MOST

ICSE
International Centre for STEM Education

Conference Book

EDUCATING THE EDUCATORS

ETE IV conference on STEM & Open Schooling for Sustainability Education

11–12 May 2023
Naturalis, Leiden, Netherlands

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ELWIeR
Utrecht University
Naturalis Biodiversity Center

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Contents

Preface

Dear conference guests,

Our current society faces enormous environmental challenges. Now is the time to stand up for a sustainable future. This request for action also concerns our STEM education community to take the transformational potential of teaching and learning. We need to share good practices, research results and innovative classroom materials that allow for implementing approaches that support the implementation and scaling up of education for sustainability. These actions are broad in scope and attend not only to the practices of teachers, teacher educators and researchers, but also involves other important stakeholders including school principals, policy makers and the students themselves. Moreover, these actions require and appreciate the capillarity of educational institutions and their communities, and require collaboration and commitments that ensure educational opportunities and the joint responsibilities.

Against this background, the **fourth international Educating the Educators (ETE IV) conference** specifically devoted to the topic of **STEM & Open Schooling for Sustainability Education**. At the conference we welcome teachers, teacher educators, policy makers, and various other stakeholders related to STEM education.

The conference is **hosted by Naturalis Leiden and Utrecht University in collaboration with the International Centre for STEM education (ICSE, www.icse.eu) and the project MOST** (Meaningful Open Schooling connects Schools To Communities (www.icse.eu/most)). The project MOST has received funding from the European Union's Horizon 2020 research and innovations programme under grant agreement No 871155.

ETE IV will focus on implementing and scaling up innovative teaching approaches in STEM education and in particular on open schooling initiatives with respect to environmental issues. Experiences and results gained from the MOST project (2020-2023) and other Open Schooling projects will be presented and reflected upon. The aim is to discuss different approaches with a rich variety of participants on three dimensions. The personal dimension refers to the roles and pedagogies involved in teacher education. The materials dimension refers to the resources needed for supporting these pedagogies and specific ways of working. The structural dimension refers to the structures needed for implementing and sustaining innovative approaches to STEM education.

As the Conference Chairs, we would like to thank the countless people, in particular the MOST project partners, the members of the scientific and local organizing committees, and all colleagues who have helped in planning and realizing this conference and who have contributed their wit, energy, commitment and time to make it the successful conference experience.

We wish you interesting insights and fruitful exchanges. Thank you very much for attending the conference.

Kind regards

The Conference Chairs: Michiel Doorman & Katja Maass

Location and conditions

Location:

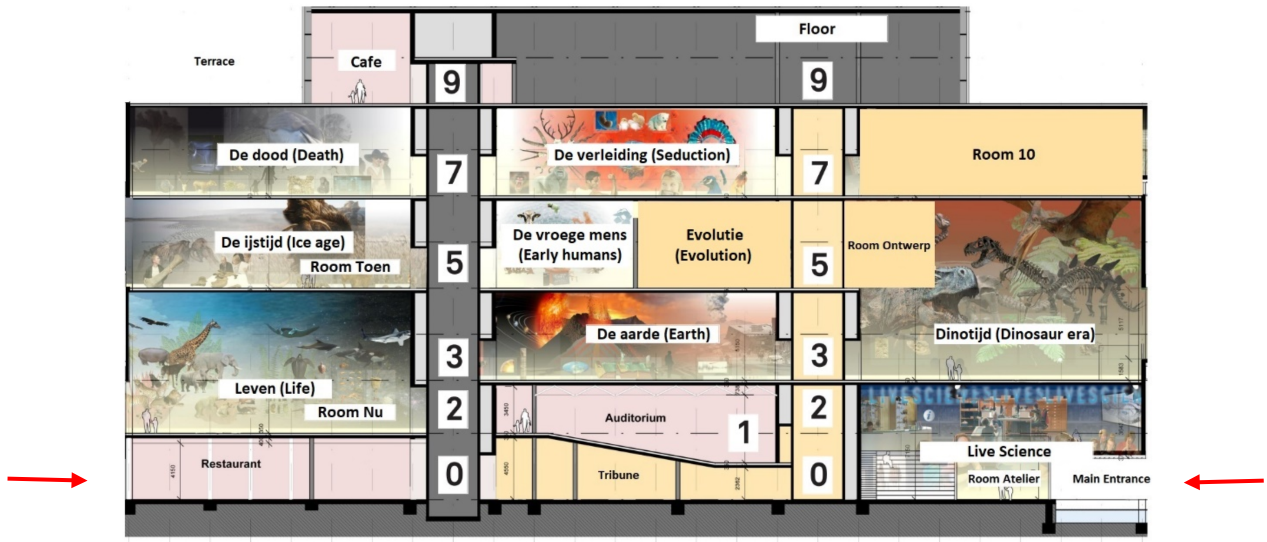
Naturalis
Darwinweg 2, 2333 CR Leiden, Nederland.

The building

The conference will be held at Naturalis museum Leiden, Netherlands. Due to the specialized laboratories in the museum it is strictly forbidden to bring any organic materials into the museum.

The architecture is inspired by natural shapes: honeycomb, cat's eyes or do you see leaves? In a sea of light, coming from every angle, all functional areas of the building come together in the atrium; collection, research and the museum. This is also the place where our staff, scientists, families and students meet. The building provides room for our growing collection and increasing numbers of visitors and scientists.
With her pattern of three-dimensional relief sculptures, the internationally renowned Dutch fashion designer Iris van Herpen has contributed a remarkable sensation of space to the natural stone facade. Inspired by evolution and the shapes it brings about, she designed 263 panels that cover a total distance of more than a kilometer, spread across both the inside and the outside of the museum. Thanks to a new technique developed specifically for this design, the concrete shapes suggest a feeling of silky smoothness. They appear to be made of fabric, just like the innovative couture created by Van Herpen for celebrities such as Lady Gaga, Beyoncé and Björk.

Site map



Red arrows show entrances of the museum (on the right is main entrance in the direction of the train station). The rooms being used for our conference are Atelier, Tribune and Live Science (on the ground floor), the Auditorium, Nu, Toen, Ontwerp and Room 10. You will need some time for finding these rooms in the museum. Guidelines will be available, but please start moving for your location at least five minutes before the start of your session.

There will be laptops available in the rooms, the presenters only have to bring an USB-stick with their presentation.

Practical information

Leiden is easy to reach with international trains. If travelling to the conference by plane, nearby airports are Amsterdam Schiphol Airport and Rotterdam The Hague Airport. Information about public transport (tickets & schedule) can be found at www.ns.nl. From Amsterdam Schiphol Airport there is a direct train connection from the airport, it takes about 10 min to Leiden. From Rotterdam The Hague Airport it takes about 1 hour with public transport.

The conference board will try to arrange a contingent of reserved rooms at hotels in Leiden for participants. When successful, we will provide a list of hotels with such contingents at the time of the registration deadline on the conference website https://icse.eu/educating-the-educators/. Please note: participants are responsible for making and paying for their own travel and accommodation arrangements.

You must register to attend the conference. The registration form is available on the conference website https://icse.eu/educating-the-educators/. Deadline for registration is **April 24, 2023**.

The schedule including times and locations can be found in this conference book and ***in the app****. There might be last minute changes in the schedule, these changes will be announced in the app. In case of contradicting times or locations, always follow the app.*

General terms and conditions

Photographic and video material of participants will be taken at the conference. By registering for the conference all participants acknowledge that the organizers may use images including participants for publications like press releases, internet web pages, social media and other promotional activities. The participants also agree to the processing of personal data (as indicated during the registration process) for any purpose that is directly connected with their attendance. Vice-versa, personal data will be used solely in connection to the organization and implementation of the conference and will not be dispatched to any third party not involved in the organisation of the conference. All registered persons (participants) agree to being included in announcements for future Educating the Educators conferences (all participants have the right to withdraw from this agreement at any point in time).

Time schedule

The time schedule for the conference can be found on https://icse.eu/educating-the-educators/ .
At the conference we will use the app Let's Get Digital to communicate the schedule with participants, to allow them to sign up for parallel sessions and to create a personal program. Most recent changes will be updated in the app. This conference book also includes scheduling times, but *please consult the app for the most up-to-date times*. And plan your personal program in the App by registering for workshops and/or paper presentations.

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Keynotes

Keynote 1: Learning our way out of systemic global dysfunction: rethinking STEM education in the Capitalocene

Arjen Wals Wageningen University, The Netherlands
Thursday, 11 May 2023, 10:00-10:45, Auditorium

Abstract

Our planet is in crisis. Interrelated global challenges like; runaway climate change, mass extinction, extreme wealth inequality and global pandemics, are affecting billions of people across the globe as well as other species. Many people, especially young people, worry about the future that lies ahead. This existential threat poses questions about the role of education. Can we learn our way out of this crisis?

Innovation and education go hand in hand. But what if innovation lacks a moral compass and unwillingly accelerates unsustainability by damaging social foundations and ignoring planetary boundaries? Are our schools developing the qualities and competencies humanity needs to be able live more lightly, equitably and healthily on the planet or have they become an extension of the globalizing economy and the world of unbridled consumerism? What are those qualities and competencies? How can schools develop them? What is the role for STEM and Open Schooling? In this keynote I hope to provide some answers using the perspective of a Whole School Approach to realizing quality education that is relevant, responsible, re-imaginative and hopeful in light of urgent global challenges.

Biography

Arjen Wals is a professor of Transformative Learning for Social-Ecological Sustainability and UNESCO Chair in the field of Learning for Sustainability. Wals' expertise lies in designing, monitoring, and evaluating learning processes and environments that actively engage citizens – from young to old – in sustainability issues related to, for example, climate, biodiversity, waste, food security, and energy. In his teaching and research, he also focuses on sustainability competencies such as system thinking, dealing with confusion and insecurity, harnessing diversity, envisioning alternative futures, and bridging the gap between thinking and doing.

Keynote 2: School-community Projects as Keys to Sustainability Education in the STEM Domains MOST

Marta Romero Ariza Most Project & University of Jaén, Spain
Katja Maaß Most Project & University of Education Freiburg, Germany
Thursday, 11 May 2023, 13:30-14:15, Auditorium

Abstract

What if STEM and sustainability education are far away from seeding the sense of ownership and empowerment people need to fully engage in the creation of a better world? What if we are not hearing important voices? What if we are not giving room for shared inspiration and creativity? What if are failing in really engaging people (from the youngest to the oldest) and losing capacity and talent in our societies? Are our schools actually triggering fundamental values, knowledge, capacities and commitment to face current environmental and societal issues?
The MOST project is a H2020-funded European project involving 23 institutions of 10 different countries. It builds networks of open schools that share motivations and exchange best practices and strategies to address the previous questions, while promoting more meaningful and transformative STEM and sustainability education. A key element in the MOST approach is the development of School Community Projects (SCP). SCP arise from students' concerns and communities' needs and actively engage different stakeholders in the

solution of local problems with global implications. During the process, students have the opportunity to meaningful apply science and mathematics to co-create sustainable solutions, improving life in their schools, families and communities.
After the presentation of some inspiring cases and illustrative examples of SCP developed in different contexts, within the MOST project, we will analyse the implications of this approach for teaching, research and policy in STEM and sustainability education and for the society as a whole.

Biography

Marta Romero Ariza is an Associate Professor at the Department of Didactics of Sciences in the University of Jaén, especially interested in research about sustainable development, education and how to enhance science learning through the use of innovative approaches and technological resources. She has been actively engaged in several international projects such as COMPASS, PRIMAS, mascil and PARRISE among others, in the latter, as the leader of the Spanish team.

Katja Maass is a researcher, educator and leader of international projects in mathematics and science education. She is professor at the University of Education Freiburg and director of the International Centre for STEM education (ICSE). Her main professional interests are modelling and applications and inquiry-based science teaching. Next to teaching and research in these fields, her work is characterised by a strong practical and melioristic concern towards advancing mathematics and science teaching. Maass has successfully coordinated numerous large-scale European projects to foster innovation in STEM education. Her work is distinguished by both a local and international orientation and she relies on excellent networks to research, policy and practice.

Keynote 3: Panel Discussion: How do we envision education-oriented communities to stand-up for sustainability?

Jesper Boesen Jönköping University, Sweden – moderator
Rivka Meelis FridaysForFuture, Netherlands – student
Yolanda Garrido School Alfredo Cazabán, Spain – teacher
Caroline Lewis-Jones Birralee International School, Norway – school leader
José María Sanchís Conselleria d'Educacio de Valencia, Spain – policy maker
Jiří Kulich The Rýchory Centre of Environmental Education and Ethics, Czech Republic – NGO
Harold Brockbernd Extinction Rebellion & Stedelijk Gymnasium Hilversum, Netherlands – teacher
Friday, 12 May 2023, 11:30-12:30, Auditorium

Abstract

Socio-scientific issues are complex and controversial, and require bridges between different communities, engaging different agents and processes of co-creation. With this panel discussion we will, in the spirit of school-community projects, try to bridge policy and practice initiatives with the aim to create an inspiring atmosphere around experiences with and images of sustainability education. The leading question for the discussion is: How do we envision education-oriented communities to stand up for sustainability? With contributions from the panelists we will illustrate the complexity and interdisciplinary aspects of environmental issues, such as climate change, energy transition and waste reduction. From various perspectives will be reflected on these issues. In particular we will focus on the role of education to better prepare our students and to have schools become active agents for sustainability in their communities. The audience will be involved to think with us about the opportunities in the current situation, possible first collaborative steps, and what is needed in the near future to empower people and build solutions together.

Workshops

MOST policy seminar – Opening up school education: Ways to support schools on their path to institutional change MOST

Thursday, 11 May 2023, 11:00-12:15, Auditorium

To meet the global challenges of our time, we need citizens who are used to thinking in an interdisciplinary and solution-oriented way, who have the courage to act and take responsibility. To this end, we need concepts and educators in STEM subjects that more closely align research, innovation, and practices in science education with the needs and ambitions of society and reflect its values. Education is the key to societal change. A promising approach for a high-performing school of the future is to open up school education and let society learn with and from each other.
In the EU funded MOST project, schools were supported to open the doors of their classrooms to work on projects in real-life contexts in collaboration with community members. In these participatory projects, participants tackled an environmental challenge relevant to their community and brought their respective expertise to the problem-solving process. Here, the schools get involved in the community, the participants experience themselves as self-effective and learn to deal with different perspectives.
Although educational systems constantly must face societal changes, they often seem to be less flexible, when it comes to spontaneously adapting to these changes. Therefore, it is desirable to establish a particular space within the curriculum or timetable to provide opportunities to open up schools. In doing so, open schooling can become a driving force of institutional change.
In order to discuss what teachers need to integrate participatory projects such as Open Schooling activities into the classroom on a regular basis, the MOST project invites decision-makers in education at regional, national and international level, representatives of education networks as well as teachers and school headmasters to this policy seminar. The main objectives of this event are:

→ To highlight the importance of opening up school education and to present examples of good practice.

→ To discuss and reflect how this promising approach can be integrated in the day-to-day teaching.

→ To discuss what schools and their teachers need to initiate institutional change and transform into an open school.

Introduction speeches will be held by Agueda Gras-Velazquez from the European Schoolnet (EUN), Tobias Feitkenhauer from the initiative “Schule im Aufbruch (school on the move),” Germany and Antonio Quesada from the MOST project, University of Jaén, Spain. We look forward to a lively exchange in the subsequent world café with representatives from policy and research from across Europe as well as with members of the European Open Schooling network.

Sustainability Education Movement for network leaders with the CARE–KNOW–DO Open Schooling Framework

Okada, Alexandra Open University, UK
Gray, Peter Norwegian University of Science and Technology, Norway
Thursday, 11 May 2023, 11:00-12:00, Toen

1. Introduction

The rapid growth in demand for green jobs and green skills is evidence of growing demand in the wider economy (Deloitte, 2021). Secondary education is currently considered as the most important enabler for the green skills agenda including green life, health, and wellbeing over the next five to ten years. We argue that Sustainability Education has a key role in preparing students to identify, analyse and solve problems that affect life on the planet for this and subsequent generations. Educators must prepare students as co-learners and co-researchers to anticipate risks that threaten sustainability, or more accurately survival (McDonnell et al, 2020).

Educators, practitioners, policymakers, and network leaders should therefore design interventions that maximise diversity, inclusion, and equity, to promote green competences. Underpinned by the literature (Wiek et. al., 2016; European Commission, 2020; Bianchi, 2020; Okada & Gray, 2022), we define 'green competence' as the ability to take 'care' of the planet, to 'know' what to 'do', how, and whom to obtain support for responding to the social, economic, and natural environment responsibly and sustainably considering the interdependent effects of climate change and other factors that affect life on Earth.

2. CARE-KNOW-DO principles

CARE –KNOW–DO is an open schooling framework for making science more meaningful, engaging, and relevant for students to develop knowledge, skills, and attitude with enjoyment (Okada & Sherborne, 2018; Okada, 2022). It supports real-life problem solving with socio-scientific issues by situating the curriculum content within three integrated phases:

- CARE: refers to students' engagement with real-life problems that matter and motivate them to learn.
- KNOW: refers to students' acquisition of knowledge to understand the problem and discuss solutions.
- DO: refers to students' performance of a science action to develop skills and solve problems using the knowledge learned.

Here, we propose that the framework can provide a foundation for a new education movement to expand the close cooperation between universities, schools, community members and science enterprises for the joint development of actions for the Agenda 2030.

We-CARE: The first stage is mainly informal learning with professionals and family, designed to introduce the challenge around a future-orientated issue, stimulate questions and create a 'need to know' that teachers can harness in the next stage.

We-KNOW: The second stage is formal learning focused on students acquiring the scientific understanding and skills they need to make decisions and take action in the final stage,

We-DO: In this stage, students apply the acquired skills and knowledge to participatory science actions, defining ways to approach the given challenge and minimise its impact.

3. Methodology

Initially we will invite participants to join our CONNECT platform (https://connect-eu.exus.co.uk/groups/icse). Then, we will introduce the CARE-KNOW-DO framework used by the CONNECT networks in Europe and Brazil to design curriculum resources, fun participatory methods, and self-reflective tools (Okada, 2022; Okada & Matta, 2022) with open badges and personalised feedback (https://7a0a0732.flowpaper.com/ccse) .

We will showcase practices (https://www.connect-science.net/best-practices/) supported by teachers, experts, and families for students who became:

1 Campaign leaders to reintroduce species back to ecosystems

2 Teenage activists to reduce microplastic pollution

3 Young entrepreneurs to design energy savers devices with AI https://chat.openai.com/chat

4 Carbon consultants to advice cafes about carbon neutrality.

Participants will think about a Sustainability Education networks for "green and digital transition that connect a variety of actors, artefacts, and actions to empower young people.

We will discuss about results and recommendations related to science capital and affective engagement from data generated by hundreds of teachers and thousands of disadvantaged students from different educational levels.

Finally, participants will map key questions, new ideas and their own practices (https://padlet.com/alexandraokada/SE) supported by the CARE-KNOW-DO toolkit to expand the Sustainability Education movement.

Acknowledgements
This study is funded by The Open University UK and also by CONNECT - inclusive open schooling with engaging and future oriented science, funded by the European Union n. 872814.

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Roles, Practices and Competencies of STEM-Teacher Educators

Rotschnig, Sarah-Maria University Klagenfurt, Austria
Zehetmeier, Stefan University Klagenfurt, Austria
Thursday, 11 May 2023, 11:00-12:00, Nu

1. Relevance of the Topic concerning the Overall Conference Theme
The focus of the conference is on Educating the Educators. This theme includes professionalisation aspects that relate to different dimensions. On the one hand, current research in this area focuses on the roles of teacher educators; on the other hand, questions about the quality of professional development approaches and also the professional identity of teacher educators are in the spotlight.
A lot is already known about the design criteria for effective teacher education (Lipowsky & Rzejak: 2021). Comparatively less is known about the competencies and practices of teacher educators. The demands in this professional field are high, which makes it worthwhile to take a closer look at how teacher educators act.
In particular, we refer to the following question "Which roles and ways of working have to be considered in the professional development courses for PD course leaders and facilitators in professional learning?" (Call for Papers: p. 3)

2. Content in a Nutshell

"Teacher educators are all those who actively facilitate the (formal) learning of student teachers and teachers", states an article by the European Commission (2013: p. 8). This quote makes clear that teacher educators are active in both initial and in-service teacher education and play essential roles in this regard (European Commission: 2013).

Teacher educators have a central function in the educational system which, despite its importance, has long been neglected by scholars. Some authors, therefore, refer to this profession as a "hidden profession" (Livingston: 2014; Meeus et al.: 2018).

In the last 30 years, international research has begun to focus increasingly on teacher educators. The term "teacher educator" encompasses an extremely heterogeneous professional group (Schrittesser: 2020). Teacher educators can be university lecturers, researchers, school teachers, mentors, supervisors, and school administrators (Schrittesser: 2020).

A relevant reference point in this field is the literature review by Lunenberg and colleagues (2014). The authors shed light on the professional actions of teacher educators in different roles. In particular, they emphasize: "Hence, if we wish to take the profession of teacher educator seriously, this situation asks for a solid analysis and synthesis of what is known in this field". (Lunenberg et al., 2014: p. 1)

Lunenberg and colleagues capture the knowledge and skills of teacher educators in six different roles: "teacher of teachers", "researcher", "coach", "curriculum developer", "gatekeeper", and "broker" (Lunenberg et al.: 2014). Each role emphasizes a different focus in the work of a teacher educator and is associated with differentiated tasks, demands, and actions.

Our contribution will focus on the role "teacher of teachers".

Essential for this role are the corresponding subject-specific, subject-didactic and pedagogical expertise (Shulman: 1986) in this field of action.

The role “teacher of teachers” is central not only to prepare teaching content in an appealing way, but also to express principles and theories based on it (Lunenberg et al.: 2014). For example, knowledge about adult-oriented teaching and learning settings, self-regulated learning, or dealing with various challenges that may arise during work.

In this context, a research gap is identified, which we want to address and discuss in order to “map the terrain” and to obtain diverse perspectives on it:

“The work as a teacher educator requires a variety of competencies, such as subject knowledge, subject didactic and pedagogical competencies or counselling competencies. The higher education didactic and adult education skills of teacher educators must be systematically enhanced. Research on and evaluation of competencies and practices of teacher educators in pre-service education as well as in continuing education are a valuable research desideratum, especially in connection with the impact and transfer [...]” (Müller et al., 2019: p. 131f.)

2. Aims and Methods of our Co-design space

The aims of our co-design space are to offer a critical forum for discussion, to enable active networking and exchange between participants, to identify relevant topics for future research, and to look for and initiate possible ways of cooperation.

At the beginning of the session, we will give a short impulse by referring to a conceptual model of the “International Forum for Teacher Educator Development” (InFoTED). This model (Vanassche et al.: 2021) focuses on professionalisation aspects in this professional field and provides a suitable introduction to our topic.

Afterwards, we will work together with the participants on the following questions:

- What competencies and practices do STEM teacher educators need for the professional development of teachers?
- What is known about the competencies and practices of STEM teacher educators in the role of "teacher of teachers" in the participants’ countries?
- What complexity must be considered in the role of "teacher of teachers"? (Second-order teaching, adult learners as target group, etc.)

