Domain-specific subject		*	*	

In the national curriculum, environmental education is embedded into various disciplinary subjects, or recommended as a cross-disciplinary study topic in *integrated practical activity curriculum* (IPAC). In the '*Green School*' nomination supervised by the MEP, schools are recommended to make a systematic plan on integrating environmental education components. As we have confirmed in chapter 9, such a task can only be achieved at the macro level, namely, organized by the MoE. It would otherwise be impossible for the schools to accomplish, since there is no readiness of cross-disciplinary knowledge, approaches, and epistemology. Even if it did succeed with great difficulties, or with tremendous investments of time and personal effort for gaining experiences, or external support by experts, there would be still a problem of legitimate accountability in educational assessment. As we know from chapter 9, fortunately the leading publishing house of MoE has been working on integrating the fragmented multi-disciplinary infusions in the national curriculum since 2009. Also an institutional change that dates from 2010 holds more promises to have a climatic reform in the national curriculum, namely, the Center of Education for Sustainable Development (CESD) has been re-organized into the Faculty of Education, Beijing Normal University, where the national curriculum in China is defined. This means that environmental education has entered the mainstream educational system and now has an opportunity for 'greening' the curriculum system, and not to be marginalized.

As we know, in current school practice, the schools have most autonomy in the school curriculum and extra-curricular activities. In the rhetoric of curricular policy, schools are encouraged to develop their own school curriculum for environmental education, as a domain-specific subject. And in extra-curricular activities such as class meetings, environmental education is recommended as a cross-disciplinary topic for the students to collectively apply the knowledge and methods learned from their disciplinary courses. Only in some provinces is environmental education developed into teaching materials in the local curriculum. School curriculum is a reform in decentralization. Nonetheless, merely granting the freedom or autonomy can in fact imply a shift of responsibility to school level practitioners. Knowing from our study, on the one hand school autonomy is encouraged in policy rhetoric but on the other, no further training or resources are offered to support the schools. The knowledge, skills, and epistemology are still lacking for the teachers to become curriculum developers who commit to the true value of environmental education. Particularly, the teachers define the educational purpose and judge the efficiency on the basis of an exam-oriented cultural context in which they themselves are situated. In the tradition of Confucianism, the examination carries a lot of social and cultural meanings, especially in that it provides an educational selection, an avenue for students to enter to a higher level in social-economic hierarchy (Wong & Wong, 2002). If in the school entrance selection the standard examination is replaced by plural assessment, the selection will be even more complicated in involving the students' proficiency acquired from advantageous family conditions (Lin, Chen, & Zhang, 2005). Admittedly against such a background, the school curriculum is expected as an innovation to be stimulated from the micro level, and maybe nourishes a false hope to enhance environmental education in the school agenda. To boost that hope, school level practitioners should be convinced of the value of environmental education. The problem posing approach should also be applied in engaging the teachers into the process of school curriculum development. The school curriculum of environmental education, as an innovation, should be initiated from the teachers' existing interest, or from the problem that they want solve, so that they themselves see the direction, the purpose of pursuing.

Taken together, we argue that the point is not whether environmental education should be marginalized or prioritized in the school agenda. The issue is how, within its legitimated application modes, to optimally enact the expected ideal features at the operational level with the true commitment of the practitioners. The three modes, as now defined in the Guideline (CEE2, p. 25), multi-disciplinary integration, cross-disciplinary topic (kua xue ke), and domain-specific subject may respectively relate to the three basic models of cross-disciplinarity distinguished by Becker, Jahn, and Stieß (1999). The model of multi-disciplinarity is goal-oriented, in which various individual disciplines are combined in a theme for achieving an objective specified by policymakers. Professional knowledge, concepts, methods and tools adhere almost entirely to their own disciplines. There is little impetus to reach a 'synthesis' in the scientific research process, rather than merely adding together the results. Inter-disciplinarity is problem-oriented, and in the cooperation, different disciplines agree on a common description of the problems under review. Different disciplines have a joint central research question and objective, and also exchange research findings. The research process works on using the customary disciplinary theories and methods that have not yet been reviewed critically on their limitations. The third model, trans-disciplinarity is self-reflexive, in which each disciplinary perspective is critically examined and recognizes that the research issue lies beyond a traditional subject matter, but constitutes a trans-disciplinary field in itself. It further promotes theoretical, methodological, and conceptual reorientations with respect to the core concepts in the study issue. The related disciplines should agree on a common conceptual framework and research process, and requires therefore delicate negotiations among the actors. In Chinese curricular policy documents, there is no thorough discussion of the cross-disciplinary nature of the three modes of application, but they are presented in vague terms. As Becker (2002), Becker et al., (1999), and Klein (2004, 2008) emphasize, there is an urgent need to understand environment or sustainability related research from its trans-disciplinarity. When each discipline remains within its own field of specialization, several disciplines together are insufficient to solve problems of socio-ecological complexity. Rather than depending on a fragmented knowledge base, innovation arises from a co-construction of knowledge, methodology and a common conceptual framework. The school curriculum offers a favorable opportunity, for micro-level practitioners to search and test heuristic strategies for possible problem solutions that can meet the expectations of ideal environmental education, and are at the same time affordable in the dominant culture of assessment. Macro-level reform or reorganization will bring a multi-disciplinary national curriculum closer to the meaning of sustainability. And in the school curriculum, the knowledge, approaches, and techniques are empirically warranted. Therefore, it is a realistic hope that the school level practitioners will finally attain a systematic understanding of the complex and interdependent nature of environmental issues and sufficient know-how to guide their students to reach the same reflection. The hope can grow further when the worked-out school curriculum obtains context-bound theory and advice for a local curriculum and the national curriculum, or at least improves their operational quality, since school-level practitioners will then have the competence to reach their upper level administrative actors with their own, argued communication for consensus.

References

Andersen, M. S., & Massa, I. (2000). Ecological modernization—origins, dilemmas and future directions. *Journal of Environmental Policy and Planning, 2*(4), 337–345.

Anderson, J. R., Reder, L. M., & Simon, H. A. (1996). Situated learning and education. *Educational Researcher, 25*(4), 5–11.

Baker, S., Kousis, M., Richardson, D., & Young, S. (1997). *The Politics of Sustainable Development: Theory, Policy and Practice within the European Union*. London: Routledge.

Banchi, H. & Bell, R. (2008). The Many Levels of Inquiry. *Science and Children, 46*(2), 26–29.

Barrett, M. J. (2007). Homework and fieldwork: investigations into the rhetoric–reality gap in environmental education research and pedagogy. *Environmental Education Research, 13*(2), 209–223.

Bates, R. (2002). The impact of educational research: alternative methodologies and conclusions. *Research Papers in Education, 17*(4), 403–408.

Becker, E. (2002). Transformations of social and ecological issues into transdisciplinary research. In UNESCO (Ed.), *Knowledge for Sustainable Development: an insight into the encyclopedia of life support system, vol. 3,* (pp. 949–963). Paris/Oxford: UNESCO/Eolss Publishers.

Becker, E., Jahn, T., & Stieß, I. (1999). Exploring uncommon ground: sustainability and the social sciences. In E. Becker, & T. Jahn (Eds.), *Sustainability and the Social Sciences: a cross-disciplinary approach integrating environmental considerations into theoretical reorientation* (pp. 1–22.). London: Zed Books.

Berelson, B. (1952). *Content Analysis in Communication Research* (pp. 18). Glencoe, Ill. : Free Press.

Bian, H. (2004). Integrating environmental education into the elementary school curriculum. *Chinese Education and Society, 37*(4), 48–52.

Billett, S. (1996). Situated learning: bridging sociocultural and cognitive theorizing. *Learning and instruction*, *6*(3), 263–280.

Biraimah, K. L. (2003). Transforming education, transforming ourselves: contributions and lessons learned. *Comparative Education Review, 47*(4), 423–443.

Blumer, H. (1969). Symbolic Interactionism: Perspective and Method. Englewood Cliffs, NJ: Prentice-Hall.

Boersma, K. Th., Eijkelhof, H. M. C, & Bulte, A. M. W. (2006). The selection of social practice as starting point for the construction of science curricula. Unpublished manuscript.

Boersma, K. Th., & Waarlo, A. J. (2009). On the theoretical input and output of 'design research'in biology education. In M. Hammann, A. J. Waarlo, & K. Th. Boersma (Eds.), *The Nature of Research in Biological Education: old and new perspectives on theoretical and methodological issues. A selection of papers presented at the VII:th Conference of European Researchers in Didactics of Biology, ERIDOB* (pp. 463–479). Utrecht: Utrecht University.

Bowers, C. A. (1993). *Education, Cultural Myths, and the Ecological Crisis.* Albany, NY: State University of New York Press.

Bowers, C. A. (1997). *The Culture of Denial.* Albany, NY: State University of New York Press.

Brill, J., Kim, B., & Galloway, C. (2001). Cognitive apprenticeships as an instructional model. In M. Orey (Ed.), *Emerging perspectives on learning, teaching, and technology Vol. 5*. E-book available at: http://itstudio. coe. uga. edu/ebook/

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32–42.

Bruning, R. H., Schraw, G. J., & Ronning, R. R. (1999). *Cognitive Psychology and Instruction* (3rd ed.). Columbus, OH: Merrill.

Carnoy, M. (2006). Rethinking the comparative—and the international. *Comparative Education Review, 50*(4), 551–570.

China Centre for Modernization Research (2007). *China Modernization Report 2007: a study of ecological modernization*. Beijing: Beijing University Press.

Chu, H-E., Leeb, E. A., Kob, H. R., Shinb, D. H., Leeb, M. N., Minb, B. M., & Kang, K. H. (2007). Korean year 3 children's environmental literacy: a prerequisite for a Korean environmental education curriculum. *International Journal of Science Education, 29*(6), 731–746.

Clair, R. S. (2003). Words for the world: Creating critical environmental literacy for adults. *New Directions for Adult and Continuing Education, 2003*(99), 69–78.

Collins, A., Brown, J. S., & Newman, S. E. (1989). Cognitive apprenticeship: teaching the crafts of reading, writing, and mathematics. In L. B. Resnick (Ed.), *Knowing, Learning, and Instruction: essays in honor of Robert Glaser*, Hillsdale, NJ: Lawrence Erlbaum.

Cui, Y. H., & Wang, X. Z. (2006). The curriculum reform in basic education: values, progresses, and problems. *The Global Education, 2006*(1), 78–82. (In Chinese.)

Cunningham, D. J. (1992). Beyond educational psychology: steps toward an educational semiotic. *Educational* Psychology Review, *4*(2), 165–194.

Cunningham, W. P., & Cunningham, M. A. (2008, 5th ed.). *Principles of Environmental Science: inquiry and applications*. Boston, MA: McGraw Hill Higher Education.

Daly, H. E. (1996). *Beyond Growth: The Economics of Sustainable Development*. Boston, MA: Beacon Press.

Daun, H. (2007). Globalization and the governance of national education systems. In D. Holger, (Ed.), *School Decentralization in the Context of Globalizing Governance: international comparison of grassroots responses* (pp. 5–26). Dordrecht: Springer.

Davidson, D. (1980). *Essays on actions and events*. Oxford: Oxford University Press.

Dewey, J. (1997). *How We Think*. New York: Dover Publications.

DiSessa, A. A., & Cobb, P. (2004). Ontological innovation and the role of theory in design experiments. *Educational Researcher, 32*(1), 77–103.

Disinger, J. F., & Roth, C. E. (1992). *Environmental literacy* [*ERIC/CSMEE digest*]. Columbus, OH: ERIC Clearinghouse for Science, Mathematics, and Environmental Education (CSMEE), Ohio State University.

Dobson, A. (1996). Environment sustainabilities: an analysis and a typology. *Environmental Politics 5*(3), 401–428.

Dobson, A. (1999). *Justice and the Environment: Conceptions of Environmental Sustainability and Theories of Distributive Justice*. Oxford: Oxford University Press.

Dryzek, J. S. (1997). *The Politics of the Earth: Environmental Discourses*. Oxford: Oxford University Press.

Eash, M. (1991). Curriculum components. In A. Lewy (Ed.), *The International Encyclopedia of Curriculum* (pp. 71–73). Oxford: Pergamon Press.

Edelson, D. C. (2006). Balancing innovation and risk: assessing design research proposals. In J. Van den Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (Eds.), *Educational Design Research* (pp. 100–106). London: Routledge.

Ernst, J. (2009). Influences on US middle school teachers' use of environment-based education. *Environmental Education Research, 15*(1), 71–92.

Fien, J. (1993). *Environmental Education: a pathway to sustainability*. Geelong: Deakin University.

Fisher, D. R., & Freudenburg, W. R. (2001). Ecological modernization and its critics: assessing the past and looking toward the future. *Society & Natural Resources*, *14*(8), 701–709.

Fiske, E. B. (1996). *Decentralization of Education: Politics and Consensus*. Washington, D. C. : The World Bank.

Freudenthal, H. (1991). *Revisiting Mathematics Education*. Dordrecht: Kluwer.

Fullan, M. (2006). Leading professional learning. *School Administrator, 63*(10), 10.

Glasersfeld, E. von (1997). Amplification of a constructivist perspective. *Issue in Education: contribution from educational psychology, 3*(2), 203–219.

González-Gaudiano, E. (2007). Schooling and environment in Latin America in the third millennium. *Environmental Education Research, 13*(2), 155–169.

Goodlad, J., & Associates (1979). *Curriculum Inquiry: the study of curriculum practice*. New York: McGraw-Hill.

Gouldson, A., & Murphy, J. (1997). Ecological modernization: restructuring industrial economies. *The Political Quarterly*, *68*(B), 74–86.

Gravemeijer, K., & Cobb, P. (2006). Design research from a learning design perspective. In J. Van den Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (Eds.), *Educational Design Research* (pp. 17–51). London: Routledge.

Gruenewald, D. A., & Manteaw, B. O. (2007). Oil and water still: How No Child Left Behind limits and distorts environmental education in US schools. *Environmental Education Research, 13*(2), 171–188.

Hacking, E. B., Scott, W., & Barratt, R. (2007). Children's research into their local environment: Stevenson's gap, and possibilities for the curriculum. *Environmental Education Research, 13*(2), 225–244.

Hajer, M. A. (1995). *The Politics of Environmental Discourse*: *Ecological Modernization and the Policy Process*. Oxford: Oxford University Press.

Hargreaves, A., & Fullan, M. (2012). *Professional Capital: Transforming teaching in every school.* New York: Teachers College Press Columbia University.

Hart, R. (1997). *Children's Participation: the theory and practice of involving young citizens in community development and environmental care*. London: Earthscan/Unicef.

Hawkins, J. N. (2000). Centralization, decentralization, recentralization: educational reform in China. *Journal of Educational Administration. 38*(5), 442–454.

Heck, P. (2006). Material flow analysis and material flow management. In *Consulting Report for the World Bank Project on Policies for Promotion of a Circular Economy in China* (pp. 20–21). Beijing: The World Bank.

Herron, M. D. (1971). The nature of scientific inquiry. *School Review 79*(2), 171–212.

Holsti, O. (1969). *Content analysis for the social sciences and humanities.* Reading, MA: Addison-Wesley.

Huang, Y. (2003). The development and trends of environmental education in China. *Environmental Education, 2003*(2), 9–15. (In Chinese.)

Huckle, J., & Sterling, S. (Eds.) (1996). *Education for Sustainability*. London: Earthscan.

Hungerford, H. R., & Peyton, R. B. (1976). *Teaching environmental education*. Portland, ME: J. Weston Walch.
Hungerford, H., Peyton, R. B., & Wilke, R. J. (1980). Goals for curriculum development in environmental education. *The Journal of Environmental Education*, *11*(3), 42–47.
Hsu, S. J., & Roth, R. E. (1999). Predicting Taiwanese secondary teachers' responsible environmental behavior through environmental literacy variables. *Journal of Environmental Education, 30*(4), 11–18.
Jaramillo, J. A. (1996). Vygotsky's sociocultural theory and contributions to the development of constructivist curricula. *Education, 117*(1), 133–140.
Jänicke, M. (2008). Ecological modernization: new perspectives. *Journal of Cleaner Production*, *16*(5), 557–565.
Jänicke, M., Mönch, H., Ranneberg, T., & Simonis, U. E. (1989). Economic structure and environmental impacts: east-west comparisons. *Environmentalist, 9*(3), 171–183.
Johansson, M. (2005). Mathematics textbooks–the link between the intended and the implemented curriculum. In *The Mathematics Education into the 21st Century Project, Malaysia* (pp. 119–123).
Klaassen, K. (1995). *A Problem-Posing Approach to Teaching the Topic of Radioactivity*. Utrecht: CD-ß Press.
Klein, F. (1991). *The Politics of Curriculum Decision Making: issues in centralizing the curriculum*. Albany, NY: State University of New York Press.
Klein, J. T. (2004). Prospects for transdisciplinarity. *Futures, 36*(4), 515–526.
Klein, J. T. (2008). Evaluation of interdisciplinary and transdisciplinary research: a literature review. *American journal of preventive medicine, 35*(2), 116–123.
Kortland, J. (2001). *A Problem Posing Approach to Teaching Decision Making about the Waste Issue*. Utrecht: Cdß Press.
Krippendorf, K. (1980). *Content Analysis: An Introduction to Its Methodology* (p. 21). Beverly Hills, CA: Sage.
Plomp, T. (2006). Educational design research: a research approach to address complex problems in educational practice. Paper presented at the Fifth International Forum on Educational Technology, Wuhan, China.
Langhelle, O. (2000). Why ecological modernization and sustainable development should not be conflated. *Journal of Environmental Policy and Planning, 2*(4), 303–322.
Lashley, T. J., Matczyniski, T. J., & Rowley, J. B. (2002). *Instructional Models: strategies for teaching in a diverse society* (2nd ed.) Belmont, CA: Wadsworth/Thomson Learning.
Lave, J. (1988). Cognition in practice: Mind, mathematics and culture in everyday life. Cambridge: Cambridge University Press.
Leach, J., & Scott, P. (2003). Individual and sociocultural views of learning in science education. *Science & Education, 12*(1), 91–113.
Leontiev, A. N. (1978). *Activity, consciousness, and personality*. Englewood Cliffs, NJ: Prentice-Hall.
Letschert, J., & Kessels, J. (2003). Social and political factors in the process of curriculum change. In J. van den Akker, W. Kuiper, & U. Hameyer, (Eds.), *Curriculum Landscapes and Trends* (pp. 157–176). Dordrecht: Kluwer Academic Publishers.
Lijnse, P. L. (1995). 'Developmental research' as a way to an empirically based 'didactical structure' of science. *Science education, 79*(2), 189–199.

Lijnse, P. (2000). Didactics of science: the forgotten dimension in science education research? In R. Millar, J. Lean, & J. Osborne (Eds.), *Improving Science Education–the contribution of Research* (pp. 308–326). Buckingham: Open University Press.

Lijnse, P., & Klaassen, K. (2004). Didactical structures as an outcome of research on teaching–learning sequences?. *International Journal of Science Education, 26*(5), 537–554.

Lin, Z. Z., Chen, J. S., & Zhang, S. (2005). The difficulties in and debates on integrative curriculum in China mainland, Taiwan, and Hong Kong. In Z. Z., Lin, J. S. Chen, & S. Zhang (Eds.), *Curriculum Organization* (pp. 141–160). Beijing: Educational Science Publishing House. (In Chinese.)

Linn, M. C., Bell, P., & Davis, E. A., (2004). Specific design principles: elaborating the scaffolded knowledge integration framework. In M. C. Linn, E. A. Davis, & P. Bell (Eds.), *Internet Environments for Science Education* (pp. 315–340). Mahwah, NJ: Lawrence Erlbaum Associates.

Lotz-Sisikta, H., & Schudel, I. (2007). Exploring the practical adequacy of the normative framework guiding South Africa's National Curriculum Statement. *Environmental Education Research, 13*(2), 245–263.

Ma, G. X. (2003). *Environmental Education.* Beijing: Science Press. (In Chinese.)

McBeth, W., & Volk, T. L. (2010). The national environmental literacy project: a baseline study of middle grade students in the United States. *The Journal of Environmental Education, 41*(1), 55–67.

McGinn, N., & Welsh, T. (1999). *Decentralization of education: why, when, what and how?* Paris: UNESCO.

McKenney, S., Nieveen, N., & van den Akker, J. (2006). Design research from a curriculum perspective. In J. Van den Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (Eds.), *Educational Design Research* (pp. 67–90). London: Routledge.

McManus, P. (1996). Contested terrains: politics, stories and discourses of sustainability. *Environmental Politics 5*(1), 48–73.

Meijer, M. R., Prins, G. T., Bulte, A. M., & Pilot, A. (2008). Method of Educational Design-Based Research in science education: why and how? Paper presented at the International Society for Design and Development in Education (ISDDE) conference, Egmond aan Zee, the Netherlands.

Mok, K. H., & Currie, J. (2002). Reflections on the impact of globalization on educational restructuring in Hong Kong. In K. H. Mok, & D. Chan (Eds.), *Globalization and Education: the quest for quality education in Hong Kong* (pp. 259–278). Hong Kong: Hong Kong University Press.

Mol, A. P. (1995). *The Refinement of Production*: *Ecological Modernization Theory and the Chemical Industry*. Utrecht: Van Arkel.

Mol, A. P., & Spaargaren, G. (2000). Ecological modernization theory in debate: a review. *Environmental Politics, 9*(1), 17–49.

National Development and Reform Commission of China (2010). *The General Plan on Qaidam Circular Economy Pilot Area in Qinghai Province.* (In Chinese.) http://www. gov. cn/jrzg/2010-03/19/content_1560336. htm (Last retrieved in August, 2013)

Needles, M., & Knapp, M. (1994). Teaching writing to children who are underserved. *Journal of Education Psychology, 86*(3), 339–349.

Orr, D. (1992). *Ecological Literacy.* Albany, NY: State University of New York Press.

Orr, D. (1994). *Earth in Mind* . Washington, DC: Island Press.

O'Sullivan, E. (1999). *Transformative Learning: educational vision for the 21st century*. London: Zed Books.

Palincsar, A. S. (1998). Social constructivist perspectives on teaching and learning. In J. T. Spence, J. M. Darley, & D. J. Foss (Eds.), *Annual Review of Psychology, (49),* 345–375.

Pearce, D. (1993). *Blueprint* 3: *Measuring Sustainable Development*. London: Earthscan Publications.

Phillips, D. C. (1997). How, why, what, when, and where: perspectives on constructivism in psychology and education. *Issues in Education: contributions from educational psychology, 3*(2), 151–194.

Piaget, J. (1937). La *construction du réel chez l'enfant*. [*The construction of reality in the child*.] Neuchatel, Switzerland: Delachaux et Niestle.

Prawat, R. S. (1992). Teachers' beliefs about teaching and learning: a constructivist perspective. *American Journal of Education, 100*(3), 354–395.

Prawat, R. S. (1996). Constructivisms, modern and postmodern. *Educational Psychology, 31*(3/4), 215–225.

Prawat, R. S., & Floden, R. E. (1994). Philosophical perspectives on constructivist views of learning. *Educational Psychology, 29*(1), 37–48.

Plomp, T. (2006). *Educational design research: a research approach to address complex problems in educational practice*. Paper presented at the Fifth International Forum on Educational Technology, Wuhan, China.

Plomp, T. (2009). Educational design research: an introduction. In T. Plomp, & N. Nieveen (Eds.), *An Introduction to Educational Design Research* (pp. 9–35). Enschede: Netherlands Institute for Curriculum Development.

Reeves, T. C. (2006). Design research from a technology perspective. . In J. Van den Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (Eds.), *Educational Design Research* (pp. 52–66). London, UK: Routledge.

Ren, Y. (2007). The circular economy in China. *Journal of Material Cycles and Waste Management, 9*(2), 121–129.

Ren, Y., Chen, Y. P., & Feng, D. F. (2005). The paradigm of curricular economy development in China. *China Population Resource and Environment 15*(5), 137–142. (In Chinese.)

Ren Y., & Wu, Y. P. (2005) Discussion on connotation and relevant theoretic issues of the concept of the Chinese circular economy. *China Population Resource and Environment 15*(4), 131–136. (In Chinese.)

Ren, Y., & Zhou, G. M. (2009). *The Paradigm and Policy of Circular Economy Development in China*. Bei Jing: China Environmental Science Press. (In Chinese.)

Resnick, L. B. (1987). Learning in school and out. *Educational Researcher, 16*(9), 13–20.

Roth, C. E. (1992*). Environmental literacy: Its roots, evolution, and directions in the 1990s*. Columbus, OH, ERIC/SMEAC information Reference Center.

Sachs, W. (1997). Ecology, justice and the end of development. *Development Journal of the Society for International Development, English Edition (2)*, 8–14.

Schell, J. W., & Black, R. S. (1997). Situated learning: an inductive case study of a collaborative learning experience. *Journal of Industrial Teacher Education, 34*(4), 5–28.

Schwab, J. J. (1962). The teaching of science as inquiry. In J. J. Schwab, & P. F. Brandwein (Eds.), *The Teaching of Science* (pp. 3–103). Cambridge, MA: Harvard University Press.

Shu, Z. B. (2004). An overview of environmental education in middle school natural science courses. *Chinese Education and Society, 37*(4), 64–67.

Simmonis, U. E. (1989). Ecological modernization of industrial society: three strategic elements. *International Social Science Journal 121*, 347–361.

Simmons, B. (1995). *The NAAEE Standards Project: Papers on the development of environmental education standards*. Troy, OH: North American Association for Environmental Education.

Smith, G. A. (2007). Place–based education: breaking through the constraining regularities of public school. *Environmental Education Research, 13*(2), 189–207.

Smith, G., & Williams, D. (1999). *Ecological Education in Action: on weaving education, culture, and the environment*. Albany, NY: State University of New York Press.

Snyder, J., Bolin, F., & Zumwalt, K. (1992). Curriculum implementation. In P. W. Jackson (Ed.), *Handbook of Research on Curriculum: a project of the American Educational Research Association* (pp. 402–435). New York: Simon & Schuster Macmillan.

Spaargaren, G. (1997). The ecological modernization of production and consumption: essays in environmental sociology. Wageningen: Wageningen Agricultural University.

Stevenson, R. B. (1987). Schooling and environmental education: contradictions in purpose and practice. In I. Robottom (Ed.), *Environmental Education: practice and possibility* (pp. 69–82). Geelong, Australia: Deakin University Press.

Stevenson, R. B. (2007). Schooling and environmental/sustainability education: From discourses of policy and practice to discourses of professional learning. *Environmental Education Research, 13*(2), 265–285.

Swanepoel, C. H., Loubser, C. P., & Chacko, C. P. C. (2002). Measuring the environmental literacy of teachers. *South African Journal of Education, 22*(4), 282–285.

Taba, H. (1962). Curriculum Development: theory and practice. New York: Harcourt, Brace&World.

The Ministry of Education, China (1997). *A Report on Curriculum Application of the Nine-Year Compulsory Education*. Beijing. (In Chinese.)

The Design-Based Research Collective (2003). Design-based research: an emerging paradigm for educational inquiry. *Educational Researcher, 32*(1), 5–8

Tian, Q. (2004a). Historical Review of Environmental education in China. *Chinese Education and Society, 37*(3), 34–38.

Tian, Q. (2004b). Integrate and extend—from environmental education to education for sustainability, *Journal of Subject* Education, *2004*(8), 7–11. (In Chinese.)

Tian, Q. (2010). The practice trace from environmental education to education for sustainability since 1997 in China Mainland: a case study of EEI program and its influences on education in China. *Geography Teaching, 2010 (1),* 8–10*, 2010*(2), 4–7. (In Chinese.)

Tian, Q., Yun, Y. R., & Yin, P. H., (2007). The history and trend of environmental education research in China, *China Population, Resource and Environment, 17*(1)*,* 130–134. (In Chinese.)

Turner, K. R. (1993). *Sustainable Environmental Economics and Management: Principles and Practice.* London: Belhaven Press.

UNCED (1992). *The Earth Summit: Agenda 21*. Rio de Janeiro: United Nations Conference on Environment and Development (UNCED).

UNESCO (1980). *Environmental Education in the Light of the Tbilisi Conference*. Paris: UNESCO.

UNESCO (2004). *United Nations Decade of Education for Sustainable Development 2005-2014: Draft Implementation Plan, Volume 1*. Paris: UNESCO.

UNESCO–UNEP (1978). The Tbilisi Declaration. Connect, Vol. III (1), (pp. 1–8).
Valverde, G. A., Bianchi, L. J., Wolfe, R. G., Schmidt, W. H., & Houang, R. T. (2002). According to the Book. Using TIMSS to investigate the translation of policy into practice through the world of textbooks (p. 13). Dordrecht: Kluwer Academic Publishers.
Van den Akker, J. (1999). Principles and methods of development research. In J. Van den Akker, R. M. Branch, K. Gustafson, N. Nieveen, & T. Plomp (Eds.), *Design Approaches and Tools in Education and Training* (pp. 1–14). Dordrecht: Kluwer Academic Publishers.
Van den Akker, J. (2003). Curriculum perspectives: an introduction. In J. van den Akker, W. Kuiper, & U. Hameyer, (Eds.), *Curriculum Landscapes and Trends* (pp. 1–10). Dordrecht: Kluwer Academic Publishers.
Van den Akker, J., Gravemeijer, K., McKenney, S., & Nieveen, N. (2006). Introducing Educational Design Research. In J. Van den Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (Eds.), *Educational Design Research* (pp. 1–7). London: Routledge.
Van Koppen, C. S. A. (2007). Curriculum development for environmental education: experiences in the Netherlands, and international debates. In *2007 Jeju International Environmental Education Forum. Program and Collection of Papers* (pp. 105–125). Jeju: International Council for Local Environmental Initiatives.
Vanderlinde, R., & van Braak, J. (2010). The gap between educational research and practice: views of teachers, school leaders, intermediaries and researchers. *British Educational Research Journal, 36*(2), 299–316.
Vanderbilt, Cognition and Technology Group (1997). *The Jasper project: Lessons in Curriculum, Instruction, Assessment and Professional Development.* Mahwah, NJ: Lawrence Erlbaum Associates.
Vollebregt, M. J. (1998). *A Problem Posing Approach to Teaching an Initial Particle Model.* Utrecht: CD-ß Press.
Vygotsky, L. S. (1981). The genesis of higher mental functions. In J. V. Wertsch (Ed.), *The Concept of Activity in Soviet Psychology (pp. 144–188).* Armonk, NY: M. E. Sharpe.
Walker, D. (2006). Toward productive design studies. In J. Van den Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (Eds.), *Educational Design Research* (pp. 9–18). London: Routledge.
Wang, F., & Hannafin, M. J. (2005). Design-based research and technology-enhanced learning environments. *Educational Technology Research and Development, 53*(4), 5–23.
Wang, J. L., He, Y. Y., Li, Y., He, X., Wang, X. F., & Jue, Y. M. (2004). An analysis of environmental awareness and environmental education for primary school and high school students in Kunming. *Chinese Education and Society, 37*(4), 24–31.
Wang, M., Wei, D. Y., & Huo, Z. L., (2005). From environmental education and education to sustainable development, *Environmental Education, 2005*(11), 21–25. (In Chinese.)
Wang, M., Wei, D. Y., & Huo, Z. L., (2006). Environmental education and education for sustainable development. *Journal of Beijing Normal University (Social Science), 195*(3), 131–136. (In Chinese.)
Wasmer, C. (2005). *Towards Sustainability: Environmental Education in China-A German Strategy for Chinese Schools?* (No. 73). Duisburger Arbeitspapiere zur Ostasienwirtschaft.
Westbroek, H. B. (2005). *Characteristics of Meaningful Chemistry Education: the case of water quality.* Utrecht: CD-ß Press.

Westra, R. H. (2008). *Learning and Teaching Ecosystem Behaviour in Secondary Education: systems thinking and modeling in authentic practices.* Utrecht: Utrecht University Press.

Weale, A. (1992). *The New Politics of Pollution*. Manchester: Manchester University Press.

Wilke, R. (1995). Environmental Literacy and the College Curriculum: Colleges and Universities Have a Challenge to Meet. *EPA Journal*, *21*(2), 28–30.

Wilson, D. N. (2003). The future of comparative and international education in a globalised world. *International Review of Education, 49*(1-2), 15–33.

Wong, N. Y., & Wong. Y. (2002). The 'Confucian Heritage Culture' learner's phenomenon. *Asian Psychologist, 3*(1), 78–82.

WCED (World Commission on Environment and Development), (1987). *Our Common Future*. Oxford: Oxford University Press.

Woolfolk, A. (2005). *Educational Psychology (9th ed.)* (pp. 318–320). Boston, MA: Allyn&Bacon.

Yin, R. K. (1989). *Case study research: design and methods*. Newbury Park (CA, USA): Sage-Applied Social Research Methods Series, vol. 5.

Zhang, L., Mol, A. P., & Sonnenfeld, D. A. (2007). The interpretation of ecological modernization in China. *Environmental Politics*, *16*(4), 659–668.