- How to prepare STEM teacher educators and how to design professional development for them?
- Which theoretical and conceptual frameworks could be used as lenses to research the role of STEM teacher educators?
- Which questions could/should be addressed by research in the future?

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Minecraft: Education Edition as a tool for PBL in STEM

Roumpas, Konstantinos Physicist BSc & Minecraft Education Developer, ATERMON B.V Rotterdam, The Netherlands

Gkogkas, Grigorios Health Visitor BSc & Minecraft Education Developer, ATERMON B.V Rotterdam, The Netherlands

Thursday, 11 May 2023, 11:00-12:00, Ontwerp

1. Introduction

Minecraft: Education Edition (M:EE) is an educational tool based on the engine of the popular sand-box game: Minecraft. As the pandemic created new needs for digital learning, and game-based learning is an admittedly under-developed field, this of course raises the question of how effective M:EE is in the classroom as a platform. We aim to focus more on STEM subjects, as there are more resources dedicated to them and M:EE has already created tools with STEM education in mind. The approach that we will have will involve pedagogical methods like Project Based Learning, Game Based Learning and experiential models.

For the purposes of this proposal, the definition of STEM Project Based learning is: An ill-defined task with a well-defined outcome situated within a contextually rich task requiring students to solve several problems, which when considered in their entirety, showcase student mastery of several concepts of various STEM subjects. PBL here is the use of a project that offer results in the emergence of various learning outcomes in addition to the ones anticipated. The learning is dynamic as students use various processes and methods to explore the project. The project is generally information rich, but directions are kept to a minimum. The richness of the information is often directly related to the quality of the learning and level of student engagement. The information is often multifaceted and includes background information, graphs, pictures, specifications, generalized and specific outcome expectations, narrative, and in many cases the formative and summative expectations. (Capraro, Slough, 2013).

This proposal intends to summarize the progress that PBL has had in STEM and how Minecraft: Education Edition as a tool can be used to highlight this method, from the point of view of the educators as well as the developers physically constructing the courses. It relates to the Material Dimension of the conference, in the sense that we presenting a powerful tool fit to enhance the quality of mathematics and science teaching. This is a study of the tool itself, and on the role that it can play on the students. The participants on this workshop will get to try multiple courses of M:EE designed by us, and they will indulge in different kinds of learning methods (ie singe-player, multi-player, with/without aid from the teacher, etc).

2. PBL/ GBL integrations with STEM

The focus of STEM subjects specifically with PBL stems from the fact that project ideas can be produced organically. It is easy and clear to identify the learning goals, while the teacher develops expectations for the authentic task to be completed or the artifact to be constructed along with the necessary constraints to establish boundaries for the learning. The constraints are often included in the design brief and are the most basic requirements that are considered essential. Therefore, not meeting the constraints would indicate an inadmissible attempt. The design brief contains both the constraints and the criteria informed by knowing exactly which objectives or standards students will be expected to master. The criteria are measurable. These criteria help students know how they are progressing on the tasks and it is these criteria that inform assessment. In fact, this is the criteria that form the basis of all assessments used through the PBL.

A subcategory of PBL is GBL (Game-Based Learning), where it is easier to make the connections with M:EE, therefore it would make more sense if we started introducing GBL specific methods. Game-based learning refers to the borrowing of certain gaming principles and applying them to real-life settings to engage users (Trybus, 2015).

Games have been used in education ever since computers became easily available for families. Availability came together with parental approval, thus creating an ongoing competitive market of educational games, which gives us a lot of material to study and compare to Minecraft: Education Edition. However, the educational games industry quickly fell off, since at the same time commercial and high-quality entertainment games rose in popularity. Despite that, games are now being revisited as educational tools by several leading organizations, such as MIT's Education Arcade and Games-to-Teach project, Woodrow Wilson Foundations' Serious Games Initiative, University of Wisconsin's Games Learning Society, the Federation of American Scientists, the Bill and Melinda Gates Foundation, and the U.S. Department of Education. (Rapini 2012).

Where digital games are more effective than the traditional lesson is their ability to keep the user engaged and motivated. This gives the student an experience through a different angle, which could also interest them to motivate the subject after the lesson, for more effective game strategy making (Squire 2011).

As it has been highlighted in the PBL section, STEM education is very limited when it is not experienced. Similar to laboratory courses, games can be developed in a way where they let students make their own experiments and hypotheses without a strict or set direction. Getting the student in a simulated environment, where they get to experience the applications of a mathematical formula in the appropriate context, creates a better structured course, in relation to a traditional one. Another edge of digital game education is the instant feedback that students receive. A player who makes a lot of mistakes is forced to adapt and end up adjusting their way of thinking into the one that will help them combat the problems at hand.

Another issue of game-based learning is that generally, harder subjects are more difficult to incorporate inside a game, and games tend to be easy in difficulty in order to not restrain any students (Chang 2009). However, Minecraft: Education Edition, is designed to provide an immersive personalized experience to each student. According to multiple internet blogs, children as young as 3 years old can start playing Minecraft, therefore the environment is easy for students to get used to, if they aren't already familiar with it. This generally surpasses a lot of problems that educational games have had in the past, as it approaches game-based learning from the point of view of the game, and not the classroom.

3. Minecraft in the classroom

The goal of integrating Minecraft and its various tools in the classroom, is to give it its own section, in order to fit organically to the syllabus, without taking the place of other practices that this tool cannot replace, like reflection and thinking. Similar to experiential models, Minecraft aims to be the tool that will help the students contextualize their newly earned knowledge. This in particular fits in well with PBL models, as the production of the project result itself carries the student through the process of contextualizing information. (M. Pusey, G. Pusey, 2015)

It is shown that the use of Minecraft: Education Edition in classes can be highly engaging for students. Moreover, the interest that students had in science seems to have increased after experiencing the M:EE course. The only issues that seem to have appeared each time are technical, which Microsoft is currently working on and is constantly providing new tools for the better moderation of the class, as it can be seen in the next paragraph.

Integrating the Minecraft: Education Edition platform provides the teachers with an easy-to-use tool that already provides the boundaries that they can alter even at will. The class can be well monitored with the use of the "Classroom Mode" tool, where the educator can moderate the chat and the abilities of each player.

There is also an active community hub of IT experts and educators who use Minecraft: Education Edition. Also, there are courses and resources for educators that will help them have a better grasp on the software.

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Nature-based School Yard Safari

Joven, Marian University of Applied Sciences Leiden, The Netherlands

Ottenheim, Mart University of Applied Sciences Leiden, The Netherlands

Thursday, 11 May 2023, 11:00-12:30, Outdoor (meet-up at the main entrance)

→ This workshop takes 90 minutes instead of 60 minutes

Relation with overall theme

The world is at the beginning of a 'decade of transformation' in which we strive to achieve the Sustainable Development Goals (SDG) as proposed by UNESCO (2022). Education plays a key role in this process. For several years now, the Whole School Approach (WSA) to sustainable development has been recommended internationally (WUR, 2022). This approach, as endorsed by the key note speaker Arjen Wals, calls for innovation at all levels of education. The Center of Expertise for Professionalization through Educational Pedagogic Practical Research (POP in Dutch acronym) of the University of Applied Sciences Leiden is conducting a number of research projects and offers courses to support professionals in their endeavours to teach in a sustainable practice. The Center of Expertise POP consists of three groups, two of which focus on the theme of sustainability. The research group Child Development and Nature aims at nature-inclusive education and the research group Values of Waldorf education focuses on child development from a democratic, sustainable and holistic perspective. The Center of Expertise POP offers students Sustainable

Education in different ways. Likewise we offer participants of the conference three examples in three different workshops, each with a different focus: discover (The Minor “Education Outdoors”), experience (The nature-based school yard safari) and co-create (Master's program “Sustainable Educator”). This workshop focuses on “The nature-based school yard safari”.

Workshop: The nature-based school yard safari

Teaching STEM in primary school is focused around meeting the natural environment, understanding physics concepts and creating understanding by inquiry-based learning. At the basis of teaching STEM are fostering a sense of wonder in the students and promoting love and care for the world we live in, encouraging sustainable behaviour.

We make the case that nature based school yards facilitate STEM teaching and sustainability (Maas et al., 2021)

In a growing number of school yards in The Netherlands, concrete slabs are being removed and replaced by natural elements like scrubs, grass, water features and trees. Research shows that these nature based school yards have several advantages over “grey” school yards (Van Dijk-Wesselius, 2020). At green school yards children engage in more physical active play, social play, exploratory play, constructive play, and risky play. Furthermore, children engage with the natural elements of the school yard with all their senses, using their body to fully ‘understand’ their surroundings. This embodied learning helps children to grasp complex abstract physical concepts. A nature based school yard can also be a restorative place where children regain their concentration and feel better (Prins, 2022). Schools in The Netherlands are often situated in highly populated neighbourhoods where the biodiversity is limited and under stress. Nature based school yards can be a hub for biodiversity. Increased biodiversity in schoolyards creates a richer teaching environment. Finally, a green school yard can contribute to climate change resilience. Unpaved areas, wadies and ponds buffer the runoff of rain, and mitigate heat stress.

In this workshop we will visit a nature-based schoolyard and use an assessment-tool developed bij the VU university of Amsterdam to observe different aspects of the schoolyard. Together we will discuss and consider all the opportunities the yard offers. Participants are encouraged to view the yard from their own expertise and share their perspectives. The workshop will take place outdoors.

The relationship to personal and/or material dimension

Personal dimension: Teacher trainers should be aware of the importance of ecological and social sustainability in the development of children. Teacher trainers must be aware that they are a role model, just as the (student) teachers will be a role model for the children they teach. The outside world is ever changing. Therefore, teachers must be able to adjust their teaching to the learning needs of their students and the learning opportunities presented to them. The outside world provides ample opportunities to teach about math, science, language, biodiversity, and sustainability. It is up to the teacher to see and use the rich learning environment the world is.

Material dimension: Creating a meaningful learning environment outside the school is essential in teaching for sustainability. Nature invites students to learn. Students can use tablets, mobile phones, loose parts, and their hands to explore the outside world driven by their curiosity. It is up to the teacher to direct this learning in a useful direction.

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Drawing on Drawing for Competence in Teaching Sustainability

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Thursday, 11 May 2023, 14:30-15:30, Toen

1. Introduction

Sustainability is a key aspect of education today. Teaching based on theoretical knowledge is necessary but insufficient to raise awareness and promote competence. In addition, schools and teachers need to use supplementary ways, approaches, and/or methods of teaching.

One such approach in science and environmental teaching is combining science and art. In this context, we explore the potential of drawing to facilitate collaborative learning and engagement with scientific and environmental issues within school and the wider community.

Arts-based environmental education, that combines artistic practices with learning about the natural world, has the potential to unlock communication and co-creation, generate engagement and bind people together, and thereby reveal itself as central for community interaction and open schooling.

The proposed workshop will address the topic in the context of merging art and science in a trans-disciplinary, participatory, and collaborative workshop, according to Trott et al.'s (2020) framework, with the aim of increasing the participants' preparedness for teaching environmental issues for a sustainable future in new ways. We will focus on the personal dimension, working to develop the participants' knowledge and skills related to the use of drawing also in STEM contexts.

2. Empirical background

Over the last two years, we have gained valuable experiences from organizing professional learning communities in science and drawing, and these constitute the basis for this workshop. These experiences happened in the context of Yard4All, an Erasmus+ project focusing on developing innovative methodologies in order to enable the success of all learners and establish a sense of belonging. Our contribution was to develop ways of working with scientific concepts through drawing in a permaculture garden (Bichão et al., 2022). Viewed as a whole, the experiences have shown how teachers who engaged in experiential drawing workshops were able, by integrating these workshops with their place-based and pedagogical content knowledge, to develop new ways of approaching science and environmental education in their schools, and also attending to issues of inclusion.

3. Connecting theory and practical skills

The workshop focuses on the process of drawing rather than on its products. We consider the more productive question of "what drawing is *for?"* rather than what "the drawing is *of"* (Adams, 2022), taking a performative perspective on learning. Performative perspectives highlight that learning and knowledge is created, expressed, and shared through language, gesture and other modes of expression with the help of different materials, in a process that is relational in essence (Østern et al., 2021). Attending to the assemblage of humans, materials, ideas and modes of interacting becomes prominent and sets the stage for collective exploration of new ways of acting. Arts-based environmental education that combines artistic practices with learning about the natural world, and the use of experiential reflexive workshops (Van Boeckel, 2020) constitute an important precedent for our approach.

By immersing participants in a personal and interpersonal experience of drawing, we seek to spark discussions about ownership, collaboration, peer interaction and perspective. We also want to engage participants in discussions about how the design of drawing activities can serve pedagogical purposes in science, sustainability and beyond, while centering the significance of art-based approaches in raising awareness, and deepening experience, of embodied emotions.

4. Practical information about the workshop

We invite the participants to embark on a drawing experience of slow looking and drawing, followed by interaction, asking the question, “what this leads us to?”.

The workshop offers participants opportunities to experience drawing in science in new ways. We use drawing as a starting point to deepen individual observation and to construct knowledge about biological objects. Participants are then encouraged to interact with each other’s drawings, by changing places and picking up where another person has left their drawing. Our intention is to challenge feelings of individual ownership and prestige, often connected to drawing.

The workshop is designed for 15 participants (though it can accommodate up to 20) and a duration of 60 minutes (ideally 90 minutes). The approximate timeline is: Introduction – 10 minutes, Drawing your object – 15 minutes, Drawing “around” the table – 25 minutes, Reflection and discussion – 10 minutes. (Note that participants do not have to be good at drawing in order to attend the workshop. In fact, in the best-case scenario, participants have diverse feelings towards, and experiences of, drawing).

5. Acknowledgement

The development and implementation of the Field Guide, and teaching material for drawing in science, was supported by the EU Erasmus+ program through the project: “Yard4All – Using the schoolyard for ALL children’s wellbeing and development”, Grant agreement KA201-8A5F302D.

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Girl empowerment in STEM education by means of Summer Camps

Farrugi, Josette, University of Malta, Malta

Evagorou, Maria University of Nicosia, Cyprus

Kreuz, Dita ICSE, University of Education Freiburg, Germany

Jonker, Vincent Utrecht University, The Netherlands

Thursday, 11 May 2023, 14:30-15:30, Nu

Abstract

Around half of Europe’s population is female, yet only 15% work in tech sectors and even less, 2,4% in ICT related fields. Only around 20% of the females are entrepreneurs. The untapped source of female technology, innovation and entrepreneurial potential leaves Europe with a huge and growing gender and skills gap in these sectors. Education certainly is the most important lever to enable and encourage girls to pursue studies and careers linked to STEM, particularly information and communication technology (ICT), and entrepreneurship.

The project 'Girl empowerment in STEM Education' (GEM) focussed on increasing girls' interest in STEM and ICT subjects, studies and careers, by organising summer camps for girls in 10 European Countries and by establishing a network of European institutions with the same objectives.

Higher education institutions from 10 European countries organized summer camps for girls, piloting various learning activities, which specifically supported the development of a diverse range of STEM related and personal skills. Skills that enable girls to contribute to Europe's digital innovation processes.

In this workshop we like to start with an overview of the pedagogical starting points used in the summer camps, and the case studies we carried out in the different countries. We like to share some of the learning activities used in the camps, and we finalize with some evaluation results from the different countries, and some questions.

Why STEM for girls summer camps

The GEM project[1] (with 10 European countries involved) used an out of classroom context to support female students towards STEM. The decision to focus on out of school context is supported by previous studies based on which such a context has more possibilities to enhance young students' interest in STEM (Heeg, Smith & Avraamidou, 2022; Wieselmann, Roehrig & Kim, 2020) as opposed to a formal setting because a formal setting (i.e. school) might limit the authenticity of the experience (Braund & Reiss, 2006). The activities developed as part of the summer schools afford the ability to blair the boundaries between the STEM disciplines in a way that provides authentic integration. Additionally, the summer school setting allowed us to design activities that are longer in duration, provide authentic experiences through visits and field trips, and make it possible to work with scientists from multiple STEM disciplines because of the flexibility of the schedule. Previous studies report that summer schools and after class STEM activities should include hands-on nature of activities, collaboration, and opportunities to fail without the stress of being evaluated in a formal setting (Moore et al., 2014). The evaluation of previous summer schools and afterclass activities highlight that they are successful in increasing students motivation and STEM career aspirations (Kitchen, Sonner & Sadler, 2018), they empower students (Habig, Gupta, Levine & Adams, 2020) and can improve students' knowledge and interest in learning (Chen, Tomsovic & Aydeniz, 2014; Pitri, Evagorou & Stylianou, in print).

Pedagogical starting points for summer camps

In the context of this GEM collaboration the different European partners agreed on some pedagogical starting points:

- *Inquiry-based learning*
  All activities will be based on collaborative activities, where girls have freedom to choose, to hypothesize, to collect, etc. And, as stated above, avoiding activities that resemble classical old-school STEM practices.
- *Context*
  The contexts used in the summer camps were choosen from a wide range of socio-scientific issues, like energy transition, sustainability, waste problem, etc.
- *Culture*
  When you only bring girls together another environment is created than a normal classroom situation. In all summer camps extra attention was given to a safe learning environment and a feeling of belonging
- *Role models*
  In all summer camps female role models (from the workplace, from education) were central to the activities and workshops, in order to have this important input and enviroment for all girls.
- *Entrepreneurship*
  This is strongly connected to the first issue mentioned: inquiry-based learning. It is putting the girls in their strength, putting extra effort into a growth mindset that entrepreneurs need.

Three examples of summer camps: Cyprus, Malta and the Netherlands

Cyprus: Observations, comments and reflections from the first implementation of the STEM summerschool were used by the local research group in Cyprus to prepare the new version that was implemented in June 2022. The main objectives of the new materials were to: engage young students with different STEM disciplines; make students understand STEM stereotypes, bring students in contact with female STEM professionals as role models; help students appreciate different aspects of STEM professions, engage students with skills linked to STEM (i.e. creativity, programing, inquiry-based learning, problem solving), engage students in problem solving and entrepreneurial activities.

Malta: In september 2022 about 60 girls joined for a Girls4STEM Week, and they worked in small groups of 6 to 7 students at a time. They were accompanied by a young female mentor. Activities like: Electromagnetics in medical diagnosis and treatment; Science in the investigation and preservation of Malta's national cultural heritage; NASA's Moon Survival Challenge, and of course some Coding activities.

The Netherlands: To get a good and meaningful learning environment we decided to have the three 'Autumn Girl Days' associated with 'bigger ideas'

- Trees Monday: measuring and calculating trees, practical 'exciting surfaces' and drawing a pythagorean tree;
- The Eye Tuesday: eye-tracking, medical physical research on eyes and building and using a camera obscura; and
- The Design Wednesday: mathematical folds, pseudo-coding and heights

Each day there was a meeting between the 20 participating girls and a so-called Girl of the Day talking about her scientific research and a speaker combining a workshop with a super interesting presentation. On the last day, as a group activity, the physics topics around forces, gravity and altitude were combined with a climbing workshop.

Examples of learning activities used in the summer camps

In the GEM Consortium we collect the learning activities that were used throughout the summer camps, in order to get an online collection that can be used in different situations (new summer camps, extra school activities, etc.), see Figure.

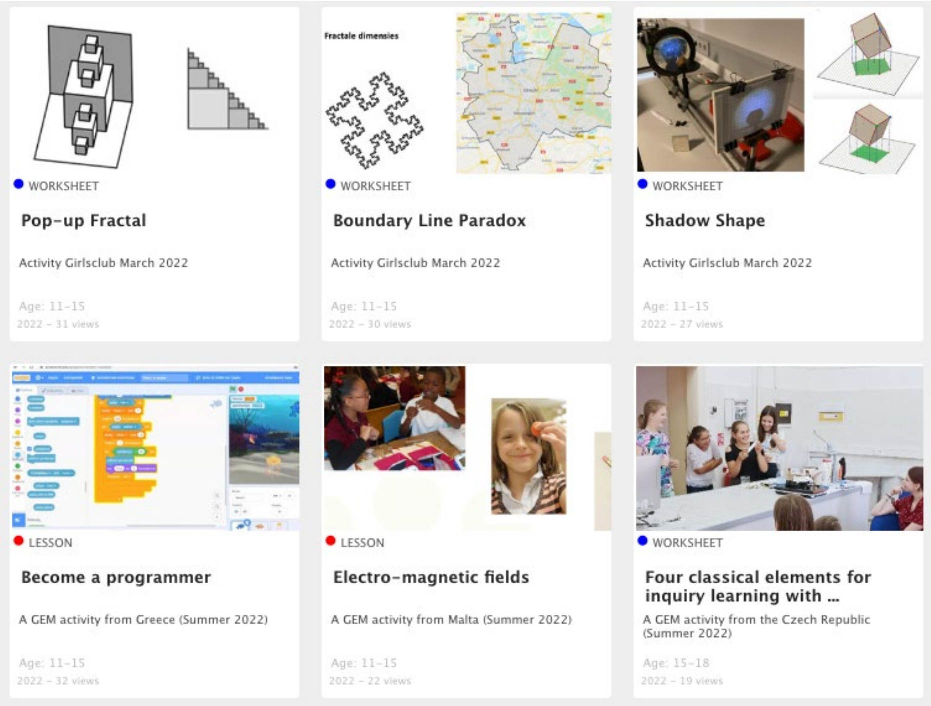

Figure - Online repository of learning activities - https://www.fi.uu.nl/publicaties/subsets/girls4stem_en/

In all learning activities we collect the central idea, the way the activity was used in the camp, the materials used, the experience. We take an example from Cyprus: How colors can be used to improve the wellbeing of scientists (Working towards prototypes (ideas), supported by the so called design thinking process).

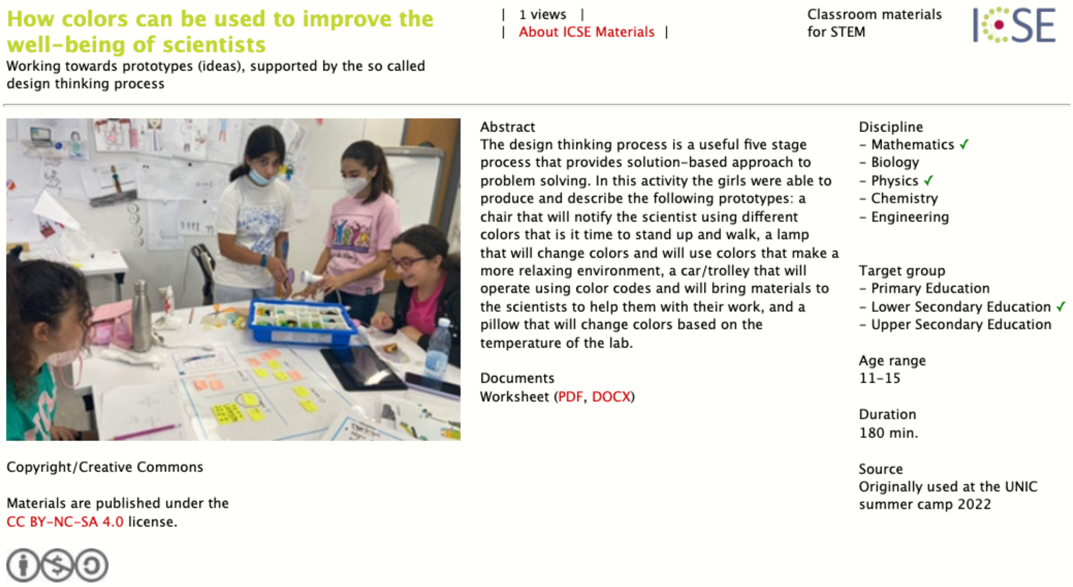

Figure - Example of a learning activity
https://www.fisme.science.uu.nl/toepassingen/29141/

This collection of activities can be used for free, and can be found at the ICSE and GEM website.