Appendix I: Abbreviations

Center for Environmental Education and Communication (CEEC)
Center of Education for Sustainable Development (CESD)
Communist Party of China (CPC)
Integrated Practical Activity Curriculum (IPAC)
Ministry of Education (MoE)
Ministry of Environmental Protection (MEP)
Municipal Bureau of City Administration (MBCA)
National College Entrance Examination (NCEE)
National Development and Reform Commission (NDRC)
National Environmental Education Guideline (the Guideline)
Nine-Year Compulsory Education (NYCE)
State Education Commission (SEC, former MoE)
State Environmental Protection Administration (SEPA, former MEP)
Syllabus on Environmental Subject for Students in Secondary and Primary Schools (the Syllabus)
United Nations Conference on Environment and Development (UNCED)

Appendix II: Document List

1. Policy documents for general school education

SE1: *21st Century Action Plan for Invigorating Education.* (MoE, 1998, the State Council, 1999).
SE2: R*esolution to Comprehensively Promote the Essential-qualities-oriented Education.* (the CPC Central Committee and the State Council, 1999).
SE3: P*roject Overview of the Basic Education Reform.* (MoE, 1999).
SE4: *Resolution on Basic Education Reform.* (the State Council, 2001).
SE5: *Outline of Basic Education Curriculum Reform.* (MoE, 2001a).
SE6: *'Interim Measure for School Textbooks. Composing, Approving and Management, and a Pilot Program for Compulsory Education Curriculum.* (MoE, 2001b)
SE7: *Pilot Plan of Compulsory Education Curriculum.* (SE7) (MoE, 2001c).
SE8: *2003-2007 Action Plan for Invigorating Education.* (the State Council, 2004).

2. Policy documents for environmental education

EE1: *China's Agenda 21.* (the State Council, 1996).
EE2: *The Decision of CPC Central Committee on Several Issues Concerning Socialist Cultural and Ideological Promotion.* (the CPC Central Committee, 1996).
EE3: *Decision of the State Council on Several Issues Concerning Environmental Protection.* (the State Council, 1996).
EE4: *National Action Outline of Environmental Publicity and Education 1996-2010.* (SEC, SEPA, and Publicity Department of CPC, 1996).
EE5: *National Action Outline of Environmental Publicity and Education for 2001-2005.* (Publicity Department of CPC, SEPA, and MoE, 2001)
EE6: *The 9th 5-Year Plan on National Economic and Social Development and the Development Outline by 2010.* (the National People's Congress, 1996)
EE7: *The 9th 5-Year Plan for China's Educational Development and the Development Outline by 2010.* (SEC, 1996).
EE8: *The 9th 5-Year Plan for China's Environmental Protection and the Development Outline by 2010.* (the State Council, 1996).
EE9: *The 10th 5-Year Plan on National Economic and Social Development and the Development Outline by 2015.* (the National People's Congress, 2001)
EE10: *The 10th 5-Year Plan for China's Educational Development and the Development Outline by 2015.* (MoE, 2001).
EE11: *The 10th 5-Year Plan for China's Environmental Protection and the Development Outline by 2015.* (the State Council, 2001).
EE12: *The 11th 5-Year Plan on National Economic and Social Development and the Development Outline by 2020.* (the National People's Congress, 2007)
EE13: *The 11th 5-Year Plan for China's Educational Development and the Development Outline by 2020.* (MoE, 2007).
EE 14: *The 11th 5-Year Plan for China's Environmental Protection and the Development Outline by 2020.* (the State Council, 2007).
EE15: *2003-2007 Action Plan for Invigorating Education.* (the State Council and MoE, 2004).
EE16: *The Outline of Educational Reform and Development of China.* (the State Council, 1993).

3. Curricular documents for general school education

CSE1: Curriculum Standard of Chinese (Trial) for Compulsory Education (Beijing Normal University, 2001)
CSE2: Curriculum Standard of English (Trial) for Compulsory Education (Beijing Normal University, 2001)
CSE3: Curriculum Standard of Mathematics (Trial) for Compulsory Education (Beijing Normal University, 2001)
CSE4-a: Curriculum Standard of Morality and Life (Trial) for Compulsory Education (Beijing Normal University, 2001)
CSE4-b: Curriculum Standard of Morality and Society (Trial) for Compulsory Education (Beijing Normal University, 2001)
CSE5: Curriculum Standard of Science (Trial) for Compulsory Education (Beijing Normal University, 2001)
CSE6-a: Curriculum Standard of Music (Trial) for Compulsory Education (Beijing Normal University, 2001)
CSE6-b: Curriculum Standard of Fine Art (Trial) for Compulsory Education (Beijing Normal University, 2001)
CSE7: Curriculum Standard of Sports and Health (Trial) for Compulsory Education (Beijing Normal University, 2001)
CSE8: Curriculum Standard of Integrative Practical Activity Curriculum (Trial) for Compulsory Education (Beijing Normal University, 2001)

4. Curricular documents for environmental education

CEE1: *Syllabus on Environmental Subject for Students in Secondary and Primary Schools.* (MoE, 2003a).
CEE2: *National Environmental Education Guideline.* (MoE, 2003b).

Appendix III: Interview Question List

Part 1 Introduction

Part 2 Curriculum (systematic overview)

1. What is your definition of "curriculum", especially in the field of environmental education?
2. EE be integrated into various existing school subjects or be offered as a separate subject. In your opinion, what form(s) should be chosen in schools?
3. What are criteria to choose the content in either integrative form or separate form? In the integrative form, what are the principles to choose the relevant disciplinary subjects; and what are the principles to decide how each subject's involvement in EE is? For example the subjects of biology, science and geography?
4. What is the current EE curriculum development system in China? What can be defined as national curriculum/local (provincial) curriculum/school curriculum?
5. Who are developers or researchers involved in development of EE curriculum at national/provincial/school levels?
6. Who are the stakeholders involved in research on development of EE curriculum? How does the funding flow?
7. In your experience, in developing an EE curriculum, what are the considerations that guide the design? (addressing social vs. natural science aspects; knowledge or values or emotion, link to daily life world; interdisciplinarity; local context)

Part 3 Curriculum (design and implementation)

1. In existing curricula, which ones do you perceive as representative?
2. What do you see as the role of national curricula in regulating the development of local and school curricula? What do you see as the freedom of making choice leaving in national curriculum to local and school curriculum development? And what is the role of 'green school'?
3. *"Implementation Guideline on Environmental Education for Primary and Secondary Schools"* and *"Educational Outline on Environmental Subject for Students in Middle and Primary Schools"* are the two most important documents to guide curriculum development at all levels. What are you aware of as the major obstacles when applying them?
4. As far as you know, what are the main difficulties in developing curriculum for local and school level? What is your experience or suggestion to improve the curriculum design in such circumstances?
5. Some observations at school level (with reference to my preliminary field data from schools), EE are only randomly applied in classes. And very often course time for EE is used for other majors. What do you see as bottlenecks in the implementation? Do you think curriculum design can play a role in overcoming the bottlenecks? How would you advise on modifying curriculum design principles so that these bottlenecks can be better overcome?
6. In your opinion, at the schools level what counts as a successful multi-disciplinary curriculum of EE that involves relevant subjects? What are the principles that help integrate disciplines' contributions?
7. What is your comment on the notion of the "rhetoric-practice gap", the contrast between the purpose of schooling, dominant policy discourse and the goal of EE; the contrast

between current schooling and EE in curricular and pedagogical aspects? Do you see the evidence of the gap in China or the opportunities of narrowing the gap?

8. Please recommend widely disseminated or successful textbooks, school-based curriculum, local curriculum, important curriculum designers.

Appendix IV: Interviewee List

Interviewee A is a university researcher of education for sustainable development, a designer and teacher trainer involved in several curial materials designs for students and for teachers.

Interviewee B, as well, is a university researcher of education for sustainable development, a designer and teacher trainer involved in several curial materials designs for students and for teachers.

Interviewee C is a university researcher of education for sustainable development, a designer and chief editor of several curial teaching materials, and one of the key participants in developing The Guideline (CEE1).

Interviewee D is a program officer, designer, teacher, and teacher trainer in a NGO.

Interviewee E is a program officer, designer, and teacher trainer in a NGO, and one of the key participants in developing The Guideline (CEE1).

Interviewee F is an official, project manager, designer, and teacher trainer in national government.

Interviewee G is a university researcher of education for sustainable development and a designer of teacher training materials.

Interviewee H is a university researcher of education for sustainable development, and a designer of several teaching materials for students and for teachers.

Interviewee I is an official of a local administrative department of education

Appendix V: Teaching Materials List

1. WWF (2004). *Yangtze River*, (zou jin sheng ming zhi he). People's Education Press.
2. Li, l. (2004). *Environmental Education for Primary School*, (xiao xue huan jing jiao yu). Environmental Science Press of China.
3. Wang, H.Q. (2004). *Environmental Education for Heilongjiang Province*, (huan jing jiao yu hei long jiang fen ce). Environmental Science Press of China.
4. Yao, X. (2004). *Activities of Environmental Protection*, (huang jing bao hu huo dong). Environmental Science Press of China.
5. Beijing Normal University (1999). *Teacher Training Manual*, (jiao shi pei xun shou ce). Meteorological Press.
6. Beijing Normal University (1999). *Case Study of Environmental Education Activity for Primary School*, (xiao xue huan jing jiao yu huo dong shi li). Beijing Normal University Press.

Appendix VI: Content Analysis Coding Table

Coder ____ Coding date___

1. Book set _____
    1) Yangtze River
    2) Environmental Education for Primary School
    3) Environmental Education for Heilongjiang Province
    4) Activities of Environmental Protection
    5) Teacher Training Manual
    6) Case Study of Environmental Education Activity for Primary School

2. The lesson is based on the document of _____
    1) The Syllabus
    2) The Guideline

3. Studied environmental topic is _____
    1) Population and culture
    2) Biomes and biodiversity
    3) Food and agriculture
    4) Environmental health and hazards
    5) Climate and air pollution
    6) Water and pollution
    7) Geography and Tourism
    8) Natural resources and protection
    9) Energy
    10) Solid waste
    11) Economics and urbanization
    12) Environmental policy
    13) General

RATIONALE

4. Whether the lesson involves multi-disciplinary knowledge ______

(Definition: the lesson includes or requires knowledge from more than one discipline, e.g. natural science, social science, and humanities)

1) yes 2) no

5. And the related school subject is____
    1) Chinese
    2) Math
    3) English
    4) Morality
    5) Science
    6) Music
    7) Fine art
    8) Information technology
    9) Sports

6. Whether the concerned issue is real ___
(Definition: when the study issue is real, it is an issue that happens in reality, and it is observable for the students, in contrasting to abstract and theoretical issue.)
1) yes 2) no

7. Whether the concerned issue is practical ___
(Definition: when the study issue is practical it is an issue that the students can do something about it. For example, tree planting is practical; memorizing names of trees is not practical.)
1) yes 2) no

8. Whether the concerned issue is specific ___
(Definition: when the study issue is specific it is an issue which has a particular focus, rather than dealing with general environmental issues. For example, deforestation is specific; environmental crisis without specifying which crisis is not specific.)
1) yes 2) no

9. Whether the concerned issue is problematic ___
(Definition: whether the study issue is a problem that needs to be solved. For example, biodiversity loss is a problem, but simply introducing biodiversity in a certain area is not problematic.)
1) yes 2) no

10. Whether the conclusion or the solution is uncertain ___
(Definition: keeping the conclusion or the solution uncertain means the lesson does not draw the conclusion from the study issue, or the lesson does not decide on positions to take about the issue, or the lesson does not provide worked-out solutions of the problem.)
1) yes 2) no

GOAL

11. Whether the knowledge is for sustainable life quality ___
(Definition: knowledge is related to sustain people's life quality, in which environmental quality is a part.)
1) yes 2) no

12. Whether the knowledge is for immediate use for influencing the environment ___
(Definition: the students may already apply the knowledge to improve their life or their environment in particular, no need to wait until the future when they become adults.)
1) yes 2) no

13. Whether the knowledge in the end is for taking action for influencing the environment ___
(Definition: at the end of the lesson the students are required to act or to do something for the environment, for example, write complaint letters, plant trees, recycling, design cars that use eco-energy, design a campaign to spread knowledge on environmental protection etc.)
1) yes 2) no

CONTENT

14. Whether the information source is multiple ___
(Definition: the information is from more than one source.)
1) yes 2) no

15. Whether the information resource is complex ___
(Definition: the information introduces contradicting aspects of the issue or multiple viewpoints about the issue.)
1) yes 2) no

16. Whether the study issue is relevant to the students' real life world ___
(Definition: the lesson is concerning an issue which is recognizable in students' daily life, rather than stated in abstract theories removed from students' experience.)
1) yes 2) no

17. Whether the study issue is relevant to the students' family life ___
(Definition: the study issue is concerning students' experience living at home, rather than stated in abstract theories removed from students' experience.)
1) yes 2) no

18. Whether the study issue is relevant to the students' school life ___
(Definition: the study issue is concerning students' experience in school, rather than stated in abstract theories removed from students' experience.)
1) yes 2) no

19. Whether the study issue is relevant to the students' community ___
(Definition: the study issue is concerning students' experience living in community, rather than stated in abstract theories removed from students' experience.)
1) yes 2) no

20. Whether the study issue is relevant to the students' local area ___
(Definition: the study issue is concerning students' experience as resident in a certain place e.g. a town, a city, rather than stated in abstract theories removed from students' experience.)
1) yes 2) no

21. The factual knowledge proportion is ____
(Definition: factual knowledge is the definitions, descriptions, or explanations about facts, for example, what is the ozonosphere, why is ozone depletion occurring? Factual knowledge also includes instructional descriptions about 'how to' procedures, for example how to write a complaint letter to the government, what steps are needed to write a proposal. The proportion is the estimated number of pages of factual knowledge information divided by the entire number of pagesin the lesson.)

1) =0
2) (0, 1/4]
3) (1/4, 1/2]
4) (1/2, 1)
5) =1

PROCESS

22. Whether the process requires the students to find the problem ___
(Definition: the lesson invites the students to propose the problem recognized by them rather than directly introduce them to a pre-defined problem.)
1) yes 2) no

23. Whether the process requires the students to inquiry into the problem ___
(Definition: the lesson invites the students to investigate about the problem, e.g. causes, severity, consequences, and solutions etc.)
1) yes 2) no

24. Whether the process requires the students to solve the problem ___
(Definition: the lesson invites the students to prose their own solutions for the problem rather than provided with a ready solution.)
1) yes 2) no

25. Whether the process requires the students to take action for exerting influence on the environment ___
(Definition: the lesson invites the students to do something put into effect for improve the environmental quality.)
1) yes 2) no

26. Whether the lesson requires the students' participation ___
(Definition: the lesson invites the students to take part in the teaching and learning process in more active way rather than merely listening to what the teacher explains.)
1) yes 2) no

27. Whether the lesson requires the students to game or play ___
(Definition: for example, role playing game, sports game, and play drama etc.)
1) yes 2) no

28. Whether the lesson requires the students to experiment or do hands-on activities ___
(Definition: for example, lab experiment, crafts making etc.)
1) yes 2) no

29. Whether the lesson requires the students to observe ___
(Definition: for example, observe habit of small animals, observe the growth of plant etc.)
1) yes 2) no

30. Whether the lesson requires the students to visit ___
(Definition: including to visit a place, park, museum etc. and to visit people, for example, experts, community members etc.)
1) yes 2) no

31. Whether the lesson requires the students to share information ___
(Definition: the lesson invites the students to exchange information among each other on the studied issue.)
1) yes 2) no

32. Whether the lesson requires the students to collect information ___
(Definition: the lesson invites the students to search information on the studied issue.)
1) yes 2) no

33. Whether the lesson requires the students to express thought ___
(Definition: the lesson invites the students to talk about what they think about the studies issue.)
1) yes 2) no

34. Whether the lesson requires the students to describe life ___
(Definition: for example, the students' weekly paper consumptions, the water usage habits of the students' family, and cycling path in their communities etc.)
1) yes 2) no

35. Whether the lesson requires the students collaboration ___
(Definition: the lesson invites the students to learn in groups rather than in individual.)
1) yes 2) no

36. Whether in the lesson the students collaborate in proposing questions ___
1) yes 2) no

37. Whether in the lesson the students collaborate in finding the problem ___
1) yes 2) no

38. Whether in the lesson the students collaborate in collecting the information ___
1) yes 2) no

39. Whether in the lesson the students collaborate in sharing the information ___
1) yes 2) no

40. Whether in the lesson the students collaborate in inquiring into the problem ___
1) yes 2) no

41. Whether in the lesson the students collaborate in solving the problem ___
1) yes 2) no

TEACHER

42. Whether the teacher may shape the pedagogy
(Definition: the lesson gives the teacher the opportunity to choose or change teaching strategies, rather than limiting them on how to teach.)
1) yes 2) no

43. Whether the teacher may shape the content
(Definition: the lesson gives the teacher the opportunity to choose or change the content of teaching, rather than limiting them on what to teach.)
1) yes 2) no

STUDENT

44. Whether the students receive factual knowledge in the lesson
(Definition: the lesson provides the students with factual knowledge on the studied issue, rather than asking them to collect.)
1) yes 2) no

45. Whether the lesson requires the students to collect factual knowledge
(Definition: rather than directly providing factual knowledge to the students, the lesson asks them to search by themselves.)
1) yes 2) no

46. Whether the lesson requires the students to propose questions
(Definition: the lesson invited the students to propose their own questions.)
1) yes 2) no

47. Whether the students receive questions in the lesson
(Definition: the lesson merely invited the students to respond to questions raised by the teacher or in the lesson.)
1) yes 2) no

48. Whether the students receive answers in the lesson
(Definition: the lesson provides the students to ready answers to the raised questions.)
1) yes 2) no

49. Whether the students receive the topic in the lesson
(Definition: the lesson is decided on the topic rather than open for the students to decide what to study.)
1) yes 2) no

50. Whether the students receive an action plan in the lesson
(Definition: the lesson provides the students suggestions on what to do to improve environmental quality or to solve the problem.)
1) yes 2) no

51. Whether the lesson requires multiple answers from the students
(Definition: the lesson invited the students to provide various, alternative answers, rather than limiting them to standard answers.)
1) yes 2) no

ASSESSMENT

52. Whether the lesson adopts process assessment
(Definition: the lesson evaluates the students' learning processes)
1) yes 2) no

53. Whether the lesson adopts development assessment
(Definition: the lesson evaluates the extent to which students develop their competences)
1) yes 2) no

54. Whether the lesson adopts self-assessment of the students
(Definition: the lesson evaluation allowed students to assess their own performance.)
1) yes 2) no

55. Whether the assessment is by multiple actors
(Definition: the lesson takes a democratic judgment by more than one evaluator.)
1) yes 2) no

56. Whether the assessment adopts standard evaluation by the teacher
(Definition: in the lesson, the teacher asks the students to show they have command of standard answers, or the exam is marked by standard answers.)

1) yes 2) no

Appendix VII: Analytical Code List for Observations

Themes and sub-codes	Coding categories
Rationale	
1. Disciplinarity	1) subject
2. Problem Focus	2) real 3) practical 4) specific
3. Characteristics of study issue	5) problematic
4. Conclusion/solution	6) uncertain
Goal	
5. Function of knowledge	7) for sustainable life quality 8) for immediate use for influencing the environment 9) preparing for taking action for influencing the environment in the end
Content	
6. Information source	10) multiple 11) complex
7. Relevance to students' real life world	12) relevance to family life 13) relevance to school life 14) relevance to community life
8. Knowledge development path	15) should not be only factual knowledge which does not require students' engagement
Process	
9. Engagement	16) find the problem 17) inquiry into the problem 18)solve the problem 19) take action
10. Participation	20) game 21) play 22) experiment 23) hands-on 24) observe 25) visit 26) collect information 27) share information 28) express thought 29) describe life
11. Cooperation	30) proposing question 31) collecting information 32) sharing information 33) finding problem 34) inquiry into problem 35) solving problem
Teacher	
12. Facilitator	36) amenable to students' opinions
13. Agent	37) shape the pedagogy 38) shape the content
Student	
14. Critical role	39) give multiple answers 40) disagree with the teacher
15. Active role	41) collect or receive fact knowledge 42) propose or receive question 43) propose or receive topic 44) provide or receive answer 45) propose or receive action plan
Assessment	46) process assessment 47) development assessment 48) multiple actors 49) students' self-assessment 50) without teacher's standard evaluation

Appendix VIII: Interview Themes

1. What is your general impression about the lesson today?
2. How did you experience the teaching? What did you find successful? And what was difficult or confusing?
3. How do you comment on the students' performances? What was/was not as you expected?
4. How did you experience teaching the cross-disciplinary content knowledge included in the lesson?
5. What do you need to see to modify the teaching-learning activities?
6. In future practices, without the presence of the designer researcher, do you think it is feasible to carry out the lesson? And how would you do it?

Appendix IX: Survey of Environmental Literacy

Part 1 Knowledge

Please choose from the options that you think is correct:

1. From which matter energy may be released? (Multiple option)
   A Petroleum B Natural Gas C Water D Cotton
2. Which of the following resources are primary resources? (Multiple option)
   A Petroleum B Natural Gas C Water D Wood
3. Which of the following resources can be recycled? (Multiple option)
   A Used battery B Used clothes C Used furniture D Used Computer
4. Which mode of transportation is most environmentally friendly? (Single option)
   A Car B Bicycle C Train D Flight
5. Which cotton object is most environmentally friendly? (Single option)
   A Jacket B Coat C Handkerchief D Vest
6. What is the aim of recycling? (Multiple option)
   A Protecting natural resource B Reducing pollution C Money D Reducing garbage burden
7. Which disposal solutions may pollute the environment? (Multiple option)
   A Litter B Put in garbage bins C Landfill disposal D Recycle E Incineration
8. Which disposal solutions may waste resources? (Multiple option)
   A Litter B Put in garbage bins C Landfill disposal D Recycle E Incineration

Part 2 Affect

Please mark the option that best represents your opinion:

9. I am responsible for the existing environmental problems.
   Strongly disagree Disagree Not sure Agree Strongly agree
10. The government is responsible for the existing environmental problems.
    Strongly disagree Disagree Not sure Agree Strongly agree
11. Sawmills shall reduce lumbering although this may make some workers jobless.
    Strongly disagree Disagree Not sure Agree Strongly agree
12. Comparing the importance of economic development and environmental protection
    Economic development is more important Both are important Not sure Environmental protection is more important
13. Our country is a vast territory with inexhaustible natural resources.
    Strongly disagree Disagree Not sure Agree Strongly agree
14. Science and technology may contribute to a solution for the problem of natural resource shortage.
    Strongly disagree Disagree Not sure Agree Strongly agree
15. Going back to the simple living style of the underdeveloped past is a solution to the problem of natural resource shortage.
    Strongly disagree Disagree Not sure Agree Strongly agree
16. In China, not many paper mills can produce recycled paper conforming to the safe quality of the official standard. Knowing this, waste paper recycling is useless.
    Strongly disagree Disagree Not sure Agree Strongly agree

17. The scrap pickers work in poor sanitary conditions. Knowing this, we have no way to help them.
    Strongly disagree Disagree Not sure Agree Strongly agree

Part 3 Behavior

18. I am willing to donate one day of my pocket money for improving the environment.
    Strongly disagree Disagree Not sure Agree Strongly agree
19. I am willing to reject the stationery produced by polluting factories.
    Strongly disagree Disagree Not sure Agree Strongly agree
20. I am willing to distribute flyers on streets for promoting a friendly environment.
    Strongly disagree Disagree Not sure Agree Strongly agree
21. I am willing to write to the mayor to ask for support for environmental protection.
    Strongly disagree Disagree Not sure Agree Strongly agree
22. I plan to recycle waste.
    Strongly disagree Disagree Not sure Agree Strongly agree
23. I plan to advise others to recycle.
    Strongly disagree Disagree Not sure Agree Strongly agree

Part 4 Learning Experiences

24. The course allowed discussions and debates of different opinions.
    Strongly disagree Disagree Not sure Agree Strongly agree
25. The course favored our original ideas.
    Strongly disagree Disagree Not sure Agree Strongly agree
26. The course improved our interaction with the teacher for sharing thoughts.
    Strongly disagree Disagree Not sure Agree Strongly agree
27. Through this course, I learned to think differently.
    Strongly disagree Disagree Not sure Agree Strongly agree
28. The course included various perspectives to understand an issue.
    Strongly disagree Disagree Not sure Agree Strongly agree
29. The course presented me with some difficult questions.
    Strongly disagree Disagree Not sure Agree Strongly agree
30. I am confused by the multiple opinions in the course.
    Strongly disagree Disagree Not sure Agree Strongly agree
31. I am struggling with the various conflicting concepts in the course.
    Strongly disagree Disagree Not sure Agree Strongly agree
32. The course included interactive activities.
    Strongly disagree Disagree Not sure Agree Strongly agree
33. The course included participative activities.
    Strongly disagree Disagree Not sure Agree Strongly agree
34. In the course, I had the chance to express my own thoughts.
    Strongly disagree Disagree Not sure Agree Strongly agree
35. In the course, we had the chance to share thoughts with each other.
    Strongly disagree Disagree Not sure Agree Strongly agree
36. Through the course, I learned how to find proper answers.
    Strongly disagree Disagree Not sure Agree Strongly agree

37. The learning material provided useful information.
    Strongly disagree Disagree Not sure Agree Strongly agree
38. The course provided helpful examples.
    Strongly disagree Disagree Not sure Agree Strongly agree
39. The course inspired my way of thinking.
    Strongly disagree Disagree Not sure Agree Strongly agree
40. The course encouraged me to think from different perspectives.
    Strongly disagree Disagree Not sure Agree Strongly agree
41. In this course, I am motivated to learn.
    Strongly disagree Disagree Not sure Agree Strongly agree
42. Through the course, I learned to understand concepts by investigation.
    Strongly disagree Disagree Not sure Agree Strongly agree
43. Through the course, I learned abstract thinking.
    Strongly disagree Disagree Not sure Agree Strongly agree
44. I am motivated to extend my environmental knowledge in the future.
    Strongly disagree Disagree Not sure Agree Strongly agree
45. The course studied issues that I am concerned about.
    Strongly disagree Disagree Not sure Agree Strongly agree
46. I enjoyed learning in the course.
    Strongly disagree Disagree Not sure Agree Strongly agree
47. The course allowed us to negotiate with the teacher about the learning objectives.
    Strongly disagree Disagree Not sure Agree Strongly agree
48. The course can help me to achieve my own learning goal.
    Strongly disagree Disagree Not sure Agree Strongly agree
49. The course is about the issues that happen in our daily life.
    Strongly disagree Disagree Not sure Agree Strongly agree

Summary

The main objective of this study is to attain environmental literacy in pupils in China. More particularly, we are interested in how environmental literacy can be best included in the curriculum, taking into account a possible gap between environmental education and general schooling.

Environmental literacy in this study is understood along with Roth (1992) as a capacity to perceive and interpret the relative health of environmental systems and take appropriate actions to maintain, restore, or improve the health of those systems. As indicated by Roth, operationally, environmental literacy draws upon four strands of learning outcomes: knowledge, skills, affect (sensitivity, attitudes, and values) and behavior (personal investment, responsibility and active involvement). A prominent issue facing China and other countries is to promote people taking responsibilities to sustain the global environment, together with a continued development of the quality of life. Environmental education provides a basic avenue for capacity building in environmental reform with the aim for society of acquiring environmental literacy.

We are first of all confronted with a problem of frustrated implementation of environmental education. In contrast with the growing support stated in the educational policy discourse in China, the actual inclusion of environmental education remains marginalized in the school agenda. We see it as urgent to identify opportunities for advancing substantive environmental education practices in schools and thus for an improved learning outcome to meet its ultimate goal of an environmentally literate citizenry. A similar difficulty of environmental education implementation is found also in various other contexts such as in Canada (Barrett, 2007), in South Africa (Lotz-Sisikta & Schudel, 2007), in the UK (Hackings, Scott, & Barratt, 2007), and in the US (Gruenewald & Manteaw, 2007). Stevenson (1987, 2007) proposed the notion of the rhetoric-practice gap to explain the frustrated implementation of environmental education in schools. According to Stevenson, the rhetoric of environmental education implies particular kinds of curricular and pedagogical practices that necessitate the achievement of its goals, such as for the students to critique and defend their own environmental beliefs and choices, and to be prepared to act innovatively according to their choices, critically contribute solution to environmental problems. Whereas in reality, the practices in general schooling are primarily concerned with reproducing and maintaining the existing structure of society and thus transmit factual

knowledge, routine skills, values, and beliefs held by the dominant political and social power, and help students pursue individual status and economic well-being in a society. This study contributes to a contemporary perspective from China, by examining more critically on the nature and evidence of the gap in China. We intended not only to explicate resistances environmental education received in schools, but most importantly, the opportunities in China to advance environmental education with improved environmental literacy.

This study has two connecting parts. An explorative study addresses the first central question: *Is there a rhetoric-practice gap evidenced between environmental education and general schooling in China, and if so, how is it evidenced*? And after identifying the gap, a design study answers the second central question: *what are the characteristics of a curricular solution that effectively built environmental literacy, taking into account the probable rhetoric-practice gap in China*?

Explorative study

We take the stance of a rhetoric-practice gap (Stevenson, 1987, 2007) in exploring the current state of environmental education in China. To identify all possible contrasts between environmental education and school education and to describe explicitly what 'rhetoric' and 'practice' mean for either of them, we further included a theory of curriculum representations (Goodlad, 1979; Van den Akker, 2003) and a tripartite model of curriculum (Valverde, Bianchi, Wolfe, Schemidt, & Houang, 2002). We arrived at an analytical framework of a rhetoric-practice gap which outlines eleven possible gaps between environmental education and school education (of which environmental education is a part). In view of our research interest and limits of research time, we left aside six gaps that may occur between rhetoric and practice in school education, but focused on only three gaps:1) the institutional gap between the two rhetorics (intended curricula) of school education in general and of environmental education in particular, 2) the formalizing gap between the rhetoric (intended curriculum) and the link (potentially implemented curriculum) of environmental education, 3) the operational gap between the link (potentially implemented curriculum) and the practice (implemented curriculum) of environmental education. Moreover, the curricular and pedagogical contentions defined by Stevenson (1987, 2007) are further sorted with curriculum components identified by Van den Akker (2003). Combined, the contentions between environmental education and school education are summarized in seven curriculum elements:

1) Rationale:

The curriculum of environmental education takes a holistic, interdisciplinary approach (disciplinarity). The environmental education curriculum has its focus on real, practical, specific environmental problems (focused problem). The curriculum is determined by problematic, uncertain issues with students' involvement in inquiring, solving, and adapting to students' social constructs; therefore it is highly flexible (characteristics of the study issue). The conclusion or the solution for the studied problem is uncertain (solution and conclusion).

The curriculum of general school education takes a fragmented, disciplinary-based approach (disciplinarity). The curriculum has its focus on abstract theoretical problems removed from life experience (focused problem). The curriculum is determined by predefined issues to serve predetermined specific ends, and assessed by clearly defined criteria (characteristics of the study issue). The curriculum is composed of standard-based knowledge and predefined problems with agreed correct solutions (solution and conclusion).

2) Goal:

The analytical instrument assumes that in environmental education the function of knowledge is for immediate use for a sustainable and emancipated quality of life. In environmental education, knowledge is not merely directed toward action, but rather to prepare for inquiry and taking action in exerting influence on the environment.

The analytical instrument assumes that in general school education, knowledge is stored for students' individual future use, e.g. university attendance, job searching, and enhancement of individual status and economic well-being.

3) Content:

The content of environment education is built from complex and contradicting information resources (information source). The content is of high relevance for real life world problem (relevance to students). Content arises when students are involved in environmental problem inquiry so that knowledge is developed by students rather than directly provided to them as facts (knowledge development path).

The content of general school education is built from factual information (information source). The content developed is removed from life experience (relevance to students), without students' involvement (knowledge development path).

4) Process:

In environmental education, teaching and learning is a collaborative process (cooperation). In the teaching and learning process, students participate actively (participation). The students are engaged in dealing with the environmental problems (engagement).

In general school education, teaching and learning is an individual process (cooperation) in which the teacher is leading, and students' participation is limited to making responses to the teacher's questions (participation) that are asked largely to recite already defined factual knowledge and well-structured problems (engagement).

5) Teacher:

In environmental education, the teacher should be amenable to students' autonomous decisions. Teachers are agents with their own view and ideology about education which shape their decisions on curriculum and pedagogy.

In general school education, the role of the teacher is considered that of a dispenser of factual knowledge.

6) Student:

In environmental education, students should be active and critical thinkers, and the generators of knowledge.

In general school education, students are passive recipients of factual knowledge and already determined correct solutions.

7) Assessment:

The assessment of environmental education evaluates the process of inquiry, critique, and reflection, and evaluates the extent to which students develop and defend their own environmental beliefs and choices, as well as their ability to act according to their choices.

The assessment of school education is a content-area test for reproduction of factual knowledge, and emphasizes the mastery of fragmented facts and concepts. And the test often occurs in artificial situations on theoretical materials removed from students' life experiences.