Results from the evaluation of the summer camps

Data were collected across all summercamps (both in 2020 and in 2022), a final report on the evaluation results will follow in early 2023 (and will be included in the EtE IV workshop). A questionnaire was used to ask girls about their interest in STEM before and after the summer school (pre- and post), and based on these findings we can already state that students show an increase in their interest in learning about STEM, with the most important change in their views linked to the fact that after engaging with the curriculum most of the students report that now they understand how STEM can help them in their future careers and they everyday life. Furthermore, students were asked to provide their feedback for the learning activities. The students commented very positively on the fact that they worked in groups most of the time, with one of them reporting that “My favorite activity was working on the product that we had to prototype and I enjoyed it because we worked as a group and had fun at the same time”. Working on prototypes and presenting (half)products was reported by all students as a positive aspect of the curriculum.

How we like to organize the GEM workshop during Educating the Educators

We will introduce ourselves and the project outline, then we focus on the pedagogical starting point. We do this by working on (a part of) one of the learning activities from the Summer Camps, in small groups, to have an experience and a source for discussion with the whole group.

Acknowledgements

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Teaching the Educators

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Ligtvoet-van Dommelen, Judith University of Applied Sciences Leiden, The Netherlands
Van Seeters, Sonny University of Applied Sciences Leiden, The Netherlands
Van Duijn, Sara University of Applied Sciences Leiden, The Netherlands
Thursday, 11 May 2023, 14:30-15:30, Ontwerp

1. Relation with overall conference theme

Understanding STEM subjects is fundamental to understanding and addressing the sustainability challenges we face the coming decades. This means that how we teach STEM at primary schools has important consequences for content knowledge and future behaviour of current primary school children. The time spend on teaching STEM at Dutch primary schools is slowly dwindling from 1 hour per week to 30-45 minutes per week (Kneepkens, Van der Schoot & Hemker, 2011). This time should be used most efficiently.

Open schooling provides an opportunity to use the outdoors as a learning environment and give meaning to STEM knowledge as well as a space for building a shared responsibility between students, teachers and the community.

This workshop is aimed at teachers, student teachers, teacher trainers, curriculum designers from all sorts of educational institutions but with a major emphasis on primary school education.

2. Relation to dimensions, brief outline of workshop

At the teacher's college of the University of applied sciences Leiden, we are mostly confronted with students that hold one of two attitudes about STEM subjects: “I am bad in STEM” or “I am not interested in STEM”. Some of them do have a genuine interest in STEM. Over time we have developed a vision about how to get all our students engaged in STEM, as they will be teaching these subjects at primary school (Verkenningscommissie wetenschap en technologie primair onderwijs 2013).

We start with confronting the students with simple everyday science and technology and stimulate wonder and love. Wonder leads to ‘wanting to know’ and love leads to ‘caring’. Two attitudes that will persist the rest of their lives. Similarly, these attitudes should be addressed in sustainability education (Davis, 2010; Ginsberg & Audley, 2020). Confronting students with the dangers and disasters on the world does not lead to action but to inaction (Kok et al. 2018). Wonder will lead to curiosity about the problems we face and the search for answers. Love will lead to caring and helping the world.

Students at our teacher training college broadly have one of three attitudes towards STEM: They are interested in it, they are not interested in it, or they think they are not capable of understanding it. The result is that students who are already interested in STEM subjects develop a further interest in these subjects and like teaching it. But other students decide that STEM subjects are hard and not worth bothering with. There is a chance that these students will avoid Science and technology when teaching. On the long run this results in a shortage of students interested in STEM, in a time when there is an enormous demand of STEM related professions (Van der Aalst et al. 2019). That's why we make a case that students should be allowed to have concrete hands-on experiences through encounters with STEM phenomena and the manipulation of materials, in order to build in-depth, embodied, personal knowledge of STEM phenomena. The experiences can then be used in order to scaffold STEM theoretical knowledge.

We propose a workshop/codesign where the participants first will be actively involved in a STEM activity. This leads to conceiving a shared vision on STEM pedagogy and a discussion of how this relates to open school student assignments. Eventually extrapolating the consequences of this vision to their daily work.

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Educational Escape Games

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Straser, Oliver ICSE, University of Education Freiburg, Germany

Thursday, 11 May 2023, 16:00-17:30, Toen

1. Summary

We propose a workshop on the question how educational escape games could be used to address sustainability issues. The workshop will have a strong emphasis on actively experiencing an escape game, reflection, and discussion.

2. Why Educational Escape Games?

In the last few years, escape games and similar formats have become increasingly popular. When playing these games, many young people show great enthusiasm and persistence in collaboratively solving puzzles and complex problems, a very valuable attitude when it comes to STEM learning.

On the other hand, many students lack motivation to engage with STEM subjects and tend to have negative attitudes towards science. Therefore, escape activities and comparable formats are becoming increasingly important in STEM didactics and are establishing themselves as a method of playful learning that can improve students' motivation and attitudes towards STEM subjects, as well as to promote relevant competencies (Vidergor 2021, Borrego et al. 2021, Dugnol-Menéndez et al. 2021, Huang et al. 2020).

Well-designed escape games have the potential to particularly attract girls (Hunt-Gómez et al. 2020). By providing a big variety of problems that all students can contribute to solving, it is also a good method to address groups with heterogeneous performance.

3. Examples of Educational Escape Games

There is a big variety of different formats and providers of educational escape games. It is possible for teachers to make their own escape games for the classroom with relatively little effort. On the other hand, there are big professional educational escape rooms like the ones in Technorama that are comparable to an exhibition regarding resources.
Beneath the classical situation, where the players try to get out of a locked room, popular variations of the concept include the inverse situation, where you must break into a locked box, exit card games, combinations of escape games and city rallies and digital escape rooms.

The sense of urgency and the need for collaborative problem solving that characterize escape games connect particularly well with sustainability topics. Therefore, it is no wonder that a great variety can be found when it comes to escape games addressing such issues, like the escape room "Ocean Eye" developed by the network of Austrian science centres, the escape box and online escape game "Escape Climate Change" by Ecomove International or an escape room on sustainable consumption and production designed by students of the Rotterdam School of Management.

ICSE itself has designed some very successful educational escape rooms (classical ones, "escape boxes" and digital escape rooms) one of which the participants will be able to experience during the workshop.

4. Procedure of the workshop

After a brief introduction, participants in small groups experience an escape box that incorporates sustainability themes (approx. 35 minutes).

In the following reflection phase, the structure, and characteristics as well as conditions for the successful use of escape games in education are discussed. (10 minutes).

A brief overview of the current research situation and some input about different existing escape games that address sustainability issues (5 minutes) will lead a discussion about the following questions: What potentials and difficulties do the participants see in educational escape rooms about sustainability? What specific topics, formats, places, and creators could be particularly suitable? (10 Minutes)

5. What participants will get from the workshop

The participants will experience how it feels to play an escape game and get to know other participants of the conference through this game. They will learn the basics of which elements escape rooms typically have and what makes a good educational escape game and get inspiration and ideas from examples and discussion on how to use escape games in connection with sustainability education. We will also provide more in-depth supporting materials for the workshop.

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A key-competence approach to teaching standard topics in STEM

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Thursday, 11 May 2023, 16:00-17:30, Nu

1. Introduction

The European Commission has identified the urgent need to support the development of citizens’ key competences (European Commission, 2019). Higher education institutions (HEIs) play a major role for this support, as they are the ones to educate future teachers. Core of STEM education at school is the transfer of fundamental subject knowledge like functions, measurement and chemical reactions. Learners’ skills and attitudes in these standard topics have not been sufficiently addressed in a key-competence STEM teaching approach (Maass, Geiger, Romero & Goos, 2019). The challenge for HEIs is to learn teachers to teach key competences without neglecting subject structures needed for further study (e.g. Ploj Virtič & Šorgo, 2016).

Topics bearing controversial aspects or obvious societal relevance – such as environmental degradation or cybersecurity – require innovative educational approaches, which enable teachers to not only deliver knowledge but also foster learners’ skills and attitudes. New approaches are needed to connect traditional topics to these transversal competences. This creates the need to figure out ways to allow learners to develop key competences in the scope of these traditional topics. Unfortunately, only a few materials are available on teaching STEM content with the potential to foster the development of key competences, because these materials are often not explicitly connected with traditional curricula (Šorgo et al., 2022).

In the European STEMkey project several countries collaborated to develop modules for teacher education with the aim to learn future teachers to teach standard STEM topics with a key competence approach[1]. To achieve that we reshaped the delivery of standard STEM topics with their interdisciplinary connections and as a transversal skill critical thinking.

2. Topics for teacher education

2.1. Teaching Functions

As for many approaches to STEM education, it is essential to gain the students’ interest and to show them the relevance of functions. Even though most people do not realize it, but they use functions in many all-daily situations, be it to calculate a taxi fare with fixed start price and per kilometre travelled (linear function), the trajectory of a ball (quadratic function) or the spread of a virus (exponential function). The current situation in relation to the corona virus and societal measures shows how important it is to fundamentally understand the concept of exponential growth to act responsibly. This module starts off from open realistic situations and students are asked to mathematically model them. Mathematical modelling can simply be understood as applied mathematical problem solving, and thus involves connecting mathematics and the world around us, applying mathematics and inventing mathematics to solving problems, and therefore serves sense making in mathematics education (Drijvers, Kodde-Buitenhuis & Doorman, 2019). The module discusses how to work with open and interdisciplinary tasks, and how to orchestrate the classroom activities that support students’ autonomous construction of knowledge, investigation of strategies and presentation skills. Additionally, we

[1] https://icse.eu/international-projects/stemkey/

know that different function aspects can be better understood by using different function representations, graphs, tables, rules or verbal descriptions (Bloch, 2003) and therefore students work with these various representations. This also offers obvious use of digital tools for the purpose of analysing functions and their representations.

2.2. Teaching Measurement

Measurement provides answers about sizes of objects or phenomena and applies to basic physical quantities like length, area, volume, weight, time, speed, force and energy. These quantities can be primary (e.g. length and time) or compound quantities (e.g. speed). Measurement competences have become increasingly important in our current digital society and are needed in daily life and at the workplace. However, in day-to-day teaching measurement is treated in an abstract way with a focus on conversions of measures and practicing the staircase model. The aim of this module is to provide a rich learning experience for future teachers and demonstrate the relevance of being able to apply measurement concepts and use them to solve situations in their personal and professional lives. The module also addresses a variety of qualitative and quantitative dimensions (e.g. for acid or wind) and includes attention for everyday language like micro, kilo and tetra. Measurement is addressed with modern (mobile) tools that are needed for meaningful and critical use of technology (Gravemeijer et al., 2017). Future teachers need to understand the potential of using modern technology in their classroom, and they need to learn how they can instruct their students how to use them in today's society.

2.3 Human anatomy and physiology with smartphones

Human anatomy and physiology is part of almost all primary and secondary school curricula in the world. Most of the time it is taught as a part of life science subjects, but basically every teacher, regardless of the subject, sooner or later comes across questions that connect traditional topics from his/her subject with human beings. To illustrate, we can look at the flow of energy that connects physics and chemistry to metabolism, all in social, societal, technological, and environmental contexts. Thus, teaching and learning on these topics can be seen as challenging. The search overarching principles and transversal key competences is expected to be a preferred avenue for finding connections. This module provides activities that can be used in the classroom or outside the classroom based on observation, counting, and measurement using tablets or smartphones. The hands-on activities have been tested with students - prospective biology teachers - as part of the regular curriculum in biology didactics and will be transferred to a course. So far, in addition to the introduction (know your smartphone), three activities based on observation (smartscope), counting (smart heart), and measurement (coagulation of proteins) have been tested and protocols have been established. It was shown that the introduction of such activities in the courses for prospective teachers has the potential not only to improve knowledge, experimental and practical skills, but also to enhance competences like creativity, critical thinking and problem-solving strategies.

2.4 Teaching the periodic system

To science educators the periodic system is an invaluable tool that facilitates a succinct organization and understanding of building blocks of chemistry. Indeed, the compressing of chemical knowledge that the system offers, once initiated a transformation in teaching, from forcing students to cram brute facts – as was the fashion in the 19th and early 20th centuries (Kaji et al., 2015) – to learn by studying relationships between elements and trends in chemical properties across the table. In this module, we offer a context-based approach to introducing the periodic system to teacher students which at the same time might inspire their own future teaching about the subject in lower secondary school. A context-based chemistry teaching requires that students connect canonical science concepts with a real-world context, a connection that makes chemistry meaningful to students (King, 2012). The module includes sorting activities using Lego bricks, an introduction to the historical development of the periodic system, hands-on interaction with samples of elements, as well as socio-scientific issues related to the extraction and use of chemical elements in technological devices. By selecting elements that the students might know from their everyday lives and disseminate about their applications in society— including ethical issues– we connect the “inhabitants” of the periodic system, and thereby the system itself to real-life contexts.

2.5. Moving from theory to experience - Teaching material cycles

Learning about material cycles – and the carbon cycle in particular – bears the potential to unite different STEM subjects across the curriculum and to provide interdisciplinary learning opportunities. Curricula of various subjects highlight the importance of material cycles. In physics classes students shall learn about the water cycle and in geography and economy classes students shall encounter different cycles that are relevant to our geo-ecosystem, including the water and carbon cycle. It is crucial that (future) STEM teacher are capable to teach the ubiquity by (a) creating learning environments that allow for interdisciplinary learning instead of multidisciplinary learning of isolated pieces of knowledge, and (b) helping learners to integrate single pieces of knowledge to gain a systemic understanding of the carbon cycle. This module shows future STEM teachers how to teach material cycles in a real-world context using practical activities, which increase learners’ perceived relevance of the topic (Zeyer & Dillon, 2019). This is important, because teachers typically ask learners to reproduce knowledge on the different systems, chemical compounds, and chemical reactions of material cycles and explain graphics given in textbooks. Future STEM teachers need to experience how they can support learners to apply knowledge on material cycles in real-world contexts and develop critical thinking, which is one “of the requirements to navigate our increasingly complex world” (European Commission, 2019, p. 3). Critical thinking results when knowledge, skills, dispositions (or attitudes) and norms, values and emotions interplay when dealing with a subject or an object to take a position, make a decision and/or act and this process is controlled by intellectual standards as well as self-regulation (Rafolt et al., 2019).

2.6 Teaching chemical reactions

Chemical Reactions are a standard topic in chemistry education and therefore initial teachers need to be prepared for it. However, in traditional science classrooms this topic is often treated by showing one example and then by treating chemical equations without direct connections with experimental activities. The aim of this module was to develop an innovative teaching material on the topic Chemical reactions with rich learning experiences for school students which also nurture the development of key competences. Chemical reactions are introduced in concrete examples from everyday life and in supporting of sustainable development (industry, agriculture, transport etc.). Our focus is to introduce future teachers into ways of transforming standard “content” into tasks which give student an active role, which use real-life contexts, connect different disciplines and take into account students’ diversity. Experiments support the understanding of mutual transformations of chemicals where material cycles are associated with significant colour changes in substances, changes in the reactant state and variety of reaction types (Kolář et al., 2018). These experimental activities require creative and critical thinking, and aim at enabling future teachers to teach the basics of chemical reactions in an innovative way.

3. The workshop

In this workshop we will first present the general framework of the STEMkey project. Next we will create working groups on the modules to introduce and work on some of the activities. We will close the workshop with a general discussion on our approach for connecting the development of key competences with teaching standard topics in STEM, and the possibilities for implementing our modules in teacher education practice.

Acknowledgements

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MOST Fair MOST

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Wijers, Monica Utrecht University, The Netherlands

Korte, Sanne Utrecht University, The Netherlands

Weinberg, Lucas University of Innsbruck, Austria

Thursday, 11 May 2023, 16:00-18:15, Zaal 10

In the European MOST project, science education in schools is connected to their community (families, science education providers, citizens, businesses etc.). Together they work on environmental school-community-projects with a thematic focus on waste management and energy saving. These participatory projects directly respond to the needs and values of those involved, benefitting the community as a whole and making schools agents of community well-being. MOST's learning impact is boosted through an educational research-based approach that raises interest in science, scientific literacy and environmental responsibility (https://icse.eu/international-projects/most/). During the MOST Fair teachers, students and other representatives from all partner countries will present the results of their school community project(s). We share and evaluate best practices and learn new formats that worked well for others. In addition, community building among all participants is important, therefore we will also relate to the European Open Schooling Network (EOSnet). After this session, the MOST fair will be open for everyone to visit from 17:30-18:30.

The Earth is (y)our Classroom

Van 't Hoff, Loes University of Applied Sciences Leiden, The Netherlands
Joven, Marian University of Applied Sciences Leiden, The Netherlands
Thursday, 11 May 2023, 16:00-17:30, Outdoor (meet-up at main entrance)

Relation with overall theme

The world is at the beginning of a 'decade of transformation' in which we strive to achieve the Sustainable Development Goals (SDG) as proposed by UNESCO (2022). Education plays a key role in this process. For several years now, the Whole School Approach (WSA) to sustainable development has been recommended internationally (WUR, 2022). This approach, as endorsed by the key note speaker Arjen Wals, calls for innovation at all levels of education. The Center of Expertise for Professionalization through Educational Pedagogic Practical Research (POP in Dutch acronym) of the University of Applied Sciences Leiden is conducting a number of research projects and offers courses to support professionals in their endeavours to teach in a sustainable practice. The Center of Expertise POP consists of three groups, two of which focus on the theme of sustainability. The research group Child Development and Nature aims at nature-inclusive education and the research group Values of Waldorf education focuses on child development from a democratic, sustainable and holistic perspective. The Center of Expertise POP offers students Sustainable Education in different ways. Likewise we offer participants of the conference three examples in three different workshops, each with a different focus: discover (The Minor "Education Outdoors"), experience (The nature-based school yard safari) and co-create (Master's program "Sustainable Educator"). This workshop focuses on the Minor Education Outdoors.

Target group and scope

Our target group are (STEM) teachers in both primary and secondary education and teacher trainers that are interested in .

Workshop: The Minor "Education Outdoors: the earth is (y)our classroom"

The minor "Education Outdoors" is aimed at students training as teachers in primary and secondary education. At its core, the minor aims to empower students to become teacher that help their pupils become responsible global citizens who are aware of environmental problems, propose solutions, and take action to create a more sustainable future within their scope.

In the minor, we experience first-hand that students are concerned about the future of the earth. They feel the pressure of the responsibility to make a difference. This poses the question how we, as teacher trainers, can guide our students? And how can our students, in turn, guide the children in their class?

The minor has a scope that is broader than what is traditionally taught as "outdoor education", hence the name "Education Outdoors" and the subtitle "The earth is your classroom". We focus on all the possibilities the environment offers for teaching outside a classroom, 'terra-centred' education.

Our goal is to help our students become *teaching-outdoor-competent*. Teachers that are aware that where you teach is of importance and that the outdoor offers a rich teaching environment (Neville *et al*. 2022). To do this we encourage our students to become *outdoor-confident* by inspiring them to develop a personal connection with nature, becoming aware of the reciprocity of our relationship with nature as well as with experiential learning, hands-on activities and direct interaction with the environment.

In this workshop we invite participants to come outdoors with us, experience, discuss and consider with us how you can deal with complex issues in the context of climate change with pedagogical tact: how to encourage without putting pressure, how to teach with hope. We are inspired by, among other things, the essay by the Netherlands Youth Institute *'Educating in a warming climate. Offer children a hopeful future*.' (Yperen, 2022). The workshop will take place outdoors.

The relationship to personal and/or material dimension

Personal dimension: Teacher trainers should be aware of the importance of ecological and social sustainability in the development of children. Teacher trainers must be aware that they are a role model, just as the (student) teachers will be a role model for the children they teach.
The outside world is ever changing. Therefore, teachers must be able to adjust their teaching to the learning needs of their students and the learning opportunities presented to them. The outside world provides ample opportunities to teach about math, science, language, biodiversity, and sustainability. It is up to the teacher to see and use the rich learning environment the world is.
Material dimension: Creating a meaningful learning environment outside the school is essential in teaching for sustainability. Nature invites students to learn, it is up to the teacher to direct this learning in a useful direction.

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3D-Printing in Sustainability Education

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Straser, Olivier ICSE, University of Education Freiburg, Germany
Steurer, Peter ICSE, University of Education Freiburg, Germany
Friday, 12 May 2023, 9:00-10:00, Toen

1. Summery

We propose a workshop on the question how 3D Printing can improve integrated STEM Education with a focus on sustainability. The workshop will have a strong emphasis on actively experiencing 3D-Printing, how 3D-Printing can be included in STEM Education and what applications can be used in sustainability education as well as reflection, and discussion.

2. Why 3D Printing in STEM-education?

A wide variety of applications of 3D printing technology have led to enormous progress in many areas of industry and research in recent years. The continuous further development of future application possibilities, such as 3D printing of houses or so-called bioprinting (the printing of tissue structures or organs), also suggests that the importance of the 3D printing industry will continue to grow strongly.

Already, well-known manufacturers in the automotive and aircraft industries are using 3D printing technologies in series production to create particularly lightweight and stable components. In the medical industry, 3D printing can be used to produce prostheses for legs and arms that fit precisely and cost-effectively. In the restoration of old buildings with elaborate ornamentation, well-preserved parts are first 3D scanned and then printed out again.

These application examples are not only intended to illustrate the social relevance of this technology, but also show that 3D printing is playing an increasingly important role in more and more professions, including those outside the STEM sector.

3. Examples of applications in STEM Education

Since the availability of affordable and easy-to-use 3D printers, the implementation of 3D printing can also be a crucial methodological enrichment in the educational sector. 3D printing can be an innovative way to promote important skills such as spatial thinking and problem- solving strategies, and its vividness offers crucial added value. For example, edge models of geometric bodies can be printed in mathematics, topographical maps in geography or enlarged models of biological cells in biology. Various online portals already offer illustrative objects and experiment sets free of charge specifically for use in education. (e.g. optical illusions, mathematical bodies, chaos pendulums or linear particle accelerators). It is important to note that 3D printing - like all new media - is not an end in itself, but must be embedded in an educational concept as a new tool in the learning process. For students, the possibility of accompanying an issue from planning to realization also seems to be highly motivating. Creativity and multi-perspective approaches can be promoted through open collaboration on the 3D model; and diverse problem-solving strategies then in turn offer the opportunity to train a constructive approach to mistakes. However, such learning environments are not always easy to realize, also due to a print duration of often up to several hours.

4. Procedure of the workshop

We sketch the procedure for the case that we will be given a 60-minute slot. First, we will introduce applications of 3D-Printing in research, industry and education (10 Min)

Afterwards all participants learn, as a first example, of how to design a tooth-paste squeezer and safe waste with it(ca. 35 minutes).

Afterwards the participants learn how to 3D- printing can be used in STEM education and will be informed about the actual research stats (10 minutes) which will lead a discussion about the following questions: What potentials and difficulties do the participants see when using 3D- Printing in sustainability-education. What specific topics, formats, places, and creators could be particularly suitable? (15 Minutes)

5. What participants will get from the workshop

Participants learn applications of 3D-Printing with a strong emphasis on sustainability, learn how 3D printers work and where suitable models can be obtained free of charge. In addition, we introduce the basics of 3D design and give suggestions for the use in STEM-Education. In the concluding discussion, we answer questions on topics such as requirements, costs and effort.

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Developing student imagination and career interest through a STEM project using 3D printing with repetitive modelling, Kuen-Yi Lin, Shao-Chuan Lu, Hsien-Hsien Hsiao, Chia-Pin Kao ORCID Icon & P. John Williams

Co-Designing of MathCityMap Trails in In-Service Teacher Education

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Medová, Janka Constantine the Philosopher University, Slovakia
Bočková, Veronika Constantine the Philosopher University, Slovakia
Friday, 12 May 2023, 9:00-10:00, Nu

1. MathCityMap trails

A mathematical trail is an outdoor activity during which participants discover and solve mathematical problems, both standard and non-standard, connected to real objects. The problems in mathematical trails allow addressing the environmental issues. Mathematical trails are solved in groups. Participating pupils communicate and look for common solutions to given tasks and problems. Tasks in trails are located nearby within walking distance. When solving tasks and problems, various measuring aids such as a measuring tape or a wooden folding meter are often used (Bočková and Pavlovičová and Čeretková 2020).

Although the idea of mathematical trail has a long history, the aim of the Erasmus+ project "Mobile Math Walks in Europe" (MoMaTrE) was to connect math trails with mobile devices (Čeretková and Bulková 2020). The implementation of the trails created a freely available MathCityMap (MCM) application within the project and a MCM portal for creating mathematical trails (Barlovits and Ludwig 2020).

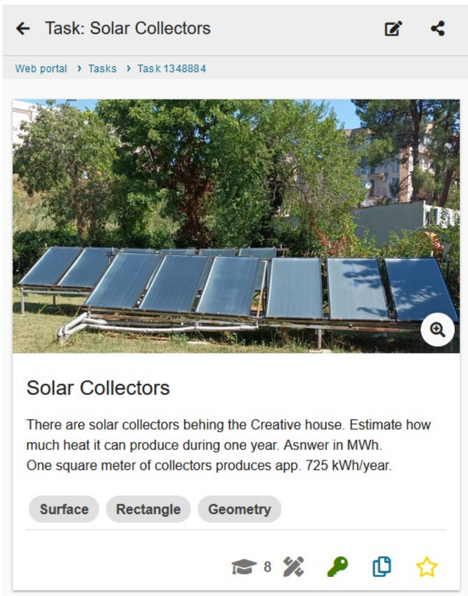

Figure 1 Example of MathCityMap task

After a short registration on the MCM portal, teachers can create their own tasks and combine them into a MathCityMap trail. Each MathCityMap trail has to contain at least four problems. When creating a task, it is necessary to take a picture of the real object to which the task is related. The picture should be taken in a way that the parameters for solving the tasks cannot be discovered directly from the image, but the participants need to arrive at the location according to the GPS coordinates. Subsequently, the task of a mathematical trail is formulated. The creator of the task can choose from different types of answers to the tasks: specific number, interval, multiple-choice questions and others. Each task should also contain hints that the participants of the trail can use to solve the task. The aid can be a formula, a sketch, guiding question or suggestion of the way of solving the problem. There should also be a model solution that can be understandable for every solver. For each task, the grade in which the task can be used is determined. MathCityMap trail can be used for private purposes or freely accessible to all MCM users. The public trail is reviewed and approved by the project administrator, who can propose changes in the assignment of tasks (Haringová and Bočková, 2021).

2. Professional development

Co-designing and enacting mathematical trails offer various possibilities in the professional development of in-service teachers as well as pre-service teachers mainly in posing the problems related to real objects and particularly, addressing the environmental issues. Involvement in co-design also places special demands on educators.

3. Aim of the workshop

In this workshop we firstly focus on the role that materials can play for in-service teachers when designing the tasks for outdoor investigation using the MathCityMap system collaboratively. Furthermore, professional development in the *spiral model* (Maass and Doorman, 2013) will be described. Further, we will share the experience with working with primary and lower-secondary mathematics teachers in designing, enacting and reflecting on MathCityMap trails and how the teachers took the advantage of the knowledge obtained during the first trail in designing, enacting and reflecting in and on the second designed and enacted MathCityMap trail. Lastly, the participants of the workshop will pose mathematical problems related to real objects in the area of Naturalis focused the environmental issues and create the tasks in MathCityMap system.

Acknowledgements

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Plastic soup with escape boxes: fostering learning on socio-scientific issues

Veldkamp, Alice Utrecht University, The Netherlands

Korte, Sanne Utrecht University, The Netherlands

Friday, 12 May 2023, 8:45-10:00, Ontwerp

→ This workshop starts earlier at 8:45

1. Abstract

Commercial escape rooms have inspired teachers to adapt the popular entertainment activity for education, especially in STEM education. This global bottom-up phenomenon in education is implemented in various ways. Students use their knowledge and skills either to solve problems and “escape” the room or finish an escape game in time. Students can also develop an escape game themselves. In open schooling projects, both ways could foster learning on socio-scientific issues and collaboration processes between students, community members and other stakeholders.

This workshop is an inspiration session and gives educators an experience with an educational escape game using escape boxes on the subject of an SSI about plastic waste, see Figure 1. Subsequently, the participants

experiences will be related to research on STEM educational escape rooms in secondary education and higher education. Subsequently, we will discuss the possibilities of escape rooms in open schooling projects. There will be hand-outs on research based practical design guidelines for educational escape rooms For a presentation on the used framework and research results, see the oral presentation “Fostering learning on socio-scientific issues with escape games” and/or the “No Escape!” dissertation (Veldkamp, 2022).

Figure 1. An escape box with the game Plastic Soup during gameplay.

2. The rise of escape rooms in education

Globally, escape rooms have been finding their way into education, especially in STEM education. Escape rooms are live-action team-based games in which players encounter challenges in order to complete a quest in a limited amount of time. The quests in the first rooms were ‘escapes’, nowadays the quest varies, for example to solve a murder mystery or break into a vault (Nicolson, 2015). STEM teachers implement escape rooms to foster learning in authentic contexts such as laboratories or outside world contexts which are out of reach, potentially dangerous or abstract for learners, like Plastic Soup. STEM escape rooms create feelings of mastery, ownership, and mutual dependence, resulting in high student engagement, regardless of age or gender (Lathwesen & Belova, 2021;Veldkamp, 2022).

3. An escape game design

Within an escape game, all problems or activities are called puzzles. As escape games are inherently team-based games, the puzzles tend to ensure that every member of a team is active and can contribute (Nicholson, 2015). The puzzles, which can be categorized as: 1) cognitive puzzles that make use of the players’ thinking skills and logic, 2) physical puzzles that require the manipulation of artifacts to overcome a challenge, and 3) a meta-puzzle, the last puzzle in the game in which the final solution is derived from the results from the previous puzzles. Cognitive puzzles seem to predominate in escape rooms (Nicholson, 2015). To solve the puzzles, players require skills such as searching, observation, correlation, memorization, (logic) reasoning, math, reading and pattern recognition (Wiemker et al., 2015). After the gameplay, the gamemaster debriefs the players on the process and what they have achieved (Nicholson, 2015). Given the list of skills required and the reflection on the achievements, it is no surprise that escape rooms expand into new areas such as education.

4. Ways in which escape games can be used in education

Usually, escape games are implemented in two ways; teams of students use their knowledge and skills either to solve the escape game or develop one while using their knowledge and skills. In a project, we combined these two ways of implementing in order to interest bachelor students in STEM teacher education or educational developer. Based on design based research, in three design cycles students developed reusable escape boxes, with various game content on plastic soup, zoonosis and carbon dioxide emission for secondary education (Veldkamp et al., 2022).

As escape games are suitable learning environments for enhancing teamwork and increasing motivation for a subject, it is expected that such activities could be useful to be implemented in open schooling projects on sustainability. For example, escape room experiences could stimulate the start of a collaboration process between students, community members and other stakeholders. In addition, the creation of an escape room by the students and members as a final product of their open schooling project could help in the dissemination of their results.

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Tipping points: Bringing mathematical modelling of an Antarctic ice shelf into the classroom

Shimwell, Joe Northumbria University, UK

Davenport, Carol Northumbria University, UK

Friday, 12 May 2023, 10:10-11:10, Toen

1. Introduction to the underpinning research and workshop

The concept of melting ice sheets as a consequence of climate change is one which is well known to many people (see e.g. Timmons and Lunn, 2022; Priestley, Heine, and Milfont, 2021). However, there is less knowledge of the likely impact of the melting of the ice sheets in Antarctica (Schleosser and Gold 2021).

The interaction of sea ice, warming ocean and atmospheric changes on the ice sheets around Antarctica are complex and not understood in intricate detail. These interactions will play a part in the timescale and magnitude of melting ice in the region and consequent global sea level rises. The Tipping Points in Antarctic Climate Components (TiPACCs) project aims to investigate the possibility of large, and sudden, changes in the sea ice, ocean and atmosphere of Antarctica. The project uses mathematical modelling to test out 'possible futures' for Antarctic sea ice and to assess the likelihood that tipping points will be reached (see e.g. Hill et al.,2021).

This ICSE workshop presents one of a suite of classroom resources based on the TiPACCs research suitable for pupils aged 9 – 11 years old. The full suite of resources consists of an introductory assembly introducing pupils to Antarctica and some of the scientists and mathematicians from the project through short online clips, and two classroom lessons. The first workshop explores the development of our scientific understanding of Antarctica, the changing processes of science, and how mathematical models are used to further our understanding. The second lesson looks in more detail at the climate components featured in the TiPACCs research project and how the ice, sea water and atmosphere all play a part in the levels of ice in Antarctica.

This workshop will allow teachers to experience the resources created for one of these classroom lessons. The workshop, *The Ice and the Oceans*, is designed to develop teachers and young children's understanding of some of the physical processes that are taking place on and around Antarctic. The workshop looks at the interaction between floating ice shelves and ocean currents coupled with the concept of a *tipping point*.

Research indicates that pre- and in-service teachers feel that it is important to incorporate climate change and environmental sustainability into the classroom (Kennelly, Taylor and Serow, 2012), and that there is a need for resources that can be incorporated by teachers into their teaching (Schleosser and Gold 2021). This workshop, and the associated resources, will provide opportunity for educators to improve their own knowledge of Antarctic science and utilise that knowledge in their teaching.

1. Workshop outline

Following a brief introduction of TiPACCs research and the team of scientists involved, the workshop will focus on developing participants understanding of Antarctica and the climate systems which are being studied in this project: the oceans surrounding Antarctica, Antarctic ice shelves, and the concept of a tipping point. Participants will have the opportunity to hear first-hand from the climate scientists through pre-recorded videos, to develop their understanding. They will then carry out the activities that form the schools' workshop with opportunity for feedback and discussion on the best way to deliver the materials in classrooms. These activities will include: using satellite imagery to track changes in ice shelves over time, using simple models to understand the interaction between glaciers, ice shelves and warming ocean currents; using models to understand the concept of a tipping point. The workshop will end by providing the participants with access to all the workshop resources, and a short feedback planning and feedback discussion.

2. How the proposal relates to the overall conference call

The workshop, and related materials, will provide teachers the opportunity to deliver high-quality lessons related to environmental sustainability using principles identified by Eileen Merritt and colleagues (2022). In using the classroom materials, teachers will be supported in their own PD in relation to mathematic and scientific research into the behaviour of ice sheets in Antarctica, as well as gaining an insight into the processes of science. It addresses the question of 'what role can carefully curated classroom materials play in professional development for science teachers?' and will also address the benefits of 'bringing scientists into the classroom' through pre-recorded online vignettes (Goldman et. al. 2013).

The workshop will address the topic through two perspectives: audience specific - teachers who wish to bring cutting-edge research into their teaching practice; and issue specific – the use of mathematical modelling to understand current and future melting of Antarctic ice sheets.

Teachers, and teacher-educators, will be encouraged to identify opportunities in their national curricula and teaching plans which would allow them to incorporate the suite of resources into their own teaching practice. Likely opportunities include geography, environmental studies, science and careers-related learning.

Acknowledgements

The workshop development and the underpinning research have received funding from European Union's Horizon 2020 research and innovation programme under grant agreement no. TiPACCs 820575 and from the NERC grant NE/L013770/1 "Ice shelves in a warming world: Filchner Ice Shelf system, Antarctica".

The authors would like to thank the TiPACCS research team at Northumbria University, and the wider project partners, NORCE, Potsdam Institute for Climate Impact Research (PIK), Alfred-Wegener Institute and Université Grenoble Alples for their support and contribution to the development of the workshops.

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The Sustainable Educator

Geerts, Jarla University of Applied Sciences Leiden, The Netherlands

Logtenberg-Prins, Angelique University of Applied Sciences Leiden, The Netherlands

Friday, 12 May 2023, 10:10-11:10, Nu

Relation with overall theme

The world is at the beginning of a 'decade of transformation' in which we strive to achieve the Sustainable Development Goals (SDG) as proposed by UNESCO (2022). Education plays a key role in this process. For several years now, the Whole School Approach (WSA) to sustainable development has been recommended internationally (WUR, 2022). This approach, as endorsed by the key note speaker Arjen Wals, calls for innovation at all levels of education. The Center of Expertise for Professionalization through Educational Pedagogic Practical Research (POP in Dutch acronym) of the University of Applied Sciences Leiden is conducting a number of research projects and offers courses to support professionals in their endeavours to teach in a sustainable practice. The Center of Expertise POP consists of three groups, two of which focus on the theme of sustainability. The research group Child Development and Nature aims at nature-inclusive education and the research group Values of Waldorf education focuses on child development from a democratic, sustainable and holistic perspective. The Center of Expertise POP offers students Sustainable Education in different ways. Likewise we offer participants of the conference three examples in three different workshops, each with a different focus: discover (The Minor "Education Outdoors"), experience (The nature-based school yard safari) and co-create (Master's program "Sustainable Educator"). Each activity made an own proposal. For this proposal the focus will be on the new Master's degree "the Sustainable Educator".

Target group and scope

Our target group are (STEM) teachers in both primary and secondary education and teacher trainers that are interested in the whole school approach.

Workshops (co-creation): Master's program "Sustainable Educator"

Answering the demand to integrate sustainability in education we are developing a Master's program for teacher-education in which we want to bring research and education together around this subject. The training of teachers plays a crucial role in the process of social change to provide a sustainable future. Future-oriented education means that education must be ahead of future developments: the world of 2040 must already be visible in education (Rijksoverheid, 2022; Teachers for Climate, 2022).

Leiden University of Applied Sciences is part of the SDG Netherlands community and has the ambition to pay attention to sustainable development in education, research and business operations (Hogeschool Leiden, 2023). In addition, there is a need for more Master's programmes in the Netherlands with great relevance for professional practice (Report Committee on the Positioning of universities of applied sciences, 2022).

The first principles are now (in draft) on paper. It will be a two-year master (60 EC) in which students are trained to become pedagogical professionals with the will and capacity to provide sustainable, ethical and inclusive education, demonstrating respect for each other and life in all its forms. This from a holistic, systemic point of view. During this workshop at the conference we want to make discussion/workgroups around three main topics:

- Climate change: Young people see the coverage and are very concerned about climate change and what this means for their future. Research shows that almost 70% of young people under the age of 18 see climate change as a worrying development (Yperen, 2022). A combination of being action-oriented, taking a break and focusing on creating hope seems like a healthy way to deal with the issue of climate change (Yperen, 2022). Does the idea of a master help to equip teachers coping with the young people and these states of mind?
- Equality of opportunity: The State of Education (2022) describes equality of opportunity as a social task of education. Not all children in the Netherlands have the same chance of finding a place in the world where they can be meaningful (Amghar, 2021; Van den Bergh et al., 2020). The government notes that children who grow up in a family with a low socio-economic status, children with a non-Western background, neurotypical idiosyncrasies or a physical disability and children who have fled from war zones, do not get the opportunities they are entitled to (State of Education, 2022). Space, love, fire – these are the things that will make a sustainable contribution to fairer opportunities for all children" (IJsseling, 2022). What is needed in a classroom in your perspective?
- Sustainable Education: According to Teachers for Climate (2020), sustainable education has the following characteristics: cross-curricular and systemic, connecting, focused on cooperation and a combination of theory and practice. How would you fill in these three components in practice?

In this workshop we will co-create content with the teachers of STEM around these three aspects in order to deepen and enrich our design. Working together on this topic will also muster ideas to implement directly in STEM teachers' own teacher-practice. At the end of the session we will also reflect on the main question: How do we integrate sustainability in our education? And which (small) idea will you take home to enrich yours?

The relationship to personal and/or material dimension

Personal dimension: Teacher trainers should be aware of the importance of ecological and social sustainability in the development of children. Teacher trainers must be aware that they are a role model, just as the (student) teachers will be a role model for the children they teach. The outside world is ever changing. Therefore, teachers must be able to adjust their teaching to the learning needs of their students and the learning opportunities presented to them. The outside world provides ample opportunities to teach about math, science, language, biodiversity, and sustainability. It is up to the teacher to see and use the rich learning environment the world is.

Material dimension: Creating a meaningful learning environment outside the school is essential in teaching for sustainability. Nature invites students to learn. Students can use tablets, mobile phones, loose parts, and their hands to explore the outside world driven by their curiosity. It is up to the teacher to direct this learning in a useful direction.

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Open Maths Meets Sustainability

Van Hoeve, Marloes Hogeschool Utrecht & Goois Lyceum Bussum, The Netherlands

Alpar, Greg Open Universiteit & Radboud University, The Netherlands

Friday, 12 May 2023, 10:10-11:10, Ontwerp

1. Introduction

We know, and can see in various media, that the climate is in crisis. For instance, according to the Intergovernmental Panel on Climate Change, "biodiversity loss, overall unsustainable consumption of natural resources, land and ecosystem degradation, rapid urbanisation, human demographic shifts, social and economic inequalities and a pandemic" can all be related to climate change (IPCC, 2022). Therefore, new sustainable ways are necessary for our lives. To find these ways, lots of innovation is needed in the coming decades. Novel technologies will provide some of the most important solutions for limiting climate change itself as well as to help people live with conditions that are already present. These innovations are often based on the STEM subjects, and in particular, mathematics. These include, understanding the problems, modelling situations, solving problems with computers, and other technical fields that apply mathematics. We need our current students on board for these novel ideas and approaches.

However, mathematics, the abstract subject of numerical and spatial relations underlying most sciences and engineering, is still mainly taught in a traditional way, with students following instructions and methods. They do not get enough opportunities to learn *how to learn mathematics* and *how to enhance their own capacities*. And most importantly, they see too few connections between the current problems in the world and the ways mathematics can contribute to their solutions. In school books there are too few good and relevant assignments with the environment and sustainability as a context. To improve the current educational situation, teachers also need to be prepared for discussions about real-world issues.

2. Open Maths

Our initiative, Open Maths (Alpár and van Hoeve, 2019), aims to teach mathematics from a growth-mindset perspective: both the teacher and the learner cherish the possibility to improve one's abilities. Because of this, students get much more involved in their own development process and in mathematics (Boaler, 2015). They relate to mathematics at a personal level as they actively reflect on how they see (abstract) structures, quantities, and visuals. They make connections among different theoretical and real-world ideas. Through different assignments, they explore and practise new approaches with a discoverer's curiosity (Foster, 2013, Kaplinsky, 2020), and they work in a safe space, in which they can make mistakes. They are encouraged to work together as this also adds to new perspectives and experiences.

We emphasise teaching students to be more confident and to learn from effort and mistakes. Beyond learning mathematical skills, teachers are encouraged to invite students to work on other competences too, such as getting a grip on complex systems (modelling), discussing what various results might indicate, and thinking about the future. From a practical viewpoint, teachers can teach students how they can think of desirable outcomes, how they can reach those, and how they can formulate opinions based on the models, calculations, and results. Importantly, teachers and students can discuss ways to take action.

All these aspects make Open Maths a suitable setting for students. In particular, mathematics can help in specific ways in the context of sustainability.

- To grasp the problems – and their scale – around the climate crisis;
- To understand potential solutions;
- To actually solve environmental problems in the future.

Figure 1 shows the important connections among growth mindset, mathematics, and sustainability. With a growth mindset, students can be more open and trusting towards the challenging future and mathematics. Mathematics can contribute to understanding sustainability problems and to giving insights into solutions. By using Open Maths, teachers can feel more confident to use this highly relevant and practical context in the classroom.

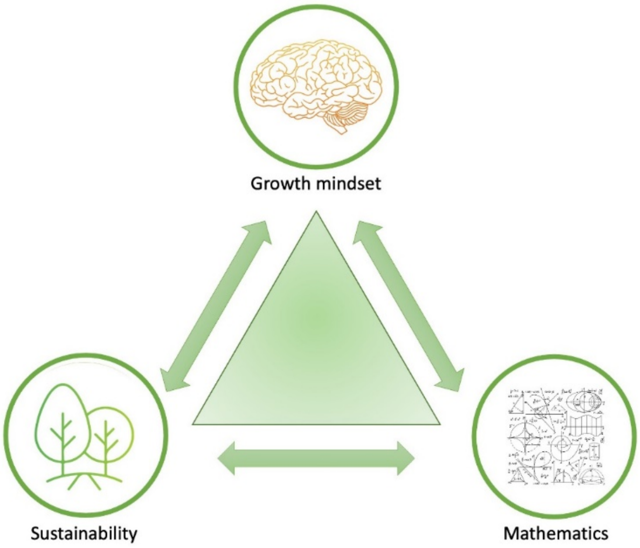

Figure 1. Positive exchange in the triangle of growth mindset, mathematics, and sustainability.

3. Workshop 'Open Maths Meets Sustainability'

Several papers discuss possible ways to include sustainability in mathematics education (Prieto-Saborit et al., 2022). However, many of them require considerable adjustments in the current curriculum. Hamilton and Pfaff (2014) suggest foundational yet practical ideas in this context, calling for the nourishment of "an educated citizenry." Based on their inspiring article and the positive exchanges depicted in Figure 1, we formulate five objectives to help integrate sustainability into just about any mathematical subject area without expanding teachers' current obligations. (1) Teach mathematics in context; incorporate sustainability-oriented content and introduce "global realities," when teaching formulas and procedures. (2) Include real-life problems; urgent examples illustrate the relevance of mathematical theory and techniques and get students to think beyond and talk about abstract concepts. (3) Emphasise "designing the future"; teach the tools of complexity, systems thinking, and design thinking, which in turn, enable students to explore new areas and to draw deep connections. Besides the above mentioned three objectives, we need students to develop a growth mindset to overcome feelings of anxiety over failing and making mistakes. Two more objectives aim to give students trust and confidence in their progress. (4) Acknowledge the ethical and psychological (moods, feelings, attitudes, etc.) aspects of the issues regarding sustainability; discuss with students their findings and learning process and have them reflect on those. (5) Teach specific mathematical and broader skills that empower students to become catalysts and leaders of change.