Each curriculum representation (the intended curricula, the potentially implemented curriculum, and the implemented curriculum) is studied for the extent of agreement with these assumed contentions about the seven curricular elements of environmental education and school education.

For the intended curricula (the rhetorics) of school education and of environmental education, we examined education policy documents and curricular documents (nine documents for general school education, and eighteen documents for environmental education), and interviewed nine policy makers and curriculum designers. The documents and the transcribed interviews are analyzed by coding themes and sub-codes generated from the seven curriculum elements (rational, goal, content, process, teacher, students, and assessment) in reference to the assumed contentions. In coding, we keep in mind the assumptions presented above as sensitizing notions, while also searching information that indicates involved actors in four curricular activities (Van den Akker, 2003) i.e. policy making, design and development, implementation, and evaluation of environmental education in particular.

For the potentially implemented curriculum (the link), namely the curriculum products, we conducted a content analysis of the teaching materials recommended by the interviewed designers (72 lessons in compulsory subjects e.g. Chinese, Math, English, in which environmental education is integrated as a component, and 193 lessons from textbooks and teachers' manuals that are developed domain-specifically for environmental education). A coding table is developed for the coding themes and sub-codes deductively generated from the seven curriculum elements and also inductively emerged from reading through the teacher materials, so that the coding analysis captures all possible features in the seven curriculum elements. For the implemented curriculum (the practice), we visited five primary schools in Qinghai province, given the condition that administrative support would be available. In the schools, we observed seven intra-curricular lessons which integrated environmental education, sixteen different types of extra-curricular activities that held domain specifically for environmental education, and we also interviewed the teachers and students involved. The data of observations and interviews are analyzed by a coding list developed based on the coding table of the teaching materials analysis.

The institutional gap, the formalizing gap, and the operational gap are identified in proving whether there is a discrepancy among each two of the curriculum representations (the intended, the potentially implemented, and the implemented curricula) in comparing to the assumed contentions.

Our analysis shows that the assumed institutional gap is clearly disapproved of in China in terms of most of the curriculum elements. Promoted by the current curriculum reform, the rhetoric of general school education has clearly abandoned the assumed conventional features as deficiencies of the past, and shifted to a set of new features that has much in common with the intentions of environmental education. However, the assumed contrasts are still evident. In terms of the rationale, general school education in its rhetoric still confirms the predefined study issues, and the new curriculum standards are still developed by discipline-based design groups. In terms of the goal, the rhetoric of general school education is to share a similar line with the assumption that has to provide intellectual support for the country's growth, and to prepare students for sharing social responsibility (with environmental responsibility being considered one) in the country's social system. And in terms of assessment, the rhetoric of environmental education still supports a standard-based end-of-pipe evaluation for the domain-specific extra-curricular activities. The Ministry of Education in China (MoE) as the leading policy maker has the responsibility for the gap. And the Ministry of Environmental Protection (MEP) has a responsibility for the gap in terms of assessment, since it has a key role in a 'Green School' campaign to assess extra-curricular activities of environmental education.

The formalizing gap is demonstrated in most of the curriculum elements since the assumed ideal features for environmental education are well supported in the rhetoric, but are inadequately adopted in the two modes of materials (the integrated and the domain-specific). The formalizing gap is evident also in that few assumed features are not supported in the rhetoric and are further disapproved of in the products. As specifically in terms of the rationale, in the integrated materials, the embedded environmental education is largely designed on predefined issues. The majority of integrated materials are developed without awareness of the assumed goal for environmental education. The undesired standard-based end-of-pipe assessment is adopted especially in the domain-specific extra-curricular activities of environmental education. The actors responsible for the occurrence of the formalizing gap are MoE, the absolute leading actor in both policy making and in the design of teaching materials, and MEP who were involved especially in extra-curricular activities and strongly supported the design of domain-specific teaching materials. Notably, many actors at the national level are involved in policy making, but in the end the vital task of school curriculum development is in fact loaded on the school level practitioners without sufficient training and support.

The occurrence of the operational gap is of a more complicated nature. The assumed difference is only partly found in the rationale, since the potentially implemented teaching materials have adopted the assumed features well as they are supported in the intention, but the implemented teaching practices largely ignored them. Mostly the operational gap occurs because the teaching materials of both modes (more often in integrated materials than in the domain-specific) are designed ignoring the assumed features that are supported in the intention, or even fail to give any information in defining the curriculum elements. Even so, a possible operational gap can be narrowed, enclosed, or avoided, since the actual implementation, especially in integrated teaching, could well be in line with some of the assumed ideal features. MoE cannot avoid its responsibility for both integrated and domain-specific environmental education, for its leading role in establishing teaching material design teams, validating and proving the products. MEP has a responsibility in the inadequate performance in extra-curricular practices made domain-specifically for environmental education. Noticeably, with the participation of MEP, the domain-specific materials are designed better to meet the desired environmental education features than the integrated materials supervised merely by MoE. Nonetheless, MEP has no further executive authority to supervise intra-curricular practices, whereas MoE has a broad supervision over much more thematic education than only environmental education, and has not yet treated it is as a distinct mission.

An expected solution to narrow the identified rhetoric-practice gap can be a top level administrative reform, for instance through greenifying MoE in collaboration with MEP. Centered on our research interest in enhancing environmental literacy, via environmental education included in the school agenda, our research effort is to contribute with a curricular solution that optimally presents the assumed ideal features, and to try out the best possible practices feasible at school level.

Design study

As the explorative study revealed, the rhetoric-practice gap for environmental education in China mainly lies in the formalizing gap, the operational gap. The attainment of environmental literacy is weakened since the abundant theoretical guidelines and policies could not yet be fully formalized into educational products or be implemented with appropriate understanding from the practitioners, especially in considering pressure from the competitive social educational background. To solve the problem, what is needed is to recognize a path along which an educational product may optimally bring the 'rhetoric' into the 'practice'. Therefore, we consider the problem of environmental education in China as a design problem. We chose a design research approach to find a context-based curricular solution to reduce the gap with optimized intentions into the design and its implementation. As an intervention, a design study is conducted at the level of school curriculum chosen from the current three-level-curriculum system in China (i.e. national-local-school curriculum system established in the 8th curriculum reform with the concern of decentralization).

Design research is a systematic but flexible methodology aimed at improving educational practices through interactive analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design criteria and theories (Wang & Hannafin, 2005). The design research approach is chosen because it is more relevant for recognizing opportunities and developing optimal solutions in addressing complex problems for which no or few solutions are made available (Meijer, Prins, Bulte, & Pilot, 2008; Plomp, 2006; Reeves, 2006). In other words, design research, through developing an intervention, aims to identify opportunities, and define optimal solutions to complex problems. In doing so, it produces knowledge about whether and why such an intervention works in a certain context, and how an intervention is developed to function. Our design study is carried out along six procedures:

1. Identifying and analyzing problems: The starting point of our design research study is the rhetoric-practice gap for which no validated solutions are available.

2. Formulating criteria to support the design: To structure and support designing the intervention an initial set of 'design criteria' is formulated from three theoretical sources: domain theories of environmental science, i.e. sustainable development and ecological modernization to clarify our environmental position, the selected study issue, and content knowledge; educational theories of teaching-learning approaches, i.e. inquiry-based learning and problem posing approach to make a deliberated plan of procedures; and educational theories of constructivism to underpin the design intention. In addition, the design intentions are also based on assumed ideal features of the seven curriculum elements. The design intentions are to be embodied in an initial design, i.e. *the ideal curriculum*, and then further tested and revised during the experimental intervention cycles. Generalizable criteria are one of our desired outcomes.

3. Developing the design: A four-lesson scenario within the school curriculum is planned as the intervention product. *The formalization of curriculum* is elaborated in detail along the procedures of motivating, questioning, investigating, applying, and reflecting. In each of the phases, we explain how the intended vision is elaborated in the scenario. Finally, the potentially implemented scenario, i.e. *the formal/written curriculum* is described in full, together with its underlying didactical structure. Given the condition that students of grade 6 are tense in preparing for the graduation examinations, grade 5 is chosen, and the scenario is developed purposefully for grade 5 students, who normally are at the age of 11-12. In the scenario, the selected study issue is solid waste management, in

correspondence with the current political discourse of circular economy in China. The main story line is to engage the students in doing a life cycle analysis of the notebook. The students are to understand their role in the material flow by looking at the life cycle of the notebooks they buy, use, and discard in everyday life. With the life cycle analysis, as adapted from Cunningham and Cunningham (2009), the students are to explore issues of five dimensions, addressed in four lessons:

Lesson 1: Life cycle of the notebook: Where does it come from? Where is it disposed of?
Lesson 2: Impact of the notebook: What is the impact evoked?
Lesson 3: My choice: What should I do to reduce the environmental impact?
Lesson 4: To be environmentally friendly: How are other stationery items related to environmental quality?

4. Implementing the design: Four schools in the city of Golmud and Xining, Qinghai province are chosen to participate in the experimental trials, with available support from the local educational administration. In total, eight cycles of trials are conducted, with 440 students and eight teachers participating in the trials. With the implementation, we explain how the vision of the seven curriculum elements is perceived by the participant teachers as shown in their performances, i.e. *the perceived scenario,* and also describe operationally what happened in each lesson considering the problem posing approach, and the errors or obstacles that were revealed, that required modifications, i.e. *the operational curriculum,* for the next round of trials.

5. Evaluating the design: The attained scenario evaluated the extent to which the four lesson unit has achieved environmental literacy in the students, i.e. *the learned curriculum*, and how the four lesson unit has been experienced by the students, i.e. *the experiential curriculum*. The improvement of attained environmental literacy is further proved by the data sets of students' individual reflection essays, and by additional comparative analyses of students' group discussions, and a survey. The data are analyzed to prove the improved environmental literacy resulting from the design study intervention in terms of knowledge, skill, affect, and behavior.

6. Reflecting to build theory: The intervention produces context-based knowledge about whether, how, and why the scenario may or may not function as a solution to enhance environmental literacy and to close the rhetoric-practice gap. The theoretical value ultimately lies in the detailed elaboration of each level of curriculum representations, namely how the

intended scenario has been developed into the potentially implemented formal product, how it further operates in actual classroom practices, and how it is perceived by the teacher, until it is finally evaluated by assessing the students' learning experiences and outcomes.

The data triangulation supported positive conclusions on the students' learning outcome measured along the four strands of environmental literacy. Participation in the design study improved the students' content knowledge of solid waste management and their ability to apply the acquired knowledge in conducting a life cycle analysis. The participating students also improved the expected skills, e.g. critical thinking, systems thinking, and the skill of more flexible and democratic discussion in cooperative learning. In the affect strand, the students showed an improved sensitivity of conflicting environmental, social, and economic impact, the locus of control, and the willingness to take personal responsibility. In behavior, the participating students are more conscious in making green choices in their daily use of stationery items, are also more willing to take action, and know more practical details to carry out the actions. However, some challenges remain for the students, e.g. dealing with multiple perspectives, accomplishing a task in cooperation.

The design study yields theoretical outputs of verified design criteria. The implementation proved that the scenario is a robust design, that as long as the teachers carry out the planned activities, the students are indeed engaged in the inquiry probes and yielded leaning outcome fairly as expected. Although our design study has proved the necessity and at least the internal validity of the design criteria, we remain critically cautious of the generalizability. From our experience, it is insufficient for a designer to select and convert the ample available criteria into a product, since these are too abstract and too similar. The design criteria verified in this study cannot alone provide empirical support for an adequate design about how to improve Chinese students' environmental literacy in solid waste management in general, without another theoretical output, a content-specific educational structure. The locally validated instruction theory, as Gravemeijer & Cobb (2006) termed it, or the didactical structure, as Lijnse & Klaassen (2004) may argue, is not merely meant to validate the theoretical basis, but is an inter-related motivational pathway. They both include structured sequences, activities, and issue knowledge in a specific domain, such as in our case, environmental education. The design criteria and the educational structure did fulfill the potential to show expected directions in the very early stage in formalizing the scenario and in teacher preparation. The theoretical value for future designer researchers still lies in the detailed elaboration of how and why the scenario is developed, that is to say whether, how, and why it functioned as a solution to enhance environmental literacy in the enclosed rhetoric-practice gap in China. And especially for future teacher designers, the theoretical value is neither in knowing the criteria nor the structure, but has to be worked out in experiencing their own design studies that empower them in professional development. At the most practical level, the contribution of the design study are the validated intervention products in the forms of a teacher guide and a booklet of students' group work sheets are disseminated to our participating schools as their school curriculum textbook for environmental education.

Conclusions in connecting the two studies

In the explorative study, we found the evidence of the rhetoric-practice gap in China, characterized the nature of the gap, and identified the tensions that create the gap. In the design study, we provided an exemplary curriculum unit developed and validated in the selected locality. With the design study, we tried to transform the worked-out school curriculum into a teaching-learning strategy for enhancing environmental literacy of pupils in China. Evaluating the quality of the design study is also based on an understanding of how and whether it enabled to close the gap.

In our design study, the formalizing gap is avoided. The development of the scenario was based on the assumptions and the design criteria, and with special attention to the inadequacies in the existing material designs. And the intentions of the design have been optimally formalized into the scenario. From our experience in the formalization, it is first crucial to select a study issue, in our case solid waste manage, which represents most of the intentions; or to say, the intentions should serve as guidance to evaluate whether the selected study issue is good enough to optimally characterize the ideal features. Secondly, it is a key to select a teaching-learning approach, in our case the problem posing approach, which structures the teaching-learning path and organizes the lessons. The problem posing approach in our design study served as a track along which the intended features are characterized into five study phases. The problem posing approach also contributed especially to defining the role of the teacher and students, so that the students' study initiative is already guaranteed in the formal scenario, the teachers and the students can have a sense of purpose in accepting this inquiry, and consequently will avoid the risk of leaving an operational gap in the next step.

The operational gap is not yet completely closed in our classroom trials, as is evident from some inadequate teaching performances, such as in over-leading the group discussion and in having difficulties to guide the students to debate about the trade-offs. Other evidence lies in the difficulties with outdoor activities and grouping. Moreover, the students also encountered problems in achieving the intended cooperative learning. And most importantly, not yet all the teachers are fully convinced of the value of the intended design. Being so, when detached from the design study, the operational gap will very likely also occur in future. Looking ahead, at the least a more systematic teacher training will be needed to improve teachers' content knowledge and to fully recognize the value of the problem posing approach. In the future, perhaps a new design study with a focus on teachers' professional development will find better solutions to improve their commitment, and ultimately have them grow to be curriculum developers themselves. In such a design study the scenario has to be implemented from the perspective of mutual adaptation or enactment.

Samenvatting

Het hoofddoel van dit onderzoek is het bevorderen van milieubewustzijn bij leerlingen in China. Meer in het bijzonder zijn we geïntereseerd in hoe milieubewustzijn het beste in het curriculum kan worden opgenomen, waarbij rekening wordt gehouden met een mogelijke kloof tussen milieueducatie en het onderwijs in het algemeen.

In dit onderzoek wordt, zoals Roth (1992) ook doet, milieubewustzijn opgevat als de capaciteit om de relatieve gezondheid van ecosystemen te observeren en interpreteren, en gepaste actie te nemen om deze systemen te onderhouden, herstellen of verbeteren. Zoals Roth aangeeft, leunt milieubewustzijn in operationele zin op vier elementen van onderwijsuitkomsten: kennis, vaardigheden, affect (gevoeligheid, houding, en waarden) en gedrag (persoonlijke investering, verantwoordelijkheid en actieve betrokkenheid). Een prominente kwestie voor China en andere landen is het bevorderen dat mensen verantwoordelijkheden op zich nemen ter bescherming van het wereldwijde milieu en ter verbetering van de kwaliteit van leven. Milieueducatie biedt een basis voor het scheppen van capaciteit voor milieuhervormingen, met als doel het ontstaan van een milieubewuste maatschappij.