Our workshop will capitalise on these objectives in combination with the Open Maths approach. We first briefly discuss some examples. Then, we explore possibilities together to change the status quo in mathematical education using Open Maths and to incorporate environmental issues. With the active participation of the workshop members, we start co-designing practical ways that include sustainability into mathematics education. Participants and co-creators from all walks of life are welcome, and even necessary, for these changes. As a result, participants can get hands-on ideas for improving mathematics education as well as inspiration for including new ways in the classroom towards addressing current, real-world challenges with a growth mindset.

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Paper Presentations

Development of STEM Education in KUSH: Task Design for Inquiry-Based Learning through Lesson Study

Ohtani, Minoru Kanazawa University, Japan

Thursday, 11 May 2023, 11:00-12:00, Live Science

1. Purpose of the Study

There is growing interest in developing the qualities and abilities to think mathematically through the process of inquiry. In addition, efforts are being made to make appropriate use of ICT in mathematics classes. The author collaborated with teachers of the mathematics department of Kanazawa University Senior High School (KUSH) to design a task "spread of Covid-19 infection" as material for Research Lesson (RL) in Lesson Study (LS) (Otani, 2021). Department of mathematics at KUSHS is working on inquiry-based, collaborative, and cross-curricular learning in collaboration with university teaching staff. We designed a task simulating the spread of Covid-19 infectious diseases with a simulation based on the assignment in the Mathematics A National Examination (Cito, 2003). At the end of 2020, in Japan, the spread had just begun in February in the Diamond Princess cruise ship and the spread became an authentic social issue. This presentation consists of three Japanese LS processes: collaborative task design for a RL, implementation of the task in the RL, and three students' perspectives on the task and their mathematical activity post the collaborative RL that included participants.

2. Task Design for Research Lesson

We designed a task for grade 12 (second year) of high school. We located the task in the third subunit "limits of sequences" (3 class hours) of unit "Functions and Limits". The subunit consists of "mathematical models of infectious diseases", "simulation of infectious diseases" (RL), and "simulation of various infectious diseases". The mathematical model of infectious diseases is represented by analytically unsolvable systems of recurrence formulae and requires the concept 'limit of sequence'. The number of infected and cured persons after a sufficient period can be estimated, so it was considered appropriate as a task for this subunit. In addition, simulation with ICT is suitable for the analytically unsolvable equation.

We adopt the Reef-Frost model with a population of *N* persons, Week 0 is the week when the first infected person appears. *Sn* , *In* , and *Rn* represent respectively the number of susceptible persons, the number of infected persons, and the number of immune persons after n weeks, where the following conditions are assumed to hold: (i) only those who are currently infected have the ability to infect susceptible persons, (ii) infected persons are cured and immune after one week, and (iii) immune persons will not be infected again. The following relation (*) holds. Figure 1 shows simulation with *N*=10000, k=0.99979 and 10 people are infected in week 0. We designed three tasks based on these conditions. Task 1: To simulate infectious diseases (*) and the effects of vaccination upon these is modelled using an Excel sheet. We expect students to be familiar with it and to share their results. Task 2: The model from Task 1 is modified to make it more realistic. Infections no longer satisfy the conditions that more than one week is required for cure and immunity always occurs after infection. It is assumed that a certain proportion *g* (0<g≤ 1) of infected persons are cured in the week following infection represented by the modified model (**). Task 3: What changes occur in the simulation results when the values of the various constants are varied? Communicate your results. Task 3 is intended to make the students aware that a smaller value of the constant *g* can lead to 'bad' infections, including some where there is an increase in the number of infections. We expect R_0 has the effect of

$$\begin{cases} I_{n+1} = (1 - k^{I_n}) \cdot S_n \\ R_{n+1} = R_n + I_n \quad \cdots \ (*) \\ S_{n+1} = N - I_{n+1} - R_{n+1} \end{cases}$$

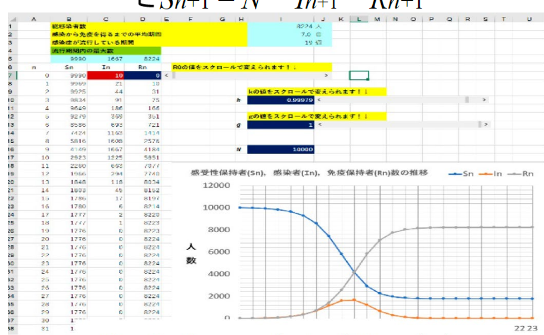

Fig.1 Screenshot of Excel sheet

substantially reducing *N*, and that if *N* is increased while *k* is fixed, the infection spreads quickly where k is a measure of the 'strength' of the infection in a population of N people, and $0 \le k \le 1$ (the smaller k, the stronger the infection. *In* task3 the students simulated the model (**) in groups by changing the values of I_0, R_0, *k*, *g* and *N*, and described what they felt, thought, understood and did not understand.

3. RL and Students' Perspectives of the RL

RL was implemented in a class of 44 students on 22 February 2020 with 27 visiting participants. Students worked in groups of four, and each group was given 12 laptop computers, but we also encouraged the use of personal computers and mobile terminals. The lesson consisted of an introduction (5 minutes), task 1 (12 minutes), task 2 (10 minutes), and task 3 (18 minutes) and a summary (5 minutes). In the introduction teacher Sakai reviewed the data of the cruise ship and the Reed-Frost model (∗). Activities for the three tasks went as planned.

$$\begin{cases} I_{n+1} = (1 - k^{I_n}) \cdot S_n + (1 - g) \cdot I_n \\ R_{n+1} = R_n + g \cdot I_n \qquad \cdots\cdots \quad (**) \\ S_{n+1} = N - I_{n+1} - R_{n+1} \end{cases}$$

Collective post RL reflection and discussion are one of feathers of the Japanese LS approach. In addition to this feature, the research collaborator selected three students (*A*, *B*, and *C*) based on the activities he observed in RL and his opportunities to listen to their ideas.

Among many reflections, regarding what they were thinking while working on task 3, student *A* said , "I changed the value of one of the variables because it was difficult to know how many values there were. I paid most attention to what would happen to the graph if I changed the value, not to what I wanted to do with this value". Student *B* said, "my group had fun working on it, we wanted to make sure that the number of people infected was all of them, and we used a lot of vaccine so that no one got infected. I should have thought more about being realistic." Student *C* said, "we tried to make *n* bigger, and we often found that everyone was infected, which is not the case in the real world, and when that happened, we thought about what was wrong with this model." When asked what they would like to simulate more, Student *A* said, "this time the value of *k* is the vaguest, I would like to simulate the actual number of people we encounter in a day, or how many people would be affected if one person contracted the disease at school." Student *B* said, "infectious diseases are actually more complicated and I don't think they can be expressed in three equations". Student *C* said, "I am similar, but I think there are factors that we have to consider in practice, but I want to think about how we can bring it closer to reality."

Fig.2 RL and Post Reflection

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STEM approach for Sustainability in the Economics classroom

Mate-Klatyik, Andrea J. Johannes Kepler University, Austria

Thursday, 11 May 2023, 11:00-12:00, Live Science

The complex world we live in today has many economic challenges. Climate change (Marks, 2021) or inequality (Bowles and Carlin, 2021) to name a few, which many young people are greatly concerned about, and consequently may be more motivated to act upon. The purpose of economic education is to create responsible citizens and effective decision makers. To enable students to understand the complexity and consequently be able to propose a well-rounded, critically thought through policy to issues of great concern, they have to be given time to explore them in more depth. One way is to engage them in inquiry-based multidisciplinary activities that provide the opportunity to consider such complex issues from different perspectives.

The importance of an interdisciplinary approach in teaching Economics has been highlighted previously many times, for example by Beckman (Beckman, 1989), arguing that it may aid the critically thought through decision-making process. The approach however poses many challenges to teachers, developing appropriately engaging and challenging materials is one of them. We explore using a template created for STE(A)M activities to provide support for teachers and enable a more in-depth exploration of such complex issues with their classes.

Testing ground

The IB Diploma Programme (IB DP) is a 'future-ready programme that builds students' inquiring mindset, fosters their desire to learn, and prepares them to excel at their careers and lead meaningful lives'(ibo.org). Although there is specific content to be covered in each chosen subject, there is a clear emphasis on students developing various skills - including critical thinking skills - and using interdisciplinary inquiry based approaches in the classroom.

The recent introduction of 21st century economic thoughts - The Doughnut Economy in specific - into the syllabus, invites new teaching approaches into the Economics classroom. Through this topic, learners discover the 'increasing dialogue with other disciplines' and 'develop an awareness of the interdependencies that exist between the economy, society and environment and the need to appreciate the compelling reasons for moving toward a circular economy' (ibo.org). To us, it is an excellent opportunity to explore the impact of using a carefully designed interdisciplinary template in guiding students through a complex decision-making process regarding, for example, various market failure, sustainability or sustainable growth issues around the world.

Template origins

Currently in Austria, STEAM approach is not a curricular requirement, however as part of a regional experiment a few schools timetable 2-3 STEAM classes per week throughout the academic year in the next 7 years to trial the effectiveness of STEAM Education. During class, the aim is to provide a rich learning experience to students, in an interdisciplinary, non-subject specific class, where various topics and phenomena are researched and worked on from different perspectives.

Teachers here work in close collaboration with other teachers to deliver multidisciplinary lessons. Most of the time teachers work outside their subject expertise hence the collaboration amongst participating teachers is essential to the groups' success.

Previously (Houghton et al., 2022) it was found that teachers need greater support and dedicated time for collaboration in order to enable them to successfully implement multidisciplinary problem and project-based lessons. However, to achieve this, the above obstacles and concerns have to be overcome.

The STEAM-Connect project focuses on new collaborative innovative methods for STEAM education and through this initiates the acquisitions of new skills and competencies important for those traditionally used in single-subject learning. It aims to develop and trial, closely working together with the participant teachers, innovative STEAM resources and pedagogies for educators making student learning more inspiring and meaningful. As a first step, the goal is to create a common template with which these innovative teaching and learning materials can be shared across schools and countries. This may ensure the effective sharing of best practices. A first version of the developed template was distributed to some of the teachers of the dedicated STEAM classes mentioned above, with the primary goal of eliciting their opinions on the usability and usefulness of the template. To get a better sense of the value of the template, researchers, teacher trainers and pre-service teachers were also asked the same questions.

Promising future

The initial findings of our research were in contrast to the perceived obstacles and barriers described previously. The general view of teachers being more reluctant to use and implement such a template was not supported. On the contrary, both practitioners and pre-service teachers were in favour of the use of this template.

As a template for STEAM lesson creation, its design and open format were particularly praised along with its excellent scaffolding structure. As a format to share ready-made STEAM lessons, its structure is easy and simple to follow while the depth of information given allows teachers to confidently recreate those lessons. By introducing the template into the Economics classroom, the potential gain is twofold: on the one hand, to enhance the teaching and learning in the Economics classroom, in schools where it is offered, on the other hand to include Economics in other subject classes. The reason for the latter is the possibility to equip all students with a better sense of Economics, its complexity and its key principles.

The aim is to use this slightly modified template in the Economics classroom to give teachers adequate support in interdisciplinary lesson creation and enable them to promote such approach in the process of economic decision-making. We are happy to share the template with the wider community, along with some of the tested lesson plans and the initial findings.

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Analysing the Perception of Families of an Open School-community Project on Climate Change

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Thursday, 11 May 2023, 11:00-12:00, Live Science

1. Introduction

The key theme of the conference - Scaling-up professional development in STEM education - is one of the flagship actions of the project “Climate Change Agents (CCA)” in which our study is framed. Such a project is developed in the virtual open-school platform eTwinning, the European online collaboration platform for more than one million teachers, offering professional learning communities, peer learning and Professional Development opportunities (Vuorikari et al, 2011). eTwinning and consequently, the project CCA, foster the involvement of students, parents and teachers as a virtual open school platform. Our study analyses the perceptions of families adopting a whole school approach that promotes the positive participation of all stakeholders to address the challenges of climate change. A further aspect that links our study to the theme of the conference is that CCA included STEAM (Hoffman, Suh & Zollman, 2021) through the integration of educational technologies, the implementation of active methodologies, and the enhancement of critical thinking. Furthermore, the project was based on climate change and integrating environmental aspects in an interdisciplinary way in the curriculum. Parents and teachers share the aim of educating children, including educating them on environmental sustainability issues. This study aims at analyzing climate change awareness amongst families from vulnerable backgrounds in Europe.

2. Methods

Our study addresses the topic of personal dimension from a specific target group as our sample applies to parents. It also adopts an international perspective as the sample (N=149) belong to parents from the Czech Republic (n=52), Greece (n=61) and Italy (n=34). Furthermore, we must highlight that the three schools are in socially deprived areas, a significant socioeconomic variable. Such a particular context will identify possible conditions for teachers and ways to approach climate change through professional development from a professional learning communities' perspective. A description of the participants, the data-collecting validated instrument used (Kuthe et al., 2019) and the descriptive non-experimental design is explained. Statistical analyses carried out including Mean and Standard Deviation, Cronbach's alpha, as well as the scale reliability per dimension, are carried out and included in tables. Kolmogorov- Smirnov's, and Kruskal-Wallis' tests results are broken down. Finally, K-means cluster analysis conducted identifies the different groups of parents and the differences between cluster centres. They are also displayed through a canonical discriminant functions image.

3. Results

The scale on its set shows a reliability according to Cronbach's Alpha statistic of 0.84. Table 1 shows the results of the mean, standard deviation, and reliability of the dimensions.

Table 1. Dimensions

Dimension	M	SD	SR
Attitude, Interest, Responsibility and Locus of Control	5,20	0.71	0.75
Personal Concern	4,04	1.40	0.96
Climate-Friendly Behaviour	4.92	0.75	0.81
M = Mean; SD = Standard Deviation; SR = Scale Reliability measured by Cronbach's alpha N = 238			

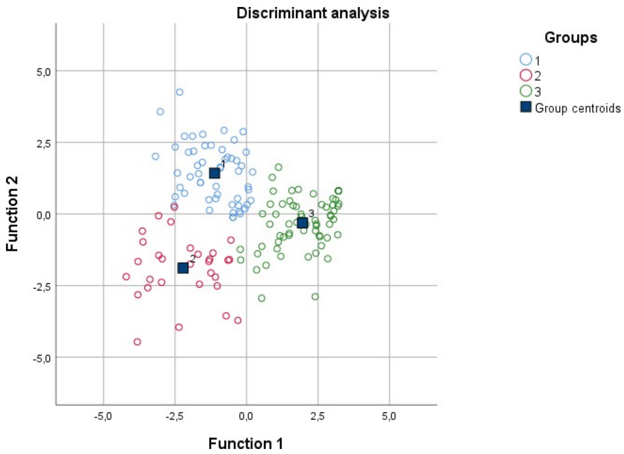
Considering the results of the Kolmogorov-Smirnov's test, we can affirm that the data do not follow a normal distribution. In the identification of the determining variables of the data model, only significant differences have been identified depending on the country, using the Kruskal-Wally's test. The Czechia has shown the lowest results in all three dimensions, and Italy the highest except in the behavioral dimension, which is behind Greece.

The analysis of K-means has generated with guarantees a classification in 3 groups, each with an N of G1 = 54, G2 = 30, and G3 = 65. There is no correlation between countries and groups generated. Table 2 shows the mean of the centroids of the groups.

Table 2. Means of the centroids of each group

	1	2	3
Attitude	5,38	4,19	5,51
Personal concern	2,90	3,22	5,36
Behaviour	5,17	3,95	5,16

The first two canonical functions of discriminant analysis explain 67.6% and 32.4% of the variance respectively. Figure 2 shows the distribution of groups in the ordering space formed by canonical functions.



4. Discussion

Results show that the general level of awareness of parents in the three schools towards climate change and the open schooling project is positive with a mean score between 4 and 5 in a 6- point scale. The cluster analysis confirmed the identification of three types of parents according to their level of climate change awareness. Nevertheless, Kuthe et al. (2019) identified four types of groups with regards to students' level of climate change awareness. This information is valuable as it can help to tailor future educational open-schooling projects, rooted in a whole school approach integrating STEM, using online platforms and increasing in an intergenerational way climate change awareness. Furthermore, the findings are also relevant for identifying possible areas to scale-up the professional development of teachers as well as offering directions for future studies.

Acknowledgements

We would like to thank all parents involved in this study.

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PATIS BIODIVERS: Engaging elementary students in authentic inquiry to improve the biodiversity of their schoolyard

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Thursday, 11 May 2023, 14:30-15:30, Auditorium

1. Rationale of the project

After the United Nations Decade on Biodiversity (2011-2020), the Convention on Biological Diversity published a first draft framing the post-2020 Global Biodiversity Strategy. In the document, which is aligned with 2030 Sustainable Development Goal, set out a plan to implement numerous actions to bring about transformation in society's relationship with biodiversity (Convention on Biological Diversity, 2021).

Learning about biodiversity is seen as a key element of this strategy. According to Van Weelie and Wals (2002), there are four main arguments for working on biodiversity: a) emotional argument, based on personal meaning through discovery and experiencing biodiversity; b) ecological argument, based on understanding the global interconnections among the variety of elements of the ecosystem; c) ethical argument, based on dealing with values and taking a moral point of view in environmental issues; d) political argument, based on making choices and developing action competences.

Having said that, Gayford (2000) alerts that although there are numerous teachers who are concerned about biodiversity loss, they do no not know how to integrate this issue to their teaching lessons. The main obstacles are: a) the complexity of this issue, which requires an interdisciplinary approach; b) the constriction of time and the need to cover the science curriculum. Furthermore, it is important to remark how important curricular materials are to support teachers in these challenging obstacles. Regarding how to create an adequate TLS, several features should be considered. For instance, learning contexts – a specific setting where students learn such as backyards and schoolyards – are revealed as an essential tool in making biodiversity meaningful for the students (Wals, 1999).

According to Afkin and Black (2003) authentic scientific inquiry means "doing of science" as the actual practice of scientific communities does. From a scientific authentic inquiry perspective, Roth and Lee (2004) also pointed out that goals in school science should be motivated by the same goals within the scientific or local community where the inquiry is taking place.

2. Overview of PATIS BIODIVERS project

PATIS BIODIVERS [*BIODIVERSE SCHOOLYARDS*] is a project with two major goals. On the one hand, to promote processes of authentic inquiry practices among kindergarten, elementary and secondary students, such as: collecting empirical data of the of their schoolyard, drawing conclusions, and promoting actions to improve the diversity of the species. On the other hand, to use this empirical data from schoolyards to do scientific research.

This project was born in the November 2021 in Vic, a small city in a semirural area 70 km from Barcelona. The materials and the resources were created collaboratively from an interdisciplinary team of researchers from Universitat the Vic – Universitat Central de Catalunya (UVic-UCC), with the support of more than 40 teachers, from 13 different elementary and high schools of Vic. All these teachers participated in two different seminars, in order to create two different kinds of materials.

First, teachers representants of these schools participated in a seminar in order to design a methodology to implement a Bioblitz in the schoolyards. In the seminar, three sessions were dedicated to discussing how to organize the students, how to collect and register data and how to help students to identify the main species of the schoolyards. The challenge was to create a common methodology that was useful from kindergarten to secondary students. More than 800 students, from kindergarten to secondary students, participated in the school Bioblitz.

Second, 26 elementary and secondary teachers representants of the schools participated in a second seminar with the main aim of create three Teaching and Learning Sequences (TLS) to work on the biodiversity of plants, invertebrates, and birds from an authentic inquiry point of view. A first draft of these TLS was created by the researchers from UVic – UCC and presented in the seminar. After the implementation of these TLS by teachers with their students, different focus groups were carried out to evaluate how the TLS worked, to improve the initials drafts.

The three final TLS share the following structure in 3 phases:

- Contextualization phase: students become familiar with a real biodiversity issue and describe the main environments of their schoolyard.
- Inquiry phase: students collect real data of birds, plants or invertebrates in their schoolyard in order to find which environment has more biodiversity.

- Action phase: students have to think and design real actions to improve the biodiversity of plants, birds or invertebrates.

Currently, the project is opened for every Catalan school interested in the project, it is expected to have between 20 and 30 schools involved in the project at the begging of next year. Now the materials are being translated in Spanish and Basque to expand the project geographically.

3. Overview to the research dimension of the project

Patis Biodivers is not just an innovative way of helping teachers to work on biodiversity in schools, but also is a good research context for understanding teaching and learning processes on Biodiversity. This communication attempt to reflect on how scientific inquiry and knowledge about biodiversity can be learn through a project like PATIS BIODIVERS. In particular, we are going to present two research goals:

a) To identify the main limitations and chances in working on biodiversity from teachers' views.

b) To evaluate the change in the students' ideas regarding the factors that promotes biodiversity and to identify he most meaningful moments in working on biodiversity from students' views.

For the purpose of this communication, it is only presented the research on the studies related to teachers' views.

3.1 Researching on teachers' views

As presented above, the focus of this research goal is to identify the main purposes, limitations and chances perceived when working on biodiversity. In our view, understanding the main purposes of working on biodiversity could help us to select and adjust the main contents of future TLS, while knowing limitations and chances could also help us to design activity more adequate for teachers' needs.

In order to achieve this goal, in the first session of the course for the creation of the TLS, a questionnaire was distributed among the in-service teachers. In particular, in-service teachers were asked to name three main ideas and three main purposes when they work on a biodiversity project with their students. 10 questionnaires were analyzed for the purpose of the study.

Apart from that, notebooks were provided to the teachers involved in the project, in order to explain how each activity of the TLS were developed with their own primary and secondary students. Finally, interviews with the teachers who participated in the project were conducted to evaluate the project and to know their experiences while implementing the TLS with their students.

3.2 Preliminary results

From the questionnaires (Fig. 1), it could be seen how teachers identify that action to improve biodiversity is the most important learning goal when they work on biodiversity with students. They also identify the classification of groups of live beings, the work on habitat concept and the recognition of the main vegetal and animals species as important learning goals.