Als eerste worden we geconfronteerd met het probleem van de niet-geslaagde implementatie van milieueducatie. In tegenstelling tot de groeiende steun die in onderwijsbeleidsstukken in China wordt uitgesproken, blijft de daadwerkelijke invoering van milieueducatie in de agenda's van scholen van marginaal belang. We zien het als urgent om kansen voor het substantieel bevorderen van milieueducatie op scholen te identificeren om daarmee bij te dragen aan een verbeterde leeropbrengst en aan het uiteindelijke doel van een milieubewuste bevolking. Een vergelijkbaar probleem bij de implementatie van milieueducatie treffen we ook aan in andere contexten, zoals in Canada (Barrett, 2007), in Zuid-Afrika (Lotz-Sisikta & Schudel, 2007), in Groot-Brittannië (Hackings, Scott, & Barratt, 2007), en in de VS (Gruenewald & Manteaw, 2007). Stevenson (1987, 2007) stelde het concept van een kloof tussen retoriek en praktijk voor om de niet-geslaagde implementatie van milieueducatie op scholen te verklaren. Volgens Stevenson impliceert de retoriek van milieueducatie het bestaan van specifieke curriculaire en pedagogische praktijken die vereist zijn voor het bereiken van de doelen van milieueducatie, bijvoorbeeld dat de leerlingen hun eigen milieugerelateerde meningen en keuzes bekritiseren en verdedigen, bereid zijn vernieuwend te handelen op basis van hun keuzes, en een kritische bijdrage leveren aan het oplossen van milieuproblemen. In de realiteit is de schoolpraktijk primair gericht op het overbrengen en behouden van de bestaande maatschappelijke structuur, en worden dus feitenkennis, routinevaardigheden en de normen en waarden van de dominante politieke en sociale machten overgedragen, en wordt bevorderd dat leerlingen individuele status en economisch welzijn binnen een maatschappij verwerven. Dit onderzoek draagt bij aan een hedendaags perpectief op deze kwestie vanuit China, door het kritisch bestuderen van de aard en aanwezigheid van de kloof in China. Ons doel was niet alleen het verklaren van de tegendruk die milieueducatie ondervindt binnen de scholen, maar ook – belangrijker – het identificeren van de kansen die er in China zijn om milieueducatie, en daarmee een beter milieubewustzijn, te bevorderen.

Dit onderzoek bestaat uit twee onderling verbonden onderdelen. Een verkennende studie richt zich op de eerste centrale vraag: *Is er bewijs voor een kloof tussen retoriek en praktijk tussen milieueducatie en het onderwijs in het algemeen, en zo ja, hoe komt deze dan tot uiting*? Nadat de kloof is geïdentificeerd, beantwoordt een ontwerponderzoek de tweede centrale vraag: *Wat zijn de eigenschappen van een curriculaire benadering die effectief is in het creëren van milieubewustzijn, waarbij rekening wordt gehouden met de waarschijnlijke kloof tussen retoriek en praktijk in China*?

Verkennende studie

Bij het verkennen van de actuele toestand van milieueducatie in China nemen we als uitgangspunt de veronderstelde kloof tussen retoriek en praktijk (Stevenson, 1987, 2007). Om alle mogelijke contrasten tussen milieueducatie en het algemene onderwijs te identificeren en expliciet te beschrijven wat 'retoriek' en 'praktijk' in beide situaties betekent, hebben we verder gebruikgemaakt van een theorie van curriculumrepresentaties (Goodlad, 1979; Van den Akker, 2003) en een drievoudig curriculummodel (Valverde, Bianchi, Wolfe, Schmidt, & Houang, 2002). We zijn uitgekomen op een analytisch raamwerk van een kloof tussen retoriek en praktijk dat elf mogelijke kloven weergeeft tussen milieueducatie en het geheel van het onderwijs op school (waar milieueducatie deel van uitmaakt). Gezien onze onderzoeksfocus en de beschikbare tijd, zijn we niet ingegaan op de zes kloven die zich kunnen voordoen tussen retoriek en praktijk in het geheel van het onderwijs op school, maar richtten we ons op slechts drie mogelijke kloven: 1) de institutionele kloof tussen de retorieken (beoogde curricula) van het geheel van het onderwijs op school en van milieueducatie in het bijzonder,

2) de formaliseringskloof tussen de retoriek (het beoogde curriculum) en de verbinding (het potentieel ingevoerde curriculum) van milieueducatie, 3) de uitvoeringskloof tussen de verbinding (het potentieel ingevoerde curriculum) en de praktijk (het uitgevoerde curriculum) van de milieueducatie. Daarnaast worden de curriculaire en pedagogische conflicten die door Stevenson (1987, 2007) zijn gedefinieerd, verder geordend met de door Van den Akker (2003) geïdentificeerde curriculumcomponenten. In combinatie worden de conflicten tussen milieueducatie en het geheel van het onderwijs op school samengevat in de volgende zeven curriculumelementen:

1. Rationale:
   Het curriculum voor milieueducatie kiest een holistische, interdisciplinaire benadering (disciplinariteit) en richt zich op echte, praktische en specifieke milieuproblemen (gericht probleem). Het curriculum wordt bepaald door problematische, onzekere vraagstukken met betrokkenheid van de leerlingen bij het onderzoeken, oplossen en aan de sociale constructies van leerlingen aanpassen; het curriculum is daardoor zeer flexibel (eigenschappen van het onderzochte probleem). De conclusie of oplossing voor het onderzochte probleem is onzeker (conclusie en oplossing).

   Het curriculum van het geheel van het onderwijs op school heeft een gefragmenteerde, disciplinair-geörienteerde benadering (disciplinariteit). Het curriculum richt zich op abstracte theoretische problemen die losstaan van ervaringen in het dagelijks leven (gericht probleem). Het curriculum wordt bepaald door vooraf vastgestelde vraagstukken die vooraf vastgestelde doelen dienen, en wordt beoordeeld op basis van duidelijk gedefinieerde criteria (eigenschappen van het onderzochte probleem). Het curriculum bestaat uit op standaarden gebaseerde kennis en vooraf vastgestelde vragen met reeds vastgestelde juiste oplossingen (conclusie en oplossing).

2. Doel:
   Het analytische instrument veronderstelt dat de functie van kennis in milieueducatie is dat deze direct gebruikt wordt voor een duurzame en zelfstandige kwaliteit van leven. In milieueducatie is kennis niet alleen gericht op actie, maar ook op het voorbereiden van onderzoek en het nemen van actie om invloed op het milieu uit te oefenen.

   Het analytische instrument veronderstelt dat in het geheel van het onderwijs op school kennis wordt opgeslagen voor individueel, toekomstig gebruik door leerlingen, bijvoorbeeld op een universiteit of bij het vinden van een baan, en ter verbetering van individuele status en economisch welzijn.

3. Inhoud:
   De inhoud van milieueducatie is opgebouwd uit complexe en elkaar tegensprekende bronnen (informatiebron). De inhoud is van groot belang voor echte problemen (relevantie voor leerlingen). Inhoud ontstaat doordat leerlingen zijn betrokken bij het onderzoeken van milieuproblematiek, zodat de inhoud wordt ontwikkeld door de

leerlingen en niet aan hen wordt verstrekt als feiten (kennisontwikkelingspad).

De inhoud van het geheel van het onderwijs op school bestaat uit feitelijke informatie (informatiebron). De ontwikkelde inhoud staat los van de realiteit (relevantie voor leerlingen), zonder de betrokkenheid van leerlingen (kennisontwikkelingspad).

4. Proces:
Leren en onderwijzen zijn een gezamenlijk proces in milieueducatie (samenwerking). Leerlingen zijn actief betrokken bij het onderwijsleerproces (deelname). De leerlingen zijn betrokken bij het omgaan met milieuproblemen (betrokkenheid).

Leren en onderwijzen zijn een individueel proces in het geheel van het onderwijs op school (samenwerking), waarbij de leraar leidend is, en de rol van leerlingen beperkt is tot het beantwoorden van de vragen van de leraar (deelname), die vooral gesteld worden om reeds gedefinieerde feitenkennis en goedgestructureerde problemen op te sommen (betrokkenheid).

5. Leraar:
Bij milieueducatie moet de leraar openstaan voor autonome beslissingen van leerlingen. Leraren zijn actoren met een eigen mening en ideologie over onderwijs die hun besluiten over curriculum en pedagogiek beïnvloeden.

In het geheel van het onderwijs op school is de rol van de leraar die van een verstrekker van feitenkennis.

6. Leerling:
Bij milieueducatie moeten leerlingen actieve, kritische denkers, en ontwikkelaars van kennis zijn.

In het geheel van het onderwijs op school zijn leerlingen passieve ontvangers van feitenkennis en reeds vastgestelde juiste oplossingen.

7. Toetsing:
De toetsing van milieueducatie evalueert het proces van onderzoek, kritiek en reflectie, evenals in hoeverre leerlingen hun eigen milieugerelateerde overtuigingen en keuzes ontwikkelen en verdedigen, en in hoeverre ze in staat zijn om conform hun keuzes te handelen.

De toetsing van het geheel van het onderwijs op school is een inhoudelijke domeintoets voor het reproduceren van feitenkennis en benadrukt de beheersing van gefragmenteerde feiten en concepten. Vaak wordt de toets gedaan in kunstmatige omstandigheden, aan de hand van theoretische materialen die ver verwijderd zijn van de levenservaring van leerlingen.

Bij iedere representatie van het curriculum (het beoogde curriculum, het potentieel ingevoerde curriculum, en het uitgevoerde curriculum) wordt gekeken in hoeverre deze overeenkomt met de bovengenoemde veronderstellingen over de zeven curriculumelementen van milieueducatie en het geheel van het onderwijs op school.

Voor de beoogde curricula (de retorieken) van het geheel van het onderwijs op school en van milieueducatie, keken we naar onderwijsbeleidsstukken en curriculumdocumenten (negen documenten voor het geheel van het onderwijs op school, en achttien voor milieueducatie), en interviewden we negen beleidsmakers en curriculumontwerpers. De documenten en de getranscribeerde interviews zijn geanalyseerd door het coderen van thema's en met sub-codes voortkomend uit de zeven curriculumelementen (rationale, doel, inhoud, proces, leraar, leerlingen, en toetsing) verwijzend naar de veronderstelde stellingnames. Bij het coderen werden we de hierboven genoemde veronderstellingen aangehouden als aandachtspunten, terwijl ook gezocht werd naar informatie die duidde op betrokken actoren in vier curriculaire activiteiten (Van den Akker, 2003) te weten het formuleren van beleid, ontwerp en ontwikkeling, implementatie, en de evaluatie van milieueducatie in het bijzonder. Voor het potentieel ingevoerde curriculum (de verbinding), te weten de curriculaire producten, hebben we een inhoudelijke analyse uitgevoerd van de door de geïnterviewde ontwerpers aangeraden onderwijsmaterialen (72 lessen in verplichte vakken, zoals Chinees, wiskunde, Engels, waarin milieueducatie als onderdeel is opgenomen, en 193 lessen uit schoolboeken en handleidingen voor leraren die domein-specifiek voor milieueducatie zijn ontwikkeld). Voor de te coderen thema's en subcodes die deductief zijn afgeleid van de zeven curriculumelementen en ook inductief opkwamen bij het lezen van de leraarmaterialen, is een codetabel ontwikkeld om er zorg voor te dragen dat de analyse alle mogelijke aspecten van de zeven curriculumelementen omvat. Voor het uitgevoerde curriculum (de praktijk) bezochten we vijf basisscholen in de provincie Qinghai, met als selectievoorwaarde dat er administratieve ondersteuning zou zijn. In de scholen hebben we zeven intracurriculaire lessen geobserveerd die milieueducatie integreerden, evenals zestien types extracurriculaire activiteiten die specifiek op milieueducatie waren gericht; ook hebben we de betrokken leraren en leerlingen geïnterviewd. De data van de observaties en interviews zijn geanalyseerd met behulp van een codelijst die is ontwikkeld op basis van de codetabel van de analyse van de leermaterialen.

De institutionele kloof, de formaliseringskloof, en de uitvoeringskloof zijn geïdentificeerd door het aantonen van een discrepantie tussen elk paar curriculumrepresentaties (het beoogde, potentieel ingevoerde en het uitgevoerde curriculum) in vergelijking met de veronderstelde stellingnames.

Onze analyse toont aan dat de veronderstelde institutionele kloof in China niet kon worden aangetoond voor wat betreft de meeste curriculumelementen. Als gevolg van de huidige curriculumvernieuwing heeft de retoriek van het geheel van het onderwijs op school duidelijk de veronderstelde conventionele karakteristieken laten varen als gebreken uit het verleden, en heeft nieuwe eigenschappen verworven die veel overeenkomsten vertonen met de doelstellingen van milieueducatie. De veronderstelde contrasten zijn echter nog niet verdwenen. Voor wat betreft de rationale bevestigt de retoriek van het geheel van het onderwijs op school nog steeds de vooraf vastgestelde studieonderwerpen, en de nieuwe curriculumstandaarden worden nog steeds ontwikkeld door ontwerpgroepen op basis van de disciplines. Voor wat betreft het doel deelt de retoriek van het geheel van het onderwijs op school een benadering met de veronderstelling die intellectuele steun moet geven aan de groei van het land, en om leerlingen voor te bereiden op het delen van sociale verantwoordelijkheid (waarvan milieubewustzijn wordt verondersteld deel uit te maken) binnen de maatschappij. Voor wat betreft toetsing ondersteunt de retoriek van milieueducatie nog steeds een op standaarden gebaseerde opbrengstgerichte evaluatie van de domeinspecifieke extracurriculaire activiteiten. Het Chinese Ministerie van Onderwijs (MoE), als de voornaamste maker van beleid, draagt de verantwoordelijkheid voor de kloof. Het Ministerie van Milieubescherming (MEP) heeft een verantwoordelijkheid voor de toetsingskloof, gezien de sleutelrol die het heeft in de 'Groene School'-campagne die gericht is op het toetsen van extracurriculaire activiteiten in het kader van milieueducatie.

De formaliseringskloof is aangetoond voor de meeste curriculumelementen, aangezien de veronderstelde ideale eigenschappen van milieueducatie goed worden ondersteund in de retoriek, maar niet adequaat worden toegepast in de twee vormen van lesmateriaal (geïntegreerde en domein-specifiek). De formaliseringskloof is ook zichtbaar in de bevinding dat maar weinig van de veronderstelde eigenschappen niet ondersteund worden in de retoriek, en vervolgens niet worden opgenomen in de producten. Specifiek voor de rationale geldt dat in de geïntegreerde materialen het opgenomen milieueducatie grotendeels rond vooraf vastgestelde problemen is ontworpen. Het merendeel van de geïntegreerde materialen is ontworpen zonder bewustzijn van het veronderstelde doel van milieueducatie. De ongewenste op standaarden gebaseerde opbrengstgerichte toetsing wordt specifiek toegepast in de domeinspecifieke extracurriculaire activiteiten van milieueducatie. De actoren die verantwoordelijk zijn voor het voorkomen van de formaliseringskloof zijn MoE, als de voornaamste maker van beleid én de voornaamste ontwerper van lesmaterialen, en MEP, dat specifiek betrokken was bij extracurriculaire activiteiten en het ontwerp van domeinspecifiek lesmateriaal nadrukkelijk steunde. Opvallend is dat op nationaal niveau veel actoren betrokken zijn bij het formuleren van beleid, maar dat de vitale taak van het ontwikkelen van het curriculum op schoolniveau uiteindelijk wordt neergelegd bij beroepsbeoefenaren op schoolniveau met onvoldoende training en ondersteuning.

Het voorkomen van de uitvoeringskloof is van een meer gecompliceerde aard. Het veronderstelde verschil kan maar deels worden herleid tot de rationale, aangezien de potentieel geïmplementeerde leermaterialen de veronderstelde eigenschappen goed hebben overgenomen zodat ze qua intentie worden ondersteund, maar in de uiteindelijke onderwijspraktijk grotendeels genegeerd worden. De uitvoeringskloof komt vooral voor doordat de geïntegreerde en domein-specifieke lesmaterialen (de geïntegreerde materialen het meest) worden ontworpen met onvoldoende aandacht voor de in de doelstellingen veronderstelde eigenschappen, of ten aanzien van deze eigenschappenzelfs geen enkele informatie geven bij het beschrijven van de curriculumelementen. Desondanks kan een mogelijke uitvoeringskloof worden beperkt, overbrugd of vermeden, aangezien de daadwerkelijke implementatie goed overeen kan komen met een deel van de veronderstelde ideale eigenschappen. MoE kan de verantwoordelijkheid voor zowel geïntegreerd als domeinspecifiek milieueducatie niet vermijden als gevolg van de leidende rol die het ministerie heeft bij het formeren van ontwerpteams voor lesmateriaal en het valideren en testen van de producten. MEP heeft een verantwoordelijkheid voor de inadequate uitvoering van specifiek voor milieueducatie gemaakt extra-curriculaire activiteiten. Het is opvallend dat de met betrokkenheid van MEP ontworpen domeinspecifieke materialen beter aansluiten bij de gewenste eigenschappen van milieueducatie dan de geïntegreerde materialen die uitsluitend onder supervisie van MoE zijn ontworpen. Desondanks beschikt MEP niet over verder uitvoerend gezag om toe te zien op de intracurriculaire praktijk, terwijl MoE binnen het thematische onderwijs de supervisie heeft over veel meer onderwerpen dan alleen milieueducatie, en milieueducatie nog niet als aparte taak opvat.