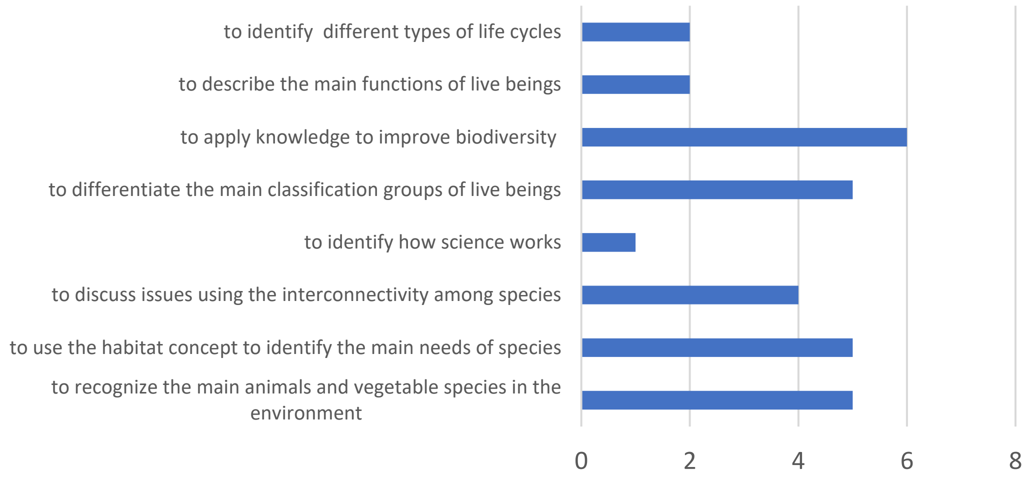

Figure 1. Main learning goals in a biodiversity project

Regarding the purpose, teachers justify the importance of working on biodiversity because students should understand the interconnectivity among species (Fig 2)

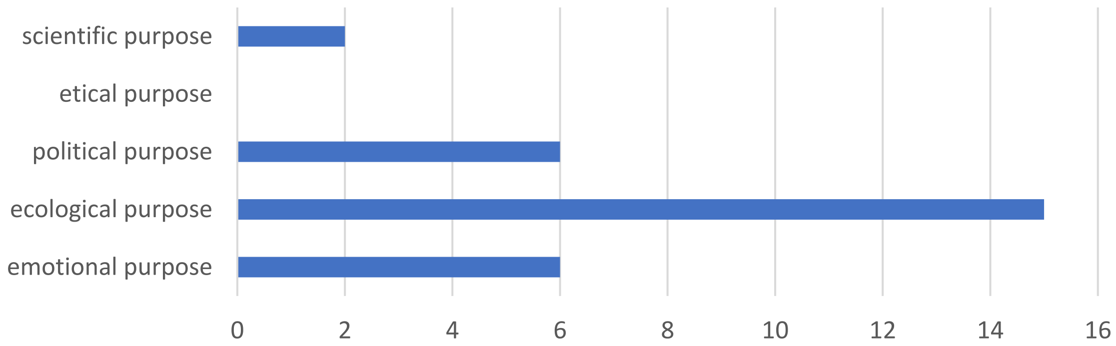

Figure 2. Main purposes to work in a biodiversity project (Based on arguments proposed by Van Weelie and Wals (2002))

From the notebooks and interviews, it could be seen how in-service teachers expressed in different moments difficulties in the identification of the most representative species. On the one hand, secondary teacher expressed the need to spend some time on working with the student in order to recognize the most representative species of the schoolyard. On the other hand, primary teachers express how difficulty was for themselves to recognize the species.

Furthermore, in-service teachers explained that the practice of analysing data from the species of the schoolyard is a time-consuming task. For this reason, some of them do analyze the data of the species that lived in the different environments of the schoolyard, in order to know how the biodiversity was distributed in the schoolyard.

Even though there are no literal excerpts regarding this topic, after analyzing what they did in the implementation of the TLS, primary and secondary students just had made decisions to improve the schoolyard, but none of these decisions were implemented.

3.3 Preliminary conclusions

From the preliminary results presented, it can be seen how even though the most common learning goal of being involved in a biodiversity project is “to apply knowledge to improve biodiversity in the schoolyard” and “the political purpose” of acting to improve and take care of the environment, actually teachers had some difficulties to guide students to do tangible actions to improve biodiversity. In this respect, probably the “ecological purpose”, as a inner purpose of the participants, pushed teachers to do more activities to focus on the biological contents, such as: identification of species, working on the idea of habitat or ecosystems, and so on.

Having said that, obviously further research is needed. After opening the project to more schools and teachers, more data will be collected using the two tools presented in this paper: a) a modified questionnaire asking questions regarding learning goals, purposes, but also activities to achieve this goals.

Acknowledgements

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MOST: Science Fairs Through Virtual Environments

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Thursday, 11 May 2023, 14:30-15:30, Auditorium

1. Introduction

Celebrating STEM through stellar, multi-faceted programmes with high entertainment value and integrity of scientific content accessible to the general public seemed an effective way of science communication. According to The Royal Society's research (2006), scientists and engineers, 69% of whom agreed or strongly agreed, would be happy to participate in a science engagement activity that someone organised. This points to the importance of the substructure of science engagement: science centres, science festivals and organisations all help to provide the places and occasions for public/scientist dialogue (Bennett & Jennings, 2011).

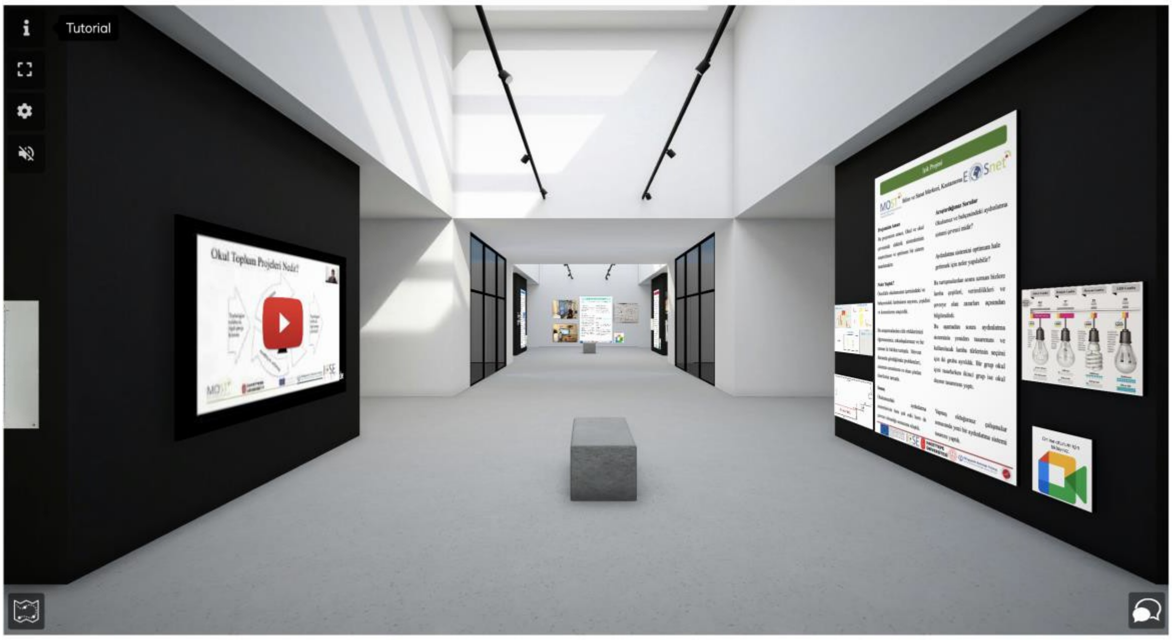
However, with the Covid-19 pandemic, meetings, training, exams, seminars, seminars, workshops, and even companies working with the classical office approach started to look for new ways to change their work and methods. These search efforts have also changed the quantity and quality of distance education systems, online meeting interfaces and digital tools. The platforms used for educational purposes changed traditional lecturing and enabled the scientific events organised in schools to be moved to these online platforms. Even art galleries or exhibitions opened in schools started to be visited online.

This study investigates the use of virtual fairs for scientific activities and the participants' experiences in this regard. In this study, we tried to better understand the process by the relevant people by sharing some applications for moving science fairs organised in schools to online environments and teachers' experiences participating in these fairs. This study was carried out within the scope of SCP fairs, where open school community projects (SCP) were shared within the scope of the MOST project. The SCP project focuses on community and service, encouraging students to explore their rights and responsibility to implement service as action in the community. The community project allows students to develop an awareness of needs in various communities and address those needs through service learning.

Within the school community projects, projects on environmental issues such as waste and energy management were carried out with the community members in science education. The school community projects were carried out independently in different regions of Turkey. However, sharing the outputs or experiences obtained from the projects with project leaders, participating students, stakeholders, and researchers is essential. In this context, it was decided that the best way to bring together projects in different parts of the country was to organise an virtual intractive fair, considering the pandemic conditions. The school community projects fair process and the participants' experiences in carrying out school community projects synchronously in a non-face-to-face structure were examined and evaluated.

2. Methodology

The study was conducted as a case study. Virtual fairs and user experiences about these fairs were determined as the case in the study. In the study, school community projects with waste and energy themes were carried out in schools under the leadership of STEM teachers. Then, the teachers prepared an interactive online poster describing each project. Then, these posters were uploaded to the system whose infrastructure was prepared by the MOST Turkey team on the "Artstep" platform (Figure 1). A Google meet link was placed next to each poster, and synchronous interaction room links were placed where teachers, students, stakeholders and anyone who wanted to get information about the SCP project could participate.



OKUL TOPLUM PROJELERİ FESTİVALİ

Figure 1. Virtual SCP fair

In the study, system recordings during the virtual fair and an interview form consisting of open-ended questions were used as data collection tools. The interview form includes questions about the experiences of project leaders in virtual fairs, the use of posters developed within the scope of school community projects, Google Meet rooms used for the presentation of posters, and the differences between face-to-face fairs. Through these questions, virtual fairs were used be handled multi-dimensionally. A data-based approach (Kurilovas, 2020) was used in the study process by creating code and theme lists based on the answers to the interview questions.

3. Findings
Data analysis studies are ongoing in the study.

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STEM education through real life contexts and sustainability issues: the teach4life case in Spain

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1. Introduction
We need highly qualified STEM professional and well-informed citizens to tackle current technological and environmental challenges. People with the capacity to address complex socio-scientific issues and to actively participate in the development of sustainable solutions. But what kind of education brings these outcomes? Are teachers prepare to adapt to current educational needs? This paper analyses and discusses how key principles for transformative Teacher Professional Development (TPD) have been addressed and enacted in Spain, during the implementation of a program to support teachers in the use of inquiry, socio-scientific issues and real-life contexts for STEM and sustainability education. This contribution is well aligned with the scope and focus of ETE IV conference because: 1) It builds on pedagogies and teaching resources that allow the integration of STEM and sustainability education to address real-life issues beyond the classroom (open-schooling). 2) It describes the structures used for a successful implementation on a classroom level: ways of working for teachers); on a school level: alignment with the school curriculum; and on a policy level: providing formal training and recognition. 3) It describes an inspiring country-specific experience, identifying key aspects for the transfer to others national contexts and for sustainability and scaling up.

2. Current challenges in teacher professional development

According to the European Commissioner Mariya Gabriel (2022), even though teaching has always been a demanding profession, the public health crisis has placed huge pressure on the teaching workforce and definitely changed the teaching experience with and through technology. As digital tools and technologies began to be widely used for the first time in school education, the school community faced new challenges and the need to find suitable digital platforms and resources to effectively support teaching and learning. However, having high- quality digital resources might not be enough if there is no clear understanding of the pedagogical principles underlying the design of these resources and how they must be used to ensure students' cognitive and emotional engagement and learning (Ariza & Quesada, 2014).
In addition, teachers usually claim that they need specific training and support to feel comfortable and self-confident when implementing new resources and innovative ways of teaching (Ariza et al., 2020; Ariza et al., 2021). But what kinds of programs and teacher professional development activities have a significant impact on teachers' beliefs and practices? Activities such as seminars, talks or conferences in which teachers tend to be passive recipients of information or even brief and sporadic workshops that are disconnected from classroom practices, and unrelated to teachers' actual needs and interests have very little effect. Some authors have referred to them as "style shows," or "spray and pray approach" given the lack of structures to provide teachers with opportunities for collaboration and for receiving feedback and follow-up support (Bautista et al., 2015).
According to the impact of TPD on teaching practices, TPD programs have been graded as transmissive, transitional or transformative, being the transformative practices usually related to the existence of a community of practice made of teachers who collaborate in the exploration and implementation in their daily teaching of innovative pedagogies, sharing experiences and reflections (Ariza et al., 2021; García et al., 2019).

3. The European project 3C4LIFE and the digital platform teach4life

Building on the previously outlined background and responding to current societal needs, the 3C4LIFE European project promotes the collaboration between researchers and policy makers in STEM TPD to develop, test and scale up the online platform called teach4life. It consists of an open access-platform with communication and collaboration tools, attractive teaching resources and inspiring information about different opportunities and multiple pathways for career development. It offers a collection of open-access educational resources including images and videos, designed by experts and implemented in different countries. The teaching resources combine inquiry approaches with the use of real-life contexts, including contemporary socio-scientific issues that make learning relevant to students, with opportunities for competence development and meaningful knowledge application to solve STEM and sustainability problems and to make informed decisions. All the teaching resources include supporting information, solutions and pedagogical guidelines with key tips to implement them in the classroom. In addition, it offers tools for teachers' communication and collaboration while trying out new pedagogies and resources, fostering reflection and the exchange of experiences and allowing the development of communities of practice.

4. The Spanish case: providing strategic support to transformative STEM TPD

To ensure appropriate structural support, we set a strategic collaboration with the main STEM teaching centre in Spain, offering the teach4life platform within the context of a formal TPD course, accredited by educational authorities. During the design and implementation process, special attention was paid to the following aspects: 1) highlighting the alignment with the Spanish educational curriculum and current teaching recommendations, including the integration of sustainability issues in a cross-disciplinary way; 2) the strategic use of existing structures to provide systemic support and 3) the official recognition of the specific training acquired and teachers' effort and commitment to undergo updated and lifelong teacher professional development. In the presentation we will discuss how we have addressed fundamental principles for effective TPD, connecting with teachers' needs and the Spanish curriculum, providing long term support and building communities of practice.

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Teacher Leadership

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1. Introduction

Teacher leadership is well-documented to promote positive educational changes for students (National Research Council [NRC], 2012). Understanding how to develop teacher leaders is a potentially powerful means to scale quality STEM education. The model we have been implementing focuses on distributed leadership at the school district-level and emphasizes (1) changes in teachers’ instructional practices; (2) the development of teacher leadership; and (3) the spread of distributed leadership across the school district during and after participation in the science education leadership program. This national sample of teachers, from ~35 school districts in seven regions of the country, helps us identify salient components of leadership within schools and districts that are transferable to other settings.

Developing teacher leaders and supporting these individuals to lead while remaining in the classroom is an important component of this work. Leading teachers need to have the requisite skills and knowledge of excellent classroom teachers *and* be able to work with other teachers and encourage them to make changes in their classrooms. Evaluation data from the seven sites has demonstrated the effectiveness of the program in developing teacher leaders who can support district initiatives in science education.

2. Program Description – Year 1

The Science Education Fellowship program is a two-year fellowship involving about 60 teachers from each of seven sites, chosen from participating districts resulting in roughly 420 teachers, total. Districts apply to participate in the program through the sponsoring university. High need districts are specifically encouraged to apply. Fellows apply within the selected districts and are selected based on their background, grade level, science content area, and essay responses. Fellow qualities such as being under-represented, committed to student learning, and potential to be a leader are important.

In year 1 of the program, the selected Fellows participate in 125 hours of professional development where teachers improve their instruction through professional learning communities (DuFour and Eaker 1998; Stoll et. al. 2006), tuning protocols (Easton 2009; McDonald et. al. 2013), and lesson study (Cerbin and Kopp

2006). This results in a program in which these potential leaders inquire into their own teaching (guided by research-based methods and the Framework/NGSS), while working collaboratively with their colleagues.

In the first semester, teams are comprised of mixed grade-level K-12 teachers, “vertical teams.” Each team chooses a course of study including a Disciplinary Content Idea and a research article regarding teaching practice. In the second semester, the teachers form “horizontal teams” across similar grade bands. Their course of study includes one Science and Engineering practice and a research article. These courses of study become the lens through which the Fellows analyze the lessons. Throughout the year, Fellows work in collaborative coaching and learning in science (CCLS) teams where they provide feedback on videos of each other’s lessons, the lesson plans, and student artifacts.

Outside of these teams, the teachers collectively work across grade levels and with teachers from other districts to explore what it means to be a teacher leader. In this setting, for instance, they learn about science education priorities in their own and other districts from District Science Coordinators.

3. Program Description – Year 2

In year 2 of the program, the teachers engage in an additional 125 hours of professional learning. A signature experience of this year is the creation and enactment of a professional development plan including a leadership project and referred to as a Growth Plan System (GPS). The GPS has two components: 1) 50 hours of support for district initiatives; and 2) 50 additional hours for a personal professional learning plan focused on improving practice. The district-aligned goal is chosen in consultation with the district science coordinator. The GPS is approved by the district coordinator and an adviser assigned by the university who meets regularly with the Fellow. In addition, there are quarterly cohort meetings with the other Fellows in their cohort. It is through their actions in year 2 that their leadership knowledge and practices are operationalized and refined so that the Fellows are supporting institutional change (see Lukacs and Galluzo 2014). This year of professional learning supports increased teacher learning and change in teacher practice. The selection and implementation of each Fellow’s GPS speaks to the need they perceive for changes in their classes and community.

Of the 413 different goals analyzed, 119 can be considered to be aligned with Open Schooling. The majority of these projects (74/119) can be grouped into six different overarching themes. These themes are: science interest/science literacy (22), project or place based learning (18), extracurricular/after school/clubs (10), outdoor learning (10), community engagement (7), and teaching strategies (7). As will be seen, there is some overlap among projects.

3.1. Science interest/science literacy in this context includes projects with the explicit focus of engaging students and fostering a deep interest in science, helping them to be more informed and science literate citizens, or encouraging the pursuit of careers in STEM. Example projects include:

- Build interest in STEM career and maximize utilizations of an outdoor learning space.
- What impact does participating in hands-on activities with the DeSoto ISD/Perot Museum partnership have on 5th Grade students’ perception of STEM? "This goal is to help students understand the relationship and of STEM plays in their everyday life.”
- Promoting scientific literacy using social issues, such as how nuclear technologies effect global politics. This approach aligns classroom content with the NGSS and district literacy goals.

3.2. Project or place based learning in this context involves students learning about science/STEM concepts either through application in specific projects or by developing solutions to community problems/engaging in the greater community. Example projects include:

- To turn the 8th Grade Science Field Trip to Rock Bridge State Park into a PBL (Project Based Learning) project that encompasses STEAM (science, technology, engineering, art, and math) as well as ELA and social studies.
- Develop a Placed Based Education project that a middle school student observes a problem and finds a solution to help solve it, and persuades others to recognize the problem.

- Hold a Project Based Learning (PBL) Lesson Study Series for educators who are trained in PBL and are committed to a learning stance in dismantling racism in classrooms through PBL.

3.3. Extracurricular/after school/clubs are interest groups and clubs designed to provide additional educational opportunities for students beyond the classroom. Example projects include:

- Begin a science of cooking after-school program…complete the online class and take pictures of students completing monthly seminars on cooking and science.
- Establish an American Chemical Society club to develop a community of students active in the pursuit of professional attitudes toward the study of and careers in chemistry or other areas of science.
- Organize and lead an after-school STEM program for 3rd-5th grade girls on campus called GEMS.

3.4. Outdoor learning in this context is projects that take students outside of the classroom and school building to apply science learning. Example projects include:

- Identify ways to push past the walls of the high school classroom and use the classroom, school building, and neighborhood in richer ways to foster differentiation and increase students' thinking and learning.
- Mobilize students, staff, and community partners to transform the schoolyard into a vibrant outdoor science learning space. This project involved researching pertinent policy documents regarding outdoor and nature-based education in the local context, documenting and inventorying our outdoor classroom infrastructure and materials, surveying teachers on interest and comfort levels in teaching outdoors, and collaborating with community partners, staff, and students to plan and execute a mural project in the outdoor classroom that tells the story of where our water comes from.
- To create sustainable garden boxes for children to become environmental stewards. The initiative will bridge the whole school community (TK-5th grade) around the responsibility of gardening and the impact we have on our school campus.

3.5. Community engagement projects looked to involve the greater community in the learning process. Example projects include:

- Revamp the overgrown, inoperable outdoor classroom at Thurgood Marshall… to give back to the campus by fixing an existing issue while working alongside students.
- To create (with students) an Urban Ecology based musical that the West Zone ELC students will perform in the spring of 2017.
- Implement an "Elementary Science Night" for students to participate/interact with a large number of science activities and lessons.

3.6. Teaching strategies projects were those where the classroom teacher engaged in a new or different teaching practice in order to build science STEM interest amongst their students. Example projects include:

- To be a more effective teacher by using podcasts to introduce and review content.
- To create a place-based learning area on our school grounds in the form of a flower/pollinator garden outdoor classroom area.
- Implement, develop, and enhance a quality "Cooking with Science" instructional program and a mentorship program between high schoolers and a second-grade class.

The projects listed above are representative of the categories that encompassed the greatest number of Open Schooling related projects. Among the projects that did not fall into these categories there are other notable projects. Some of these projects include:

- Write and publish a children's book based on educating during the pandemic in 2020.
- Write and illustrate a children's book that focuses on science inquiry as seen by a recent Latina immigrant who is just starting to learn English.
- Instead of taking a traditional approach to climate change, students will have an experience in which they collect the opinions of others about climate change and then present these opinions to a broader

audience. In order to do this, students needed to practice interpreting data, designing their own questions and survey and then analyzing and communicating survey results to the public.

As these projects demonstrate, Open Schooling can be woven into the fabric of current approaches to education. These projects enhance the educational experience for students and begin to engage the greater community. Many of these projects can contribute to creating a more scientifically literate citizenry that will be needed to address the challenges facing the world today.

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MicroMundo: Service-learning Project on Antimicrobial Resistance

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1. Introduction

Antimicrobial resistance (AMR) has become a cross-cutting problem in clinical, food and environmental areas, and so, the "One Health" approach should be undertaken (McEwen and Collignon 2018). Deficient knowledge in this topic requires education and training, according to WHO (2015) and 2030 Agenda for Sustainable Development (United Nations 2015).

To address this problem novel pedagogical strategies such as MicroMundo have recently been developed (Valderrama et al. 2018), originally implemented in 2012, in the USA with "Small World Initiative" designation (SWI; http://www.smallworldinitiative.org/). MicroMundo is a creative service-learning project that combines soil sample collection and laboratory work to discover new antibiotics. We present here our results on a pilot experience to introduce MicroMundo at the University of La Rioja, as an open schooling initiative.

2. Materials and methods

Service-learning methodology. The first step was performed at university. A team was established, consisting of one faculty member (SWIPI: Partner Instructor) and four postgraduate students (SWITAs: technical assistants). The SWIPI trained the teaching abilities of SWITAs through periodic sessions. The second step was performed in secondary school, under the general supervision of SWIPI. In this process, the 4 postgraduate students (SWITAs) and 18 students (SWISs) of a secondary school (La Rioja, Spain) were involved. They made up 13 groups, each of which analysed a soil sample.

Practical activities. Practical work was divided into five 2-h sessions following the methodology explained by Valderrama et al. (2018)

Surveys, data analysis and statistics. As a measure of the development of the project, post- surveys were carried out on SWIs and SWITAs.

3. Results and discussion

Sample characterisation and isolates recovered. Thirteen soil samples were analysed, and 260 bacterial isolates were recovered. Ten of them were selected as potential producers of antimicrobial molecules, obtained from six soil samples. Antibiosis tests revealed that three isolates produced antimicrobial molecules, with inhibitory activity against 90% of the tested indicator bacteria, including relevant pathogens. These results showed students the importance of searching for new antimicrobial agents, the risk of antibiotic resistance and the concept of One Health (Figure 1).

Figure 1. Representation of the SWI-UR work team and explanatory lessons as well as examples of the Gram-staining, antibiosis test and antimicrobial susceptibility results achieved by secondary school students during the project.

Survey results. Satisfactory results were obtained in the overall closed questions both to SWISs (value of 4.02 out of 5) and SWITAs (value of 4.6 out of 5) (Figure 2).