Een te verwachten oplossing om de vastgestelde kloof tussen retoriek en praktijk te verkleinen kan een beleidshervorming op het hoogste niveau zijn, bijvoorbeeld door het 'vergroenen' van MoE in samenwerking met MEP. Met het oog op de doelstelling van ons onderzoek - het verhogen van milieubewustzijn door het verbeteren van de in de schoolagenda opgenomen milieueducatie - draagt dit proefschrift bij door het beschrijven van een curriculumoplossing die de veronderstelde ideale eigenschappen optimaal tot uiting brengt en door het beproeven van de best haalbare praktijken op schoolniveau.

Ontwerponderzoek

Zoals bleek uit het verkennende onderzoek ligt de kloof tussen retoriek en praktijk voor milieueducatie in China vooral bij de formaliseringskloof en de uitvoeringskloof. Het bereiken van milieubewustzijn wordt afgezwakt doordat de overvloedige theoretische richtlijnen en beleidsprincipes nog niet geheel vorm hebben gekregen in onderwijsmaterialen of met voldoende begrip zijn geïmplementeerd door de beroepsbeoefenaars, vooral bij het rekening houden met druk vanuit de concurrentie in de sociale onderwijsachtergrond. Wat nodig is om dit probleem op te lossen is dat er een pad vastgesteld wordt waarlangs een onderwijsproduct de 'retoriek' optimaal in de 'praktijk' kan brengen. Daarom beschouwen we het vraagstuk van milieueducatie in China als een ontwerpvraagstuk. We hebben gekozen voor een ontwerponderzoekbenadering om een op contexten gebaseerde curriculaire oplossing te vinden om met geoptimaliseerde doelstellingen de kloof naar het ontwerp en de implementatie ervan te verkleinen. Een ontwerponderzoek wordt uitgevoerd als een interventie op schoolniveau, het derde niveau van het curriculum volgens het huidige systeem in China (te weten, nationaal-lokaal-school curriculumsysteem dat is vastgesteld in de achtste curriculumhervorming, met aandacht voor decentralisatie).

Ontwerponderzoek is een systematische maar flexibele methodologie die is gericht op het verbeteren van de onderwijspraktijk door middel van interactieve analyse, ontwerp, ontwikkeling en implementatie, gebaseerd op samenwerking tussen onderzoekers en beroepsbeoefenaars in bestaande praktijken, leidend tot contextgevoelige ontwerpcriteria en –theorieën (Wang & Hannafin, 2005). Er is voor de ontwerponderzoeksbenadering gekozen omdat deze relevant is voor het herkennen van kansen en het ontwikkelen van optimale oplossingen bij het benaderen van complexe problemen waar geen of weinig oplossingen voor beschikbaar zijn (Meijer, Prins, Bulte, & Pilot, 2008; Plomp, 2006; Reeves, 2006). Met andere woorden, ontwerponderzoek heeft als doel om door het ontwikkelen van een interventie kansen te identificeren en optimale oplossingen voor complexe problemen te vinden. Hierbij wordt kennis opgebouwd over of en waarom een dergelijke interventie werkt in een bepaalde context, en over hoe een werkende interventie wordt ontwikkeld. Ons ontwerponderzoek is opgebouwd rond de volgende zes procedures:

1. Identificeren en analyseren van problemen: het uitgangspunt van ons ontwerponderzoek is de kloof tussen retoriek en praktijk waarvoor geen gevalideerde oplossingen beschikbaar zijn.

2. Het opstellen van criteria die het ontwerp ondersteunen: om structuur en ondersteuning te geven aan het ontwerp van de interventie is een eerste groep 'ontwerpcriteria' opgesteld op basis van drie theoretische bronnen: milieuwetenschappelijke theorie - dat wil zeggen duurzame ontwikkeling en ecologische modernisering - om onze milieupositie, het gekozen studieonderwerp, en de daarmee samenhangende domein-specifieke kennis te verduidelijken; onderwijstheorieën op het vlak van onderwijsleerbenaderingen, dat wil zeggen onderzoekend leren en een probleem stellende benadering, om een weloverwogen plan van procedures op te stellen; en constructivistische onderwijstheorieën om de doelstellingen van het ontwerp te onderbouwen. Verder zijn de ontwerpdoelstellingen ook gebaseerd op veronderstelde ideale eigenschappen van de zeven curriculumelementen. De ontwerpdoelstellingen krijgen vorm in een eerste ontwerp, het *ideale curriculum*, en worden vervolgens verder getest en herzien in experimentele interventiecycli. Generaliseerbare criteria zijn een van onze gewenste uitkomsten.

3. Ontwikkelen van het ontwerp: een scenarie van vier lessen binnen het schoolcurriculum is voorzien als interventieproduct. De *formalisering van het curriculum* wordt in detail uitgewerkt, evenals de procedures voor motiveren, ondervragen, onderzoeken, toepassen en reflecteren. In iedere fase leggen we uit hoe het beoogde doel is uitgewerkt in het scenario. Tot slot wordt het potentieel geïmplementeerde scenario, het *formele/schriftelijke curriculum*, in detail beschreven, inclusief de onderliggende didactische structuur. Aangezien leerlingen in de zesde klas druk bezig zijn met de voorbereidingen van hun examens is er voor gekozen het scenario uit te werken voor leerlingen in de vijfde klas; die zijn over het algemeen 11-12 jaar oud. Het studieonderwerp waarvoor is gekozen in het scenario is

het omgaan met vast afval, in overeenstemming met de huidige politieke dialoog over de plaats van hergebruik binnen de economie in China. De hoofdlijn van het verhaal betrekt de leerlingen bij het maken van een analyse van de levenscyclus van een schrijfblok. De bedoeling is dat de leerlingen hun rol in de stroom van materialen leren begrijpen door te kijken naar de levenscyclus van de schrijfblokken die ze in het dagelijks leven kopen, gebruiken en weggooien. Met de aangepaste levenscyclusanalyse van Cunningham en Cunningham (2009), moeten de leerlingen in vier lessen aspecten van vijf dimensies verkennen:

Les 1: Levenscyclus van het schrijfblok: waar komt het vandaan? Waar gaat het heen als afval?
Les 2: Effect van het schrijfblok: Welke effecten worden opgeroepen?
Les 3: Mijn keuze: hoe kan ik de gevolgen voor het milieu verminderen?
Les 4: Milieuvriendelijk zijn: hoe verhoudt ander schrijfgerei zich tot de kwaliteit van het milieu?

4. Uitvoering van het ontwerp: Vier scholen in de steden Golmud en Xining, in de provincie Qinghai, zijn uitgekozen om mee te doen in de experimentele uitvoering, met hulp van het locale onderwijsbestuur. In totaal zijn acht testcycli uitgevoerd, waaraan 440 leerlingen en acht leraren meededen. Bij de beschrijving van de implementatie is uitgelegd hoe de zeven curriculumelementen door de deelnemende leraren worden gezien, zoals blijkt uit hun invulling van de taak, dat wil zeggen *het gepercipieerde scenario, en leggen ook operationeel uit hoe de probleemstellende* benadering verliep, evenals de fouten of obstakels die zichtbaar werden en tot aanpassingen leidden, *het operationale curriculum,* voor de volgende ronde trials.

5. Evaluatie van het ontwerp: het gerealiseerde scenario evalueerde in hoeverre de leseenheid van vier lessen leidde tot milieubewustzijn bij de leerlingen; dat is *het geleerde curriculum*, en hoe de leerlingen de vier lessen ervaren hebben, dat is *het ervaren* c*urriculum*. De verbetering van het milieubewustzijn is verder vastgesteld door analyse van de individuele reflectieopstellen van de leerlingen, en door verdere vergelijkende analyses van groepsgesprekken van leerlingen, evenals een vragenlijst. De data worden geanalyseerd om het verbeterde milieubewustzijn als gevolg van de interventie van het ontwerponderzoek aan te tonen in termen van kennis, vaardigheid, affect en gedrag.

6. Reflectie voor het construeren van een theorie: de interventie levert op context-specifieke kennis op over of, hoe en waarom het scenario al dan niet werkt als oplossing om milieubewustzijn te bevorderen en de kloof tussen retoriek en praktijk te slechten. Uiteindelijk ligt de theoretische waarde in de gedetailleerde uitwerking van ieder niveau van curriculumrepresentatie, namelijk hoe het beoogde scenario is ontwikkeld tot het potentieel geïmplementeerde formele product, hoe het vervolgens functioneert in de daadwerkelijke klassepraktijk, en hoe het wordt gezien door de leraar, en tot de slotevaluatie door middel van het beoordelen van de leerervaringen en –resultaten van de leerlingen.

Triangulatie van de data ondersteunt de positieve conclusies over de leeruitkomsten van de leerlingen, gemeten over de vier elementen van milieubewustzijn. De kennis van leerlingen over het beheer van vast afval en hun vaardigheid de verworven kennis toe te passen in het uitvoeren van een levenscyclusanalyse verbeterden door deelname aan het ontwerponderzoek. Ook verbeteren bij de deelnemende leerlingen de verwachte vaardigheden, zoals kritisch denken, systeemdenken, en het voeren van een meer flexibele en democratische discussie in een coöperatieve leeromgeving. Voor wat betreft affect, lieten de leerlingen een verbetering zien in hun gevoeligheid voor conflicterende milieueffecten, sociale en economische gevolgen, de "locus of control", en de bereidheid om hun persoonlijke verantwoordelijkheid te nemen. Voor wat betreft gedrag zijn de deelnemende leerlingen zich meer bewust van groene keuzes bij hun dagelijks gebruik van schrijfgerei, zijn meer bereid om actie te ondernemen, en kennen meer praktische details bij het uitvoeren van de acties. Er blijven echter uitdagingen voor de leerlingen, zoals het omgaan met meerdere standpunten, en het samenwerkend uitvoeren van een taak.

Het ontwerponderzoek levert theoretische uitkomsten in de vorm van geverifieerde ontwerpcriteria. De implementatie toonde aan dat het scenario een robuust ontwerp is, en dat zolang de leraren de geplande onderwijsleeractiviteiten uitvoeren, de leerlingen inderdaad betrokken zijn bij het uitvoeren van hun onderzoek, en dat de leeropbrengst in grote lijnen voldoet aan de verwachtingen. Hoewel ons ontwerponderzoek de noodzaak en de interne validiteit van de ontwerpcriteria heeft aangetoond, betrachten we enige kritische voorzichtigheid bij de generaliseerbaarheid. In onze ervaring is het niet genoeg als een ontwerper de ruimschoots beschikbare criteria selecteert en op basis daarvan een product samenstelt, omdat deze criteria te abstract en algemeen zijn. De in dit onderzoek geverifieerde ontwerpcriteria alleen kunnen op zichzelf geen empirische steun geven aan een adequaat ontwerp voor het verbeteren van het milieubewustzijn van Chinese leerlingen op het gebied van het beheer van vast afval in het algemeen, zonder een andere theoretische output, een inhoudsspecifieke onderwijsstructuur. De lokaal gevalideerde onderwijstheorie, zoals Gravemeijer en Cobb (2006) dit noemden, of de didactische structuur, zoals Lijnse en Klaassen (2004) zullen zeggen, heeft niet alleen als doel om de theoretische basis te valideren, maar is een samenhangende, motivationele ontwikkellijn. Beiden bevatten gestructureerde sequenties, activiteiten en kennis van kwesties in een specifiek domein, zoals in ons geval milieueducatie. De ontwerpcriteria en de onderwijsstructuur toonden inderdaad hun waarde bij het geven van richting aan het allereerste stadium van de formalisering van het scenario, en bij het voorbereiden van leraren. Voor toekomstige ontwerponderzoekers ligt de theoretische waarde in de gedetailleerde uitwerking van hoe en waarom het scenario is ontwikkeld, dat wil zeggen of, hoe en waarom het werkte als een oplossing voor het bevorderen van milieubewustzijn in de ontsloten kloof tussen retoriek en praktijk in China. Voor toekomstige leraar-ontwerpers ligt de theoretische waarde niet zozeer in het kennen van de criteria of de structuur, maar moet deze uitgewerkt worden in hun eigen ontwerponderzoeken die hun professionele ontwikkeling versterken. Op het meest praktische niveau is de bijdrage van het ontwerponderzoek het gevalideerde product van de interventie in de vorm van een lerarenhandleiding en een boekje met groepsopdrachten voor leerlingen die aan de deelnemende scholen zijn verstrekt als hun schoolboeken voor milieueducatie.

Conclusies bij het verbinden van de twee onderzoeken

In het verkennende onderzoek deden we bevindingen over de kloof tussen retoriek en praktijk in China, beschreven we de aard van de kloof en identificeerden we de spanningen die de kloof doen ontstaan. In het ontwerponderzoek boden we een voorbeeldcurriculumeenheid die is ontwikkeld en gevalideerd in de gekozen omgeving. Met het ontwerponderzoek poogden we het uitgewerkte schoolcurriculum te transformeren tot een onderwijsleerstrategie om het milieubewustzijn van leerlingen in China te verbeteren. Een evaluatie van de kwaliteit van het ontwerponderzoek is ook gebaseerd op het begrip van of en hoe het bijdroeg aan het slechten van de kloof.

In ons ontwerponderzoek wordt de formaliseringskloof vermeden. De ontwikkeling van het scenario was gebaseerd op de veronderstellingen en ontwerpcriteria, met speciale aandact voor de tekortkomingen van bestaande materiaalontwerpen. In het scenario zijn ook de doelstellingen van het ontwerp optimaal geformaliseerd. Op basis van onze ervaringen met de formalisering is het op de eerste plaats cruciaal een onderwerp te selecteren, in ons geval het beheer van vast afval, dat aan het merendeel van de intenties voldoet; of met andere woorden, de intenties moeten dienen als richtlijn om te evalueren of het gekozen onderwerp goed genoeg is om de ideale eigenschappen optimaal uit te werken. In de tweede plaats is het essentieel om een onderwijsleerbenadering te kiezen, in ons geval de probleemstellende benadering, die het onderwijsleerpad vorm geeft en de lessen organiseert. De probleemstellende benadering in ons ontwerponderzoek fungeerde als een pad waarlangs de beoogde eigenschappen in vijf onderzoeksfases worden gekarakteriseerd. De probleemstellende benadering droeg ook nadrukkelijk bij aan het vaststellen van de rol van leraar en leerlingen, waardoor het leerinitiatief van de leerlingen al is vastgelegd in het formele scenario, en de leraar en de leerlingen een doel hebben door het accepteren van dit vraagstuk, en daarmee het risico van een operationele kloof in de volgende stap vermijden.

De operationale kloof werd in onze experimenten in de klas nog niet helemaal gesloten, zoals blijkt uit het tekortschieten in de uitvoering van het onderwijs, zoals het te sterk leiden van de groepsdiscussie en problemen bij het sturen van de leerlingen in de discussie over wisselwerkingen. Verder kunnen aanwijzingen gevonden worden in de problemen rond buitenactiviteiten en het vormen van groepen. Ook hadden de leerlingen problemen bij het uitvoeren van het voorziene samenwerkend leren. Het belangrijkste punt is echter wel dat nog niet alle leraren volledig overtuigd zijn van de waarde van het beoogde ontwerp. Dit betekent dat, wanneer we het ontwerp los van het ontwerponderzoek bekijken, de operationele kloof ook in de toekomst zal voorkomen. Als we vooruitkijken, zal op zijn minst een meer systematische benadering van de opleiding van leraren nodig zijn om de inhoudelijke kennis van leraren te verbeteren en hen de waarde van de probleem stellende benadering volledig te laten inzien. Misschien dat in de toekomst een nieuw ontwerponderzoek dat zich met name richt op de professionalisering van leraren betere oplossingen zal vinden om de betrokkenheid van leraren te verbeteren en hen uiteindelijk te laten doorgroeien zodat ze zelf curriculumontwerpers worden. In een dergelijk ontwerponderzoek zal het scenario moeten worden geïmplementeerd vanuit het perspectief van wederzijdse aanpassing en betrokkenheid.

Acknowledgements

This book is the work of nearly six years, from November 2007 to August 2013. During this time, I also received the most precious gift in my life, my son Li Kunheng (DinDin). On the side of this PhD research, I additionally had an appointment with Xiamen University to offer courses and supervise theses. It would not have been possible to fulfill these multiple roles if weren't for having these people who gave me support, guidance, encouragement, and inspiration.

Foremost, I hold high respect for Prof. Huang Xingmin, my former leader in Xiamen University, whose tenacious effort enabled me to go for this PhD project. I admire you also for your paternal care of my career and life, as you do for every young fellow. I wish you a merry and profitable retirement with your family in the United States.