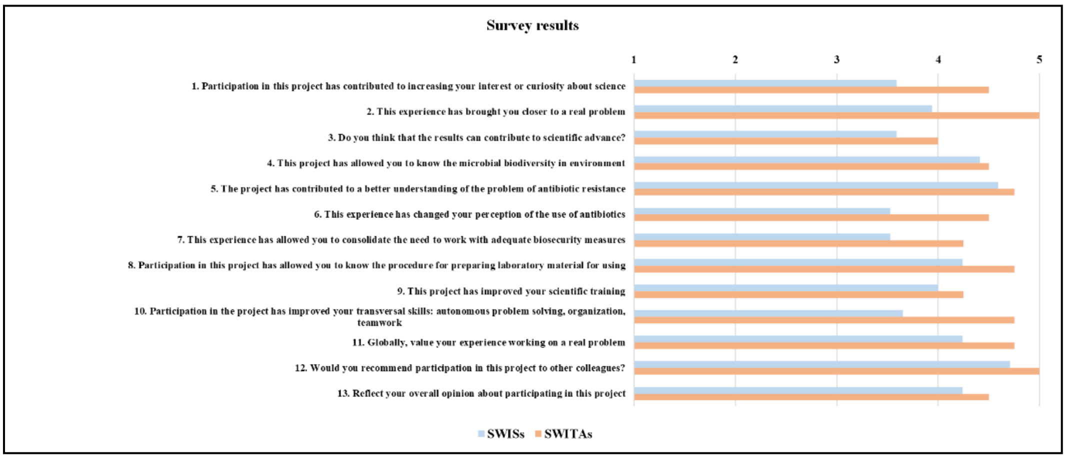

Figure 2. Survey results of the closed questions on secondary school students (SWISs) and postgraduate students (SWITAs) in the SWI experience (Likert scale from 1 to 5).

Concerning the total number of questions in relation to knowledge and perceptions regarding antibiotic resistance, results were satisfactory and statistically significant according to Fisher's test (p value ≤0.05) when compared with previous research of students of similar age who did not carry out the project (Figure 3).

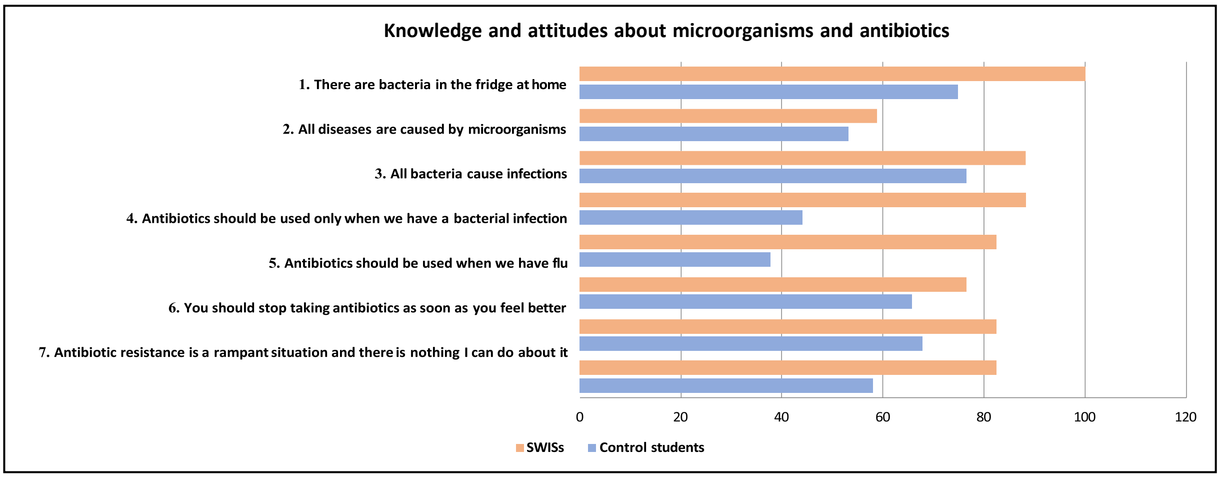

Figure 3. Comparative study, showing percentage of correct answers, of knowledge and attitudes about microorganisms and antibiotics by SWIs and control students.

Therefore, a connecting loop has been performed between teaching and research, promoting scientific vocations, and communicating scientific culture in antimicrobial resistance. This project can serve teacher educators to support teachers in the execution of open education projects on environmental issues of current interest such as antimicrobial resistance.

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How do the CriThiSE PD-model support teachers in implementing critical thinking in sustainability education at upper primary school?

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Abstract
This study is conducted within the project CriThiSE (Critical Thinking in Sustainability Education), which is a large-scale three year longitudinal initiative that aims at scaling-up the implementation of Critical Thinking (CT) in the context of sustainability education in primary school. In cooperation with teachers, we develop their CT instructions and investigate if and how these instructions are enacted in their classrooms, and further investigate the influence on students' development as critical thinkers. In this paper we focus on the structural and context dependent aspects of the professional development project based on the experiences of using a specifically developed professional-development model (PD-model) in the five different intervention schools. By using a mixed method approach including interviews and questionnaires with the teachers from the ongoing project we discuss their experiences of the PD-model and its implementation at the different local schools. Most of the teachers perceived that they got a new and developed understanding of how to teach critical thinking in the context of sustainability education. However, we also discuss the experienced obstacles relating to structural issues such as school leadership and the working organization.
Key words: critical thinking, longitudinal study, primary school, Professional Development-model, sustainability education

1. Introduction

This presentation relates to Topic 3 (Structural dimension) and addresses the question: "What structures are needed for implementing and sustaining open schooling initiatives, such as school-community projects, on environmental issues?" Our study is conducted within the context of the project CriThiSE (Critical Thinking in Sustainability Education), which is a large-scale initiative that aims at scaling-up the implementation of Critical Thinking (CT) in the context of Education for Sustainable Development (ESD) in primary school. The goal is to develop students' ability to relate critically and at the same time democratically to different perspectives on sustainability issues.

As teacher educators, we have designed a research-based Professional Development (PD) program for in-service teachers. Our aim is twofold: Firstly, to equip primary teachers in science and other subjects with knowledge about ESD and CT, as well as competencies in teaching these topics. Secondly, by working with in-service teachers across regions and countries, we aim at spreading the classroom implementation at national levels. In our presentation we will explain our PD-model, as well as the in-service teachers' perceptions on the implementation of this model. The PD-model is meant to be used by teacher educators, hence the relevance to the overall conference theme (Educating the Educators) and to Topic 3. Our presentation will be addressed from a target group-specific perspective, i.e., in-service teachers' experiences. We intend to use the oral presentation format.

2. Theoretical background and rationale

In the last decades, much research has been done in relation to continuing professional development (CPD) and related quality criteria have been developed. To be effective, CPD should be collaborative and extended over time, include time for practice, coaching, and follow-up, be grounded in students' curriculum, and aligned with local policies, be job-embedded and connected to several elements of instruction (Caena, 2011; Desimone, 2009; Lipowsky and Rzejak, 2012; Putnam and Borko; 2000). Research indicates that communicative and cooperative activities represent the core factors fostering sustainable impact of CPD programs (Lerman & Zehetmeier, 2008). Lerman and Zehetmeier (2008) also state that, in particular, providing rich opportunities for collaborative reflection and discussion (e.g., of teachers' practice, students' work, or other artifacts) presents a core feature of effective change processes. There is also growing evidence that collaboration among teachers is a key ingredient for effective CPD (e.g., Schleicher, 2016). However, we need more insights on the interplay of material, features of the CPD course and the background conditions (Lipowsky and Rzejak, 2015). In this study we therefore aim to develop and implement a PD program in different contexts and analyse the outcomes thereof.

CT has been proposed to be one of four main competences to promote within sustainability education (Church and Skelton, 2011), and suggested to be an underlying basic competence in ESD to develop students into action competent individuals in complex environmental issues (Wiek et al., 2016). Others express CT explicitly as a key competence, as going deeper into sustainability challenges will require a critical approach (UNESCO, 2017; Scheie et al., 2022) CT is also suggested to be a necessary competence in combination with the other sustainability competences (Scheie et al., 2022). However, there is a gap between policy and practice, and it has not been shown how CT can be integrated into sustainability education. In the project Critical Thinking in Sustainability Education (CriThiSE) we are addressing this issue by working with primary teachers in an educational design project where the aim is to develop teaching of CT within sustainability education and investigate the outcomes thereof. As part of the project, we therefore develop a PD program on CT within sustainability education.

3. Context: Critical Thinking in Sustainability Education (CriThiSE)

This study was carried out within the framework of the project CriThiSE (Critical Thinking in Sustainability Education). CriThiSE is a collaboration between researchers and teacher educators in Sweden and Norway. The primary objective of the project is to develop teaching of critical thinking (CT) and investigate the outcomes thereof in primary education. CT is emphasized as a central twenty-first century skill - central in education, work life and civil society. Today's schools therefore need to educate coming generations in a way that encourage them to reflect critically on their own and others' decisions. This is a crucial issue where elementary school education should contribute to coming decades in order to facilitate continued democratic advance of society, as also recognized in the new Norwegian curriculum and governing documents. Sustainability challenges are complex, where values and knowledge form the basis for the decisions made. To validate the important choices that must be made in a pluralistic and democratic society, competence in CT is crucial (Davies and Barnett, 2015).

In CriThiSE we are conducting a longitudinal study of what it means to think critically in school. We develop and evaluate teaching of CT within different contexts of ESD and within different subjects. In cooperation with teachers, we develop their CT instructions and investigate if and how these instructions are enacted in their classrooms, and further investigate the influence on students' development as critical thinkers.

4. The CriThiSE PD-model

The overall purpose of the PD program is to develop teaching methods for how ESD and CT can be taught in upper primary school and how they can be an integrated part of everyday teaching. The purpose is also to develop abilities for the students to take part in fruitful conversations about complex issues without simple answers that include a diversity of values and viewpoints, with a sound, critical stance.

The PD design was based on local PD studies (Haug and Mork, 2021; Scheie and Stromholt, 2019), as well as design principles from Caena (2011) and Desimone (2009). We run three workshops á 2 hours per semester, in total 18 meetings over a period of three school years. During each workshop teachers exchange experiences, and teacher educators present new theory, didactics and model a new classroom activity. Between meetings, teachers practice collaborative work, try-outs and student involvement. During the last school year, the teachers will plan and carry out a larger project at their own school which is based on an authentic dilemma.

5. Methodology

The data collection for this presentation used a mixed method approach including a teacher questionnaire from five intervention schools, and focus group interviews with a sample of teachers. In total, 48 Norwegian and Swedish primary school teachers answered the questionnaire. The teachers had teaching experience ranging from 0 to 40 years, averaging to 14 years. The results were analysed using descriptive statistics. Teachers from five different schools teaching 5th to 7th grade, were selected via opportunity sampling to take part in focus group semi-structured interviews. During the interview they were asked to elaborate on “can you think about how your understanding of CT has changed during the intervention and how this affects your teaching?” Interviews were subject to thematic analysis (Robson & McCartan, 2016).

6. Preliminary findings and discussion

Based on the preliminary analysis of the interview data we see that teachers from intervention schools have a more nuanced picture of CT than before, e.g., as illustrated by this statement: “Before, I thought that paying attention to sources, being critical of sources, was critical thinking. Now, because of the intervention, I am much more aware of the importance of CT and see it in relation to my students and teaching in several ways”. They are more conscious, see more possibilities on how to include CT in their teaching and see the importance of giving students the right tools, e.g., “I feel that I have become more aware of it in my teaching, how to use it. I think this has come about because we have talked more about it and tested various activities with the students. I see more now how important it is that students learn to think critically and get some tools to practice it”. Teachers see the importance of CT for students as future citizens; “CT and dilemmas in sustainability in teaching create commitment and motivation, both for me as a teacher and my students. Students reflect and think about questions that we teachers don't know the answer to either, participate in discussing dilemmas that concern them about their own lives. This will prepare students for society and help them to use their own voice”.

These qualitative results are supported by quantitative data from teacher surveys. In the survey we asked teachers about their teaching practice “before” the CriThiSE intervention and 2 years into the intervention. Their answers changed over these two years. For example, on the statement “I think that the teaching should have conversations where different perceptions are presented and discussed” the proportion who responded “to a very large extent” changed from 17% before to 48% after the intervention. Likewise replying to the statement “I should encourage students to have their own opinions on the issues we are working on” their answer to a “very large extent” changed from 28% to 52%. Furthermore, the answer to “students should examine critical the content of texts they read” changed from 22 % to 52 % in the category “to a very large extent”. Considering the statement “teaching should be linked to current events”, their answer in the category “to a very large extent” changed from 20% to 48%.

There are several success stories from teachers participating in the intervention, but both we, as a research group, and the teachers have faced several obstacles. Professional development in school depends on the principal's participation and commitment. In one of the schools, the principal was replaced twice. This had a major problematic impact on both the meetings with the teachers and the general communication with the school. At one of the other schools, the collaboration between the teachers did not work in one of the grades. This led to few conversations, elaboration and little use of dilemmas and CT in their teaching. In general, the teacher has little time for planning and preparing in depth for their own teaching, while the intervention use, in comparison, a lot of time discussion small steps in teaching about dilemmas and CT. The teachers were supposed to both discuss with their colleagues and plan for their own teaching about ideas received at the intervention. It took quite a long time to incorporate this practice with the teachers so that we could discuss experiences from their own teaching at the next meeting. It was a complicating factor that the teachers should work in interdisciplinary teams. Additionaly, the teacher groups were supposed to work together between the meetings. This also meant that the principal had to set up planning time for teacher groups between the meetings, but this often did not happen. Our obstacles are in line with Gericke and Torbjörnsson (2022), who found that scepticism, ambiguous management and local contexts hampered the intended change. Still, several teachers saw the benefit from working at school with tasks from the intervention and even though the intervention is still ongoing, teachers indicate that they benefit from it, and especially the try-outs and student involvements: “I see the benefit of these meetings more when I have carried out teaching with the student related to what we had last time. I become more motivated and also get to reflect on my own experiences from the classroom. It increases my competence as a teacher”.

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Mathematical Modelling for Critical Citizenship

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1. Background and Rationale of the Study

Life has become more daunting than ever with the accelerated globalization and rapid technological advancement. This reality calls education sectors to revolutionize teaching and learning approaches in order to help individuals become ready for their future. For this reason, the Organization for Economic Cooperation and Development (OECD) has framed competencies necessary for one to thrive in this "volatile, uncertain, complex and ambiguous (VUCA) world" (OECD 2030 Learning Framework, 2018, p.10). These competencies are expected to help students become functional, responsive, resilient, responsible, concerned, reflective and critical citizens.

Mathematics education experts have long encouraged mathematics teachers to provide learning tasks that highly engage students in solving problems and developing reasoning abilities. These tasks should help mathematics teachers facilitate students' search for meaningful connections between mathematical concepts and the world, and should also allow teachers to pose questions that will help in advancing students' reasoning skills (National Council of Teachers of Mathematics, 2014). Hence, for students to possess the competencies for sustainable future, teachers have to be equipped with the knowledge and skills for innovative and creative teaching and learning, evident from their designed learning tasks. This innovative learning engagement may be possible by integrating mathematical modelling approach. Mathematical modelling is interdisciplinary in nature and helps students make mathematical descriptions of meaningful real-life situations (Erbas et al., 2014) to make mathematics classes more meaningful, dynamic, and relevant.

In this study, the mathematical modelling tasks designed by the researchers were centered around solid waste management issues. Such tasks connect mathematics and environmental education, and exhibit bringing to life the principle that Science, Technology, Engineering and Mathematics (STEM) education should provide logical and authentic connections between and across the individual STEM disciplines (Principle 2, STEM4: The power of collaboration for change, 2020). Thus, designing such modelling tasks paves the way to not only assist students in enhancing their mathematical understanding, but also in strengthening their environmental education, in particular, knowledge on climate change, sustainable development, and sustainable solutions. This understanding helps students become more concerned about their environment, allowing them to participate in framing response mechanisms and strategies towards mitigating this environmental issue, at the community level, and thereby gradually attain a sustainable future.

2. Theoretical Underpinnings

This study was anchored on the theoretical perspectives of critical mathematics education (CME), which support addressing social development issues and views of mathematics education as a contributor towards critical citizenship (Skovsmose & Niss, 2008). In particular, mathematics education for critical citizenship was used to ascertain that students are actively engaged as critical members of the society. This study also considered O'Donnell's (2018) transdisciplinary lesson and unit framework in organizing mathematical modelling tasks on solid waste management.

The idea that mathematics education develops critical citizenship emphasizes that students can become empowered, get involved, and be engaged with a community or social issue (Skovsmose, 1994; OECD 2030 Learning Framework). These help them become active citizens (Skovsmose, 1994), who have a developed critical thinking and decision-making skills to make informed decisions (Zeidler and Nichols, 2009; Maass et.al., 2019), and one's ability to form sound opinions, ethical or social reasoning (Maass et.al., 2019). As critical citizens, individuals discern their roles as critical members of society conceiving of actions that will make a difference (Skovsmose, 1992 and 1994). The use of mathematics education for critical citizenship enhances student's literacy and numeracy skills (Skovsmose, 1994; Jazby, 2017) by applying mathematical understanding in authentic problems (Maass et.al., 2019), helps one to participate in the understanding and transformation of the society (Giroux, 1988, as cited by Skovsmose, 1992), allows to master specific mathematical skills and particular forms of knowledge (Giroux, 1988, as cited by Skovsmose, 1992), and improves students' civic competence (Skovsmose, 1994) by making them aware of their community obligations (Gramsci, 1989, as cited by Skovsmose, 1992).

3. Methods

This study employed a mixed-method research design from the advocacy and participatory worldview. The quantitative part investigated the students' level of performance in doing the mathematical modelling task while the qualitative part explored how students framed solutions in mitigating solid waste issues in school. Purposive sampling was used in determining the 31 student-participants, who are currently enrolled in solid mensuration course. This study was conducted in one of Philippine islands, categorized as a protected area by the Department of Environment and Natural Resources (DENR), at the same time, a tourist destination classified by the Department of Tourism (DOT).

For this presentation, we will only present the quantitative results of implementing one modelling task. This mathematical modelling task is an application problem on volumes of prisms and was allotted for two hours. Five groups of students were formed; four groups were composed of six members, while the other one group was composed of seven. The mathematical modelling task was assessed using the suggested features from the Guidelines for Assessment & Instruction in Mathematical Modelling Education (GAIMME, 2019) collaboratively designed by the Consortium for Mathematics and Its Applications (COMAP), Society for Industrial and Applied Mathematics (SIAM), National Council of Teachers of Mathematics (NCTM), and The Moody's Foundation. The student scores from performing the task were analyzed using the mean, standard deviation, and t-test. The overall class performance was described using the assessment guidelines of the Philippines' Department of Education (DepEd) as specified in DO 8, s. 2015.

4. Results and Discussions

The students' mathematical modelling performance was assessed in the context of building the model which focused on (1) making assumptions and acknowledging limitations; (2) defining variables and identifying parameters; (3) solutions focused on the use of meaningful mathematics; (4) analysis and assessment of model; and (5) writing style and organization (GAIMME, 2019). Since the designed mathematical modelling task addressed solid waste management issues in a research environment, the researchers added the possible impact of the proposed solution as another feature. Framing of the potential environmental solution is deemed to indicate students' active engagement as critical members of the society.

The group performances in mathematical modelling were classified according to their percentage scores. The levels, anchored on DepEd's K-12 Assessment Guidelines with minimal modification are: 'passing performance' and 'did not meet expectations.' Two of the five groups have achieved 'passing performance in doing the mathematical modelling task' while three of them achieved 'did not meet expectations.'

For convention in this study, those with passing performance belong to the upper group, those who did not meet expectations, the lower group. The students' class performances in doing the mathematical modeling task were further analyzed using the descriptors of GAIMME (2019) as ideal, satisfactory, needs improvement, and incomplete. Overall, the class performance in doing the mathematical modelling task was *satisfactory*; the upper group had an *ideal* performance while the lower group, *satisfactory*. Both groups had *ideal* class performances in making assumptions and acknowledging limitations, defining variables and identifying parameters, and in writing style and organization. The upper group had a *satisfactory* class performance in making use of meaningful mathematics in the model and in proposing potential solutions to the problem, while the lower group *needs improvement* in these areas. The performance of both groups in the area of analysis and assessment of model *needs improvement*.

From the reported average scores, the groups' performances according to the features of the mathematical modelling tasks varied extensively. To determine whether these performances differed significantly, a t-test was performed. Table 1 presents the differences in class performance in mathematical modelling using the t-test. The t-test for making assumptions and acknowledging limitations and analysis and assessment of model could not be performed because the average scores were the same. Variances are approximately equal in the remaining features of mathematical modelling as indicated by the Levene's test for equality of variances (p =

0.53, p = 0.724). This means that the distribution of the average scores in these features obtained by the upper group is similar in shape to the distribution of the average scores obtained by the lower group.

Table 1. Differences on Class Performance in Mathematical Modeling using t-test

Features of Mathematical Modeling Task	Levene's Test for Equality of Variances		t-test for Equality of Means		Interpretation
	F	p-value	T	p-value	
Building the Model: Define Variables and Identify Parameter	9.600	.053	.775	.495	Not Significant
Solution: Model Uses Meaningful Mathematics	9.600	.053	3.873	.030	Significant
Writing Style & Organization	9.600	.053	1.549	.219	Not Significant
Possible Impact of the Proposed Solution	.150	.724	3.220	.049	Significant

Further, the students' solutions using meaningful mathematics in modelling and the possible impact of the proposed solutions were statistically different between the upper and lower groups. This means that the upper group had significantly better performance than the lower group in making use of meaningful mathematics (T=3.873, p=0.030) and in proposing sustainable solutions addressing solid waste issues (T=3.220, p=0.049). Interestingly, students who are performing better in making assumptions and acknowledging limitations, defining variables and identifying parameters, and making use of meaningful mathematics in modeling were able to frame potential solutions in mitigating solid waste problems. This indicates that those who have good performances in mathematical modelling show some tendencies for strengthening their participation as a critical member of society. These groups suggested using alternative ways in reducing solid wastes aside from using compost pit and landfills. These included: reusing plastic wastes for profitable use and, creating rectangular trash bins inside the school campus to segregate biodegradable, nonbiodegradable, and hazardous wastes.

The mathematical modeling task designed for volume of prisms realizes the usefulness of mathematics education for critical citizenship. Students proposing possible solutions to mitigate the problem is an avenue for them to become empowered, get involved, and be engaged with a community or social issue (Skovsmose, 1994; OECD 2030 Learning Framework). From the suggested alternative solutions to manage solid waste problems, students displayed their potential to become active citizens (Skovsmose, 1994) by developing critical thinking and decision-making skills to make informed decisions (Zeidler and Nichols, 2009; Maass et.al., 2019), and forming sound opinions, ethical or social reasoning (Maass et.al., 2019). The students' suggestions are manifestations that they discern their roles as critical members of society and conceive of actions that will make a difference (Skovsmose, 1992 and 1994). The mathematical modelling task provided was able to enhance student's literacy and numeracy skills (Skovsmose, 1994; Jazby, 2017) by applying mathematical understanding in authentic problems (Maass et.al., 2019), mastering specific mathematical skills and particular forms of knowledge (Giroux, 1988, as cited by Skovsmose, 1992), and improving students' civic competence (Skovsmose, 1994) by making them aware of their community obligations (Gramsci, 1989, as cited by Skovsmose, 1992).