My sincerest gratitude is for my two supervisors, Prof. Kerst Boersma from Utrecht University and Prof. Kris van Koppen from Wageningen University. Prof. van Koppen initiated this PhD project and directed me to this very interesting research topic. I truly appreciated your incisive comments and your stimulation for me to write things simply and directly. Your expertise in environmental science and politics ensured the direction of this cross-disciplinary research. Thank you also for your warmly welcoming me to your family. And Prof. Boersma, my promoter, I have always found it greatly fortunate to be under your kind supervision. It has been a pleasure to learn from your all-round expertise in educational design research, and your cautious eye for detail was crucial for the overall quality of this dissertation. It was really enjoyable working with you two and especially all our inspiring meetings held in the offices, in town, and at the train station.

My special thanks are for my colleagues at FIsme. I am deeply grateful to Prof. Harrie Eijkelhof, who helped me in getting essential financial and institutional support which let me complete this work smoothly in the last two years. And Prof. Albert Pilot, it was very pleasant to have casual talks with you, in which you in fact mentored me with useful thinking that enables a mature researcher. I owe massive debt to Drs. Nathalie Kuijpers, who generously provided me professional English proof-reading of the entire manuscript, so that the non-Chinese readers can understand me as I want them to. You also so kindly did all the formatting work for the book printing for which my thanks cannot be enough. Dr. Kees Klaassen, a unique thanks to you for the debates we

had that always kept me self-critical. I was amazed by your wisdom and also benefited from it. Dr. Bart Ormel, it was my luck to be your office mate, thanks for being so patiently in helping me to get settled working at FIsme at the very beginning. Working at FIsme is also an unforgettable experience of meeting many other people whom I found charming and helpful. Dr. Hanna Westbroek, Dr. Dieuwke Hovinga, Dr. Sonja Verheijen, Dr. Arthur Bakker, thank you for being so friendly and supportive. Dr. Koos Kortland, I owe you thanks for that your dissertation has been a crucial reference for my research. Liesbeth de Bakker, it is great to have you in the institute, and thank you so much for organizing and sending DinDin the beautiful presents and card. Tine Blankenstein, you know that I really loved your sympathetic and peaceful personal style, and thank you especially that you helped me out with various administrative affairs. Nonetheless, I must admit that working in a foreign country is challenging. Happily, I made friends who fully understood this experience. Salamah Agung, Ngo Vu Thu Hang, and Victor Antwi, I appreciated our effortless understanding of each other, and our good time together in and out of work. Nienke Gerkes, thank you sincerely for the international group trip you led to Kasteel de Haar. Nguyen Phuong-Mai, I was impressed by your earnest professionalism, and beautiful English writing though being a non-native, and all these have encouraged me to keep on going.

All my friends in the Netherlands afforded me invaluable backup and alleviation so that I could complete this demanding work in a good balance. Lydia Stienstra, my best friend who connected me to Dutch society beyond academia, never refused to lend me a hand whenever I needed any help. Celine Empain, what gorgeous times we had together, the vigorous walks and talks. And the most wonderful Christmas I had was with you and your family. Liu Yunfan, Vivien Chiu, Hill Tsai, it is extremely precious for me having your honest friendship. Without you, I could not get through the most stressful stage. Bao Dongping, Shan Xinyan, Zhang Tianhui, I thank you not only for your friendships and help, but more importantly you are all excellent scholars from my country who gave me examples of being self-aware, studious, and adaptable.

My good housemates, Roger Smeets, Sengfong Lau, Merijn Brokking, and Niek Leermakers who lived with me like sisters and brothers and offered me helps with all details of life, thank you for all! My landlord, the Taya

kindly allowed me manage to keep my room during my time away for field researches, so that I always had a home in returning to the Netherlands.

I highly appreciated the researchers, the officials, and the teachers who participated in this study. You names as well as your contribution are unforgettable, though I have to address you anonymously here. The time spent with the lovely pupils in my study shone brightly in this PhD journey. They are the answer each time I doubt what this tedious work is for. Thanks also to my students in Xiamen University who loved me and cheered for me, I could move on so with their energy. I'd like to extend my thanks to all my physical therapists who saved my overused shoulders due to years of desk work. I became attached to cafés Casa Mia and Greenhouse where I wrote the most part of this dissertation. Because of the anonymous girls and boys who waited in there, I did not have to feel too isolated to concentrate. And they witnessed how this book has come into being.

Mom, dad, sister, and granny, thank you for believing in me. I feel so regretful that I had to sacrifice so much of your company during these years. My love to Li Wei, my husband, for being always on my side but not blindly. Because of you, I can keep alert professionally and remain innocent in life. And DinDin, this book is for you!

Lei

Curriculum Vitae

Lei Sun started her college education studying management. In 2000, she received her bachelor degree from Lanzhou University. Communication science then directed her attention to deepen an understanding of how people connect in conveying information. She continued her master study at Lanzhou University. In 2004, Lei Sun obtained her MA in communication science and had her traineeship as a journalist at China Central Television. During her time in graduate school and journalist traineeship, Lei Sun had her concern especially on the developmental issues of disadvantaged areas in China. She came to the Netherlands at the end of 2004, and enrolled in a master program of applied communication science in Wageningen University. There she extended her knowledge and working skills in communication in solving conflicts in natural resource management, in empowering vulnerable populations with their local products, and in explaining cross-disciplinary group dynamics between social and natural scientists, and so on. She joined in several international research projects and gained forefront views especially on sustainable development in Bhutan, in South Africa, and in China. In 2006, Lei Sun received her MSc from Wageningen University, with the major of applied communication science and two minors in organic agriculture and in food management. She then returned to China and became a lecturer at Xiamen University. In 2007, she came back to the Netherlands and started a PhD study at Utrecht University. The PhD study was mainly aimed at enhancing pupils' environmental literacy in China.

Lei Sun is now an assistant professor in the department of communication, Xiamen University, China. Her teaching and research currently focus on the public's environmental literacy, risk communication, and health communication.

FIsme Scientific Library

(formerly published as CD-b Scientific Library)

80. Mazereeuw, M. (2013). *The functionality of biological knowledge in the workplace. Integrating school and workplace learning about reproduction.*
79. Dierdorp, A. (2013). *Learning correlation and regression within authentic contexts.*
78. Dolfing, R. (2013). *Teachers' Professional Development in Context-based Chemistry Education. Strategies to Support Teachers in Developing Domain-specific Expertise.*
77. Mil, M.H.W. van (2013). *Learning and teaching the molecular basis of life.*
76. Antwi, V. (2013). *Interactive teaching of mechanics in a Ghanaian university context.*
75. Smit, J. (2013). *Scaffolding language in multilingual mathematics classrooms.*
74. Stolk, M. J. (2013). *Empowering chemistry teachers for context-based education. Towards a framework for design and evaluation of a teacher professional development programme in curriculum innovations.*
73. Agung, S. (2013). *Facilitating professional development of Madrasah chemistry teachers. Analysis of its establishment in the decentralized educational system of Indonesia.*
72. Wierdsma, M. (2012). *Recontextualising cellular respiration.*
71. Peltenburg, M. (2012). *Mathematical potential of special education students.*
70. Moolenbroek, A. van (2012). *Be aware of behaviour. Learning and teaching behavioural biology in secondary education.*
69. Prins, G. T., Vos, M. A. J., & Pilot, A. (2011). *Leerlingpercepties van onderzoek & ontwerpen in het technasium.*
68. Bokhove, Chr. (2011). *Use of ICT for acquiring, practicing and assessing algebraic expertise.*
67. Boerwinkel, D. J., & Waarlo, A. J. (2011). *Genomics education for decision-making. Proceedings of the second invitational workshop on genomics education, 2-3 December 2010.*
66. Kolovou, A. (2011). *Mathematical problem solving in primary school.*
65. Meijer, M. R. (2011). *Macro-meso-micro thinking with structure-property relations for chemistry. An explorative design-based study.*
64. Kortland, J., & Klaassen, C. J. W. M. (2010). *Designing theory-based teaching-learning sequences for science. Proceedings of the symposium in honour of Piet Lijnse at the time of his retirement as professor of Physics Didactics at Utrecht University.*

63. Prins, G. T. (2010). *Teaching and learning of modelling in chemistry education. Authentic practices as contexts for learning.*
62. Boerwinkel, D. J., & Waarlo, A. J. (2010). *Rethinking science curricula in the genomics era. Proceedings of an invitational workshop.*
61. Ormel, B. J. B. (2010). *Het natuurwetenschappelijk modelleren van dynamische systemen. Naar een didactiek voor het voortgezet onderwijs.*
60. Hammann, M., Waarlo, A. J., & Boersma, K. Th. (Eds.) (2010). *The nature of research in biological education: Old and new perspectives on theoretical and methodological issues – A selection of papers presented at the VIIth Conference of European Researchers in Didactics of Biology.*
59. Van Nes, F. (2009). *Young children's spatial structuring ability and emerging number sense.*
58. Engelbarts, M. (2009). *Op weg naar een didactiek voor natuurkunde-experimenten op afstand. Ontwerp en evaluatie van een via internet uitvoerbaar experiment voor leerlingen uit het voortgezet onderwijs.*
57. Buijs, K. (2008). *Leren vermenigvuldigen met meercijferige getallen.*
56. Westra, R. H. V. (2008). *Learning and teaching ecosystem behaviour in secondary education: Systems thinking and modelling in authentic practices.*
55. Hovinga, D. (2007). *Ont-dekken en toe-dekken: Leren over de veelvormige relatie van mensen met natuur in NME-leertrajecten duurzame ontwikkeling.*
54. Westra, A. S. (2006). *A new approach to teaching and learning mechanics.*
53. Van Berkel, B. (2005). *The structure of school chemistry: A quest for conditions for escape.*
52. Westbroek, H. B. (2005). *Characteristics of meaningful chemistry education: The case of water quality.*
51. Doorman, L. M. (2005). *Modelling motion: from trace graphs to instantaneous change.*
50. Bakker, A. (2004). *Design research in statistics education: on symbolizing and computer tools.*
49. Verhoeff, R. P. (2003). *Towards systems thinking in cell biology education.*
48. Drijvers, P. (2003). *Learning algebra in a computer algebra environment. Design research on the understanding of the concept of parameter.*
47. Van den Boer, C. (2003). *Een zoektocht naar verklaringen voor achterblijvende prestaties van allochtone leerlingen in het wiskundeonderwijs.*
46. Boerwinkel, D. J. (2003). *Het vormfunctieperspectief als leerdoel van natuuronderwijs. Leren kijken door de ontwerpersbril.*
45. Keijzer, R. (2003). *Teaching formal mathematics in primary education. Fraction learning as mathematising process.*

44. Smits, Th. J. M. (2003). *Werken aan kwaliteitsverbetering van leerlingonderzoek: Een studie naar de ontwikkeling en het resultaat van een scholing voor docenten.*
43. Knippels, M. C. P. J. (2002). *Coping with the abstract and complex nature of genetics in biology education – The yo-yo learning and teaching strategy.*
42. Dressler, M. (2002). *Education in Israel on collaborative management of shared water resources.*
41. Van Amerom, B.A. (2002). *Reinvention of early algebra: Developmental research on the transition from arithmetic to algebra.*
40. Van Groenestijn, M. (2002). *A gateway to numeracy. A study of numeracy in adult basic education.*
39. Menne, J. J. M. (2001). *Met sprongen vooruit: een productief oefenprogramma voor zwakke rekenaars in het getallengebied tot 100 – een onderwijsexperiment.*
38. De Jong, O., Savelsbergh, E.R., & Alblas, A. (2001). *Teaching for scientific literacy: context, competency, and curriculum.*
37. Kortland, J. (2001). *A problem-posing approach to teaching decision making about the waste issue.*
36. Lijmbach, S., Broens, M., & Hovinga, D. (2000). *Duurzaamheid als leergebied; conceptuele analyse en educatieve uitwerking.*
35. Margadant-van Arcken, M., & Van den Berg, C. (2000). *Natuur in pluralistisch perspectief – Theoretisch kader en voorbeeldlesmateriaal voor het omgaan met een veelheid aan natuurbeelden.*
34. Janssen, F. J. J. M. (1999). *Ontwerpend leren in het biologieonderwijs. Uitgewerkt en beproefd voor immunologie in het voortgezet onderwijs.*
33. De Moor, E. W. A. (1999). *Van vormleer naar realistische meetkunde – Een historisch-didactisch onderzoek van het meetkundeonderwijs aan kinderen van vier tot veertien jaar in Nederland gedurende de negentiende en twintigste eeuw.*
32. Van den Heuvel-Panhuizen, M., & Vermeer, H. J. (1999). *Verschillen tussen meisjes en jongens bij het vak rekenen-wiskunde op de basisschool – Eindrapport MOOJ-onderzoek.*
31. Beeftink, C. (2000). *Met het oog op integratie – Een studie over integratie van leerstof uit de natuurwetenschappelijke vakken in de tweede fase van het voortgezet onderwijs.*
30. Vollebregt, M. J. (1998). *A problem posing approach to teaching an initial particle model.*
29. Klein, A. S. (1998). *Flexibilization of mental arithmeticsstrategies on a different knowledge base – The empty number line in a realistic versus gradual program design.*

28. Genseberger, R. (1997). *Interessegeoriënteerd natuur- en scheikundeonderwijs – Een studie naar onderwijsontwikkeling op de Open Schoolgemeenschap Bijlmer.*
27. Kaper, W. H. (1997). *Thermodynamica leren onderwijzen.*
26. Gravemeijer, K. (1997). *The role of context and models in the development of mathematical strategies and procedures.*
25. Acampo, J. J. C. (1997). *Teaching electrochemical cells – A study on teachers' conceptions and teaching problems in secondary education.*
24. Reygel, P. C. F. (1997). *Het thema 'reproductie' in het schoolvak biologie.*
23. Roebertsen, H. (1996). *Integratie en toepassing van biologische kennis – Ontwikkeling en onderzoek van een curriculum rond het thema 'Lichaamsprocessen en Vergift'.*
22. Lijnse, P. L., & Wubbels, T. (1996). *Over natuurkundedidactiek, curriculumontwikkeling en lerarenopleiding.*
21. Buddingh', J. (1997). *Regulatie en homeostase als onderwijsthema: een biologie-didactisch onderzoek.*
20. Van Hoeve-Brouwer G. M. (1996). *Teaching structures in chemistry – An educational structure for chemical bonding.*
19. Van den Heuvel-Panhuizen, M. (1996). *Assessment and realistic mathematics education.*
18. Klaassen, C. W. J. M. (1995). *A problem-posing approach to teaching the topic of radioactivity.*
17. De Jong, O., Van Roon, P. H., & De Vos, W. (1995). *Perspectives on research in chemical education.*
16. Van Keulen, H. (1995). *Making sense – Simulation-of-research in organic chemistry education.*
15. Doorman, L. M., Drijvers, P. & Kindt, M. (1994). *De grafische rekenmachine in het wiskundeonderwijs.*
14. Gravemeijer, K. (1994). *Realistic mathematics education.*
13. Lijnse, P. L. (Ed.) (1993). *European research in science education.*
12. Zuidema, J., & Van der Gaag, L. (1993). *De volgende opgave van de computer.*
11. Gravemeijer, K., Van den Heuvel-Panhuizen, M., Van Donselaar, G., Ruesink, N., Streefland, L., Vermeulen, W., Te Woerd, E., & Van der Ploeg, D. (1993). *Methoden in het reken-wiskundeonderwijs, een rijke context voor vergelijkend onderzoek.*
10. Van der Valk, A. E. (1992). *Ontwikkeling in Energieonderwijs.*
9. Streefland, L. (Ed.) (1991). *Realistic mathematics education in primary schools.*
8. Van Galen, F., Dolk, M., Feijs, E., & Jonker, V. (1991). *Interactieve video in de nascholing reken-wiskunde.*

7. Elzenga, H. E. (1991). *Kwaliteit van kwantiteit.*
6. Lijnse, P. L., Licht, P., De Vos, W., & Waarlo, A. J. (Eds.) (1990). *Relating macroscopic phenomena to microscopic particles: a central problem in secondary science education.*
5. Van Driel, J. H. (1990). *Betrokken bij evenwicht.*
4. Vogelezang, M. J. (1990). *Een onverdeelbare eenheid.*
3. Wierstra, R. F. A. (1990). *Natuurkunde-onderwijs tussen leefwereld en vakstructuur.*
2. Eijkelhof, H. M. C. (1990). *Radiation and risk in physics education.*
1. Lijnse, P. L., & De Vos, W. (Eds.) (1990). *Didactiek in perspectief.*