5. Conclusion and Recommendations

The designed mathematical modelling task centered around solid waste management problems facilitates the development of mathematical understanding and critical citizenship of students. This indicates that such kind of mathematical modelling task creates a dynamic and meaningful connection of mathematics to the community. By using such tasks, mathematics teachers can learn, themselves, to become more concerned about their natural and social environment, while helping students come up with strategies for a sustainable living. Their perspectives in teaching mathematics will be broadened, allowing them to teach mathematics not only within the four walls of the classroom, but also utilizing the community as a learning laboratory. This suggests that mathematical modelling activities which explored environmental issues can be a good avenue for students to gradually become critical members of the society. Teachers who wished to venture in such undertaking will not only develop students' understanding of mathematical concepts but also of competencies for critical citizenship. Mathematics teachers may consider integrating mathematical modelling activities as performance tasks to deepen students' understanding of mathematical concepts and ideas.

Acknowledgements
The authors would like to thank the Department of Science and Technology – Science Education Institute (DOST-SEI) through the Capacity Building Program in Science and Mathematics Education (CBPSME) grant for making it possible for the first author to pursue graduate studies. Parallel gratitude is extended to Surigao del Norte State University for allowing the first author on full-time study, and to Ateneo de Manila University for honing the professional skills of the first author as a mathematics educator. Esteemed thanks is also expressed for Siargao Island Protected Landscapes and Seascapes (SIPLAS), Schools Division Office of Siargao – Department of Education, and Siargao National Science High School for allowing the researchers conduct this study.

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How outdoor learning can support STEM and sustainability education in initial teacher training

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Thursday, 11 May 2023, 16:00-17:30, Auditorium

Abstract
Outdoor learning (OL) has been reported to support understanding, knowledge, and motivation in terms of STEM and sustainability education, the latter in the context of environmental education. Pre-service and in-service teachers perceive OL as an authentic context for developing STEM and problem-solving skills in children. In terms of impact on learning and overall well-being, OL could provide additional support for open schooling. However, one repeatedly cited barrier regarding planning and implementing OL with a class is insufficient personal experience and training during initial teacher training. Practitioners and researchers argue that OL should be an integral part of initial teacher training. How to prepare (future) teachers for these approaches? And how can co-creation support this process? We want to address these two questions from the perspective of teacher educators at teacher training universities. Using OL for collaborative discovery of local phenomena provides teachers and teacher educators with a tool for teaching STEM and sustainability education, while also providing one of many opportunities for open schooling. The presentation combines findings from a systematic literature review on OL in teacher training with practical experiences of a teacher educator, who used OL in different teaching settings for STEM and sustainability education.

1. Open Schooling and Outdoor Learning (OL)

A report by Make it Open, an EU Horizon 2020 project to support open schooling, tried to define open schooling and characterize some main features to help educators to plan and structure an open schooling project or programme. In the report, Dee Halligan (Director of Forth Together CIC) explains: “Open learning and open schooling are broad terms which describe learning which is ‘open’ in terms of timing, location, teaching roles, instructional methods, modes of access, and any other factors related to learning processes. Most schools already do some level of open learning, through off site trips, on site visits and remote learning.” We intend outdoor learning (OL) has a holistic approach to learning that fits this description perfectly.

We base the definition of OL on the concept of education outside the classroom, which stems from Scandinavia. It means that school subjects are taught in real natural settings such as parks or forests, or in real cultural settings such as schoolyards, museums, or cemeteries (Barfod et al., 2016). The lessons are taught in a pupil-led, teacher-facilitated way based on experiential learning. Physical activity is not a goal, but an integral part of teaching and learning activities. Outdoor learning intends to give children the opportunity to have personal and concrete learning experiences by using their bodies and senses in a real-life environment. Like open schooling, field trips and excursions provide a level of outdoor learning. However, the goal is to have weekly or bi-weekly activities that are regularly integrated into the daily routine and curriculum (Bentsen et al., 2009; Nielsen et al., 2016).

Why is OL relevant for STEM and sustainability education? Many studies have reported that OL enhances understanding, knowledge, and motivation in STEM and sustainability education, the latter in the context of environmental education (Dale et al., 2020; Dettweiler et al., 2017; Mann et al., 2021; Rickinson et al., 2004). Through the 20th century, the focus of outdoor education moved from learners’ personal skill development and health care to science education clearly addressing environmental issues. In natural settings, OL authentically addresses the issues of access to natural resources and the learner’s place in nature. The OL practices, then, developed within a Western cultural history of opening school learning to consider the social and natural environment in which learning occurs (Wolf et al., 2022). Since the 1990’s, several studies reported positive impacts on school students’ general health and well-being, connection to nature, and engagement in learning with curriculum-based OL (Bentsen et al., 2022; Lieberman & Hoody, 1998; Lloyd et al., 2018; Marchant et al., 2019; Waite et al., 2016). Because of the growing interest in using nature and the environment for education, the U.S. and the U.K. governments even have incorporated OL into educational strategies and policy developments, e.g., learning for sustainability (Beames et al., 2011; Higgins et al., 2021), and environmental education (North American Association for Environmental Education, 2019). We would like to consider the two following questions: How to prepare (future) teachers for these approaches? And how can co-creation support this process?

2. Outdoor Learning (OL) in initial teacher training

Pre-service (Jegstad et al., 2018; Khwaengmek et al., 2021) and in-service teachers (Christie et al., 2016; Glackin, 2016; Oberbillig et al., 2014) perceive OL as an authentic context for developing STEM and problem-solving skills in children. However, one repeatedly cited barrier regarding planning and implementing OL with a class is insufficient experience and training during initial teacher training. Practitioners and researchers argue that OL and outdoor teaching should be an integral part of initial teacher training (Hammerman, 1960; Kassahun Waktola, 2009; Lindemann-Matthies et al., 2011).

In initial teacher education programs around the world, OL is offered more in science courses - such as biology or science methods - than in other disciplines and sometimes in outdoor or environmental education courses. Therefore, it seems that OL provides a holistic learning and teaching approach in STEM education. Wolf and colleagues (2022) analysed the relevant literature and found that creativity and collaboration are important skills for OL in initial teacher training, both for pre-service teachers (developing those skills) and for teacher educators (using those skills to increase the quality of their teaching). Together with critical thinking and communication, collaboration and creativity form the basic skills for learning in the 21st century, also known as the 4C-based learning model. We support the idea that teachers and teacher educators need the same skills to introduce or promote a new approach into their teaching. As teacher educators, if we are creative or innovative in designing courses, we can also inspire pre-service teachers to be creative and novel in their pedagogical ideas (Dyment et al., 2018). For example, environmental education was found to be a potent source of creativity and continuity for pre-service teachers in curriculum planning for science (Bore, 2006). Collaboration can be diverse and multi-dimensional. Wolf and colleagues (2022) described three dimensions of collaboration in initial teacher training; firstly, between teacher training universities and schools or the community (e.g., Moseley et al., 2002; Kalungwizi et al., 2020, respectively), secondly, within teacher training universities between teacher educators (Bore, 2006), or thirdly, in the context of teaching strategies, e.g., collaborative conversations (Howes et al., 2004).

3. Ways to increase OL practice in initial teacher training

We think that learning and practicing OL as a method and an approach to teaching can help pre-service teachers to become familiar with STEM and sustainability education and in the broader sense with open schooling. The presentation relates to how teacher educators proceed when introducing pre-service teachers to OL in the context of STEM and sustainability education.

Luana Monti Jermini will illustrate the content of a didactic sequence and her pupils' learning successes. This experience shaped her teacher training activities in STEM, outdoor and sustainability education. In particular, she will explain how "outdoor journeys", an approach she implemented in a secondary education geography class, support cross-curricular, place-based learning, and how it involves a high degree of student responsibility and the socio-cultural and geo-physical story of students' local landscape (Beames and Ross, 2010). This will provide an idea of what can be accomplished when educators direct their attention to local phenomena. Furthermore, we confirm to which extent place-based education "develop a readiness for social action, and, with the proper adult guidance, the skills needed for effective democratic participation" (Gruenewald and Smith, 2014, p. XX). We will share more insights on the didactic approach to OL in teacher training, which we believe can strengthen the development of teachers' professional skills and self-efficacy in STEM and sustainable education.

Research and development projects that foster collaboration between research and teacher training can be a driver for STEM and sustainability education. Increased collaboration within and across universities of teacher education could drive the development of a new curriculum for pre-service teachers that integrates holistic approaches such as OL and focuses on developing the necessary skills.

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FLEBOCOLLECT: A STEM Education and Citizen Science Project

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Thursday, 11 May 2023, 16:00-17:30, Auditorium

1. Flebocollect project and the material topic

Flebocollect is a STEM and citizen science project to study leishmaniosis disease and the impact of ecosystem alteration on human health. It started in 2019, within the framework of the BRITEC (Bringing Research Into The Classroom) project, funded by the European Union in the Erasmus+ KA2 Program (2018-2021). Currently, "Flebocollect: *Didactic strategy for the development of scientific competence through the study of emerging diseases* with reference FCT-21-16782" is an ongoing project funded by the Spanish Foundation for Science and Technology - Ministry of Science and Innovation, to carry out activities to promote scientific, technological and innovation culture. The project includes carefully designed classroom tasks and materials that are proved to be “powerful tools for enhancing the quality of mathematics and science teaching, influencing the classroom culture and fostering students’ learning”, as this topic 2 line states. Before starting it, the spiral model of professional development has been used: analysis – implementation – reflection. Project investigators carried out several pilot tests with students of different levels of education, both primary and secondary. These allowed the modification and improvement of the activities and materials that make up the project. Likewise, these pilot tests were carried out in different scenarios, both in ordinary classrooms of educational centers and in the Museum of Natural Science in Madrid. Overall, this project aims to analyse the effectiveness of STEM activities and how materials can be useful for students and community members when being involved in school-community projects on environmental issues.

2. Flebocollect project: objectives, organization and materials

2.1. Objectives of the project

Flebocollect scientific dissemination project is structured through a didactic sequence aimed at disseminating the consequences of the alteration of ecosystems in the emergence of diseases. Through this didactic sequence, designed by researchers in experimental science didactics and researchers with expertise in leishmaniosis, Flebocollect will bring science, technology, and research activity closer to students and the public through an experience in which they have to put into play the skills and knowledge of scientists. These didactic objectives are complemented by the scientific objectives of the project that focus on mapping the abundance and distribution of sand flies (insects’ vectors that transmit leishmaniosis) in the Community of

Madrid. Moreover, the focus has also been placed on the analysis of the instruments used, as well as on the possible failures derived from their implementation, to improve the methodologies and resources used. In addition, a report of each group-class participants will be provided to the teachers, with an exhaustive assessment of the degree of development of scientific competence and previous alternative ideas to know the deficiencies and strengths of the students and thus build a future didactic program that adjusts to the reality of the classroom.

2.2. Organization of the project

Students in this line take all the activities included:

1-Board game: With this activity, raise awareness about the role played by the alteration of ecosystems in the appearance of diseases is introduced in the classroom. This game has been made from fragments of real scientific research on the leishmaniosis outbreak that emerged recently in the Community of Madrid (Spain). It includes a dashboard, cards, and reports with information obtained from scientific papers to guide the investigation. Thus, the student will be able to discover the origin of this outbreak and the particularities of its infective cycle (Bermejo and Gálvez, 2022).

2-Do it-yourself traps (DIY traps): This activity is about the construction of their own DIY light traps (Do It Yourself) made with recycled materials, for the capture of phlebotomine sand flies, insects that transmits leishmaniosis (Gálvez et al., 2022). Subsequently, traps will be installed in the vicinity of the educational centers, homes, or surrounding parks. Participants are provided with the necessary materials and procedures to construct their traps. Afterward, they have to install the traps and identify captured species. Data on captured sandflies reported to researchers through online application will be used to map out their presence in the area and hence the risk of leishmaniosis.

3-Infographic contest: Students carry out the preparation and digital design of infographics that raise awareness about the leishmaniasis outbreak and provide advice and recommendations on how to avoid the infection and how to reduce the emergence of new leishmaniosis outbreaks.

2.3. Preliminary results of activity 1

By the time this congress is held, we would be able to bring some results: the level of scientific competence developed, the degree of knowledge acquired, the motivation and willingness of the students. Moreover, improvements to be made will be measured. Before and after the board game activity, a test will record the perceptions and ideas of the students. The pre-test presents questions to find out the previous ideas of the students about concepts of health and disease. On the other hand, the post-test has questions to measure the degree of development of scientific competence, questions in which students must analyze and synthesize the information given in graphs, tables, or fragments of scientific research.

Acknowledgments

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Educating the educators: an innovative M.Ed. program in Integrative STEM Education incorporating open schooling principles

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Thursday, 11 May 2023, 16:00-17:30, Atelier

1. Framing the challenge

Contemporary society is characterized by rapid development of information, science, and technology, and increased understanding that citizens are confronted daily with complex challenges requiring a holistic trans-disciplinary problem-solving perspective and multi-level competencies. (Bybee, 2013). Teachers need to develop their knowledge, skills, and practices to incorporate cutting-edge teaching, learning, and evaluation approaches into their classes and schools. To meet this challenge, an innovative M.Ed. program 'Integrative STEM Education' was developed at Beit Berl College, Israel. As the responsibility for educating the next generation lies not only on the school system but is a challenge and responsibility of our whole society, the program implements several principles of Open Schooling (OS), specifically cooperation with various societal stakeholders. Professionals from industry, academia, enterprise, civil and wider society are actively involved in bringing real-life projects into the program. The program implements the OS approach by which STEM-oriented learning processes are linked to the students' engagement in real-life science, engineering, and ethical challenges confronting society, research, and work. Such teachers can develop their pupils' perceptions, personal identity, and values, based on interacting with real-life multidisciplinary challenges and increased motivation for learning.

2. The M.Ed. program guidelines in light of the open schooling approach

The 'Integrative STEM Education' program aspires to develop teachers and professionals from various STEM backgrounds to lead change in formal and informal education settings. An assumption is that while the different STEM disciplines have their unique knowledge structure, methods, and principles, they share cross-disciplinary ideas, practices, and research methods, thus enabling to apply relevant knowledge and transfer principles and methods from one discipline to another in problem-solving processes of the real world. The program emphasises development of three main categories of skills and competencies that today's [school] graduates need to succeed in their STEM studies and careers (EU, 2018; Tytler, 2020): learning skills (i.e., critical thinking and autonomous learning); literacy skills (i.e., information processing and technology); and social skills (i.e., collaboration and leadership). In view of the central role of sustainability issues in 21st century life, much of the learning in the program is anchored in this context. The program also raises social and ethical aspects interwoven in STEM fields, including integration of females and minorities.

The curriculum addresses four main goals, developing: (1) Knowledge and understanding of the STEM fields distinctly and interactively; (2) Pedagogical content knowledge, and technology PCK in teaching STEM; (3) Skills to lead and manage an interdisciplinary STEM approach in schools; (4) Teachers' capacities to look at their work as a field for research.The program includes: (a) Mandatory courses (e.g., *Creativity and Innovation in Development and Design Processes*, *Ethics and Values in STEM Education*, *Biomimicry*); (b) Research seminars (e.g., *Reforms & Changes in STEM Education*); and (c) Electives (e.g., *Energy Past, Present, and Future*). Pedagogies implemented in the courses that seek to serve as examples and inspiration for the students' to be used in their own classes include: student-centred approach, active learning, long-term learning activities, room for choice in assignments, learning from complex case studies from academia, industry and education actively involving the stakeholders in the learning process, creating a learning community of the students and faculty, student engagement in planning their own assessment, co-teaching with faculty from different areas of expertise. These principles reflect several aspects of the OS approach (Sotirou et al. 2017) in terms of pedagogies, learning context, and personal growth.

3. Open schooling principles in the program courses

Open Schooling principles are central to the program and are expressed in all its courses. Following are two briefly presented examples.

Analysis of Interdisciplinary Projects and Research in Academia and Industry- for example, a university research group presented one of its [alternative energy-related] projects elaborating the entire research cycle from multiple viewpoints including diverse content knowledge and practices. Students, in interdisciplinary teams, engaged in a reverse engineering process, analyzing the project via relevant areas of knowledge needed, how the interdisciplinary approach plays out in the research, and various skills required of the multidisciplinary research team. In this example, OS pedagogies are expressed in teamwork, active learning, reverse engineering inquiry; OS learning context is reflected in the analysis of an authentic interdisciplinary study in which the researchers are involved in the learning process, and students' engagement according to their disciplinary background; OS personal growth is manifested in developing the students' deep understanding of the sustainability-oriented issue and research, in all its complexities, as a foundation for incorporating this in their teaching.

Development and Implementation of an Integrative STEM Educational Project- in this advanced project-based learning project, the students apply diverse knowledge and experiences acquired in previous courses toward developing, as a team, an interdisciplinary PBL-STEM learning unit, adapting, and implementing it in their respective schools, and conducting an evaluation study of the process via action research. Pedagogies associated with OS include teamwork, student-centred learning, PBL, personal time management; OS-related learning context is reflected in the selection of the driving-question, development, and implementation of the unit – all which are directed to their actual school settings; educational activities and be researchers of their own work.

4. Summary

A challenge facing contemporary education is leading change to interdisciplinary STEM education that enables deep conceptual understanding, develops 21st century skills and is relevant to the pupils' lives and motivates their interest. Regarding STEM education, interdisciplinary learning in schools still faces challenges. OS is conducive to addressing these challenges (Mulero Jiménez et al., 2022). The M.Ed. program 'Integrative STEM Education' is a 'Living-Lab' reflecting several aspects of OS, to change teachers' mindsets and build their competencies to lead incorporation of integrative STEM education in their schools. In the conference we will present the program's central concepts in terms of how it incorporates aspects of OS in the overall program structure, courses, and teaching. Via, example learning activities and students' products, we will reflect on insights regarding the contribution of OS principles to preparing our students as change agents for interdisciplinary STEM education.

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Involving Different Stakeholders in the Process of Designing, Implementing, and Evaluating a TLS about Air Pollution

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1. Introduction and research aims

In recent years, the participation of different stakeholders (e.g., citizens, teachers, students, media…) in Research and Innovation scientific projects has been strongly promoted with initiatives such as citizen science projects or open schooling activities (EU Comission, 2015). Research on this topic underlines the potential of established relationship between teachers, professional scientist, and students for the improvement of students' STEM stance: their aspirations, identity, interest… (Couso & Grimalt, 2019; Hiller & Kitsantas, 2014). However, as it has been pointed out, to also ensure students' learning in terms of scientific ideas and understanding of the nature of science, well-designed educational resources that include learning objectives and their connection with the curriculum are essential (Jenkins, 2011). Teaching Learning Sequences (TLS), being structured sequences of teaching and learning activities, are particularly useful educational resources (Méheut & Psillos, 2004).

The development of these TLS is better understood, according to the literature, as a collaborative process that involves different stakeholders in the phases of design, implementation and evaluation of TLS. This collaboration, when successfully organised, has the potential of both enriching the learning activities with multiple perspectives and increasing teachers' professional development (Couso, 2016). However, some important challenges have also been identified. The lack of time and recognition (both institutional and economic) have been considered two important barriers for the participation of both professional scientist and teachers in the process of designing, implementing and evaluating adhoc school materials (Kloetzer et al., 2021).

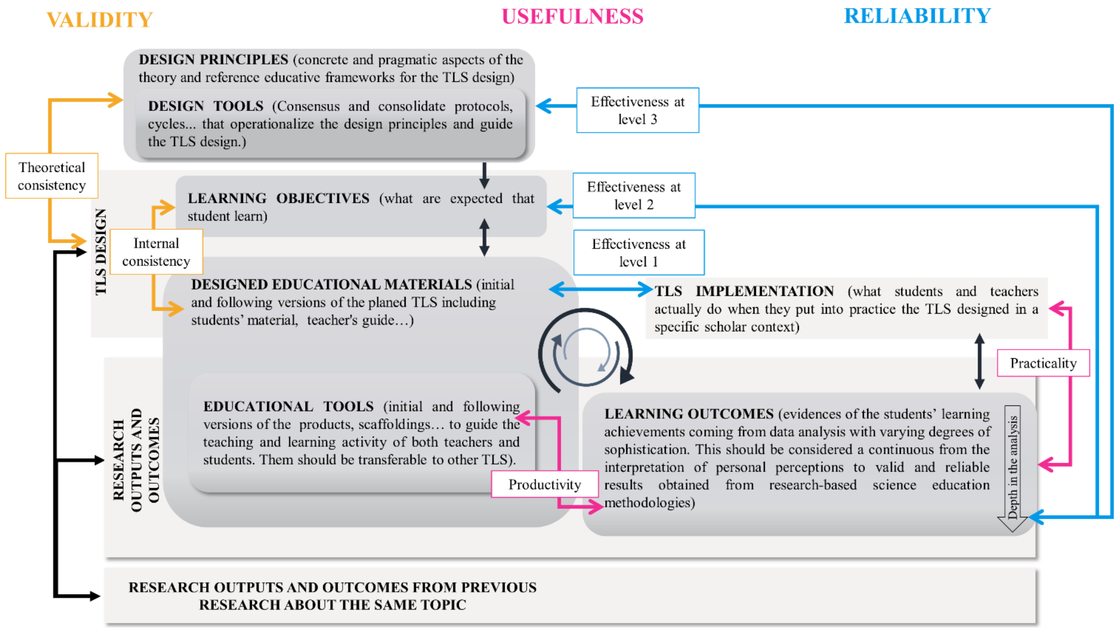
Additionally, research has pointed out that is complex to compare, replicate or evaluate these initiatives and the process followed because most of them do not report explicitly the actual collaboration between different stakeholders involved neither do they investigate their actual contributions (Couso, 2016; Méheut & Psillos, 2004).

In this context, the aims of this communication are: 1) to analyse the participation of different stakeholders (teachers and professional scientists) in the process of designing, implementing, evaluating, and improving a TLS about air pollution in the context of open school projects, identifying the different milestones achieved; and 2) to identify the main potentialities and challenges that each stakeholder recognizes regarding their involvement in these processes.

2. Context and methods

Research has been done along 3 different open school science education projects (2018- now) focused on the topic of air pollution in Barcelona: "ParticipAire" (students from 10 to 12-year-old) students, "Multipliers" (students from 12 to 14-year-old), and "Atenció" (students from 14 to 15-year-old). All projects actively involve students, their teachers and professional researchers in environmental epidemiology and science education. Additionally, Multipliers project involves other stakeholders (e.g. media or NGOs). All of them also included a common perspective of Open Schooling understood as an educational perspective in which schools become open to society by bidirectional collaborating with different institutions with the aim to: improve community well-being, enrich the curricula and pedagogical repertoire of schools and give epistemic authority. To do so the project take the advantages of knowledge, practices, visions, attitudes, resources, and values of all involved agents, empowering them to collectively transform society from a reflective and critical standpoint that focuses on sustainability, equity, social justice, and inclusion (Multipliers project, 2022). In each project, a model-based inquiry TLS that include the previous ideas has been designed, implemented and evaluated iteratively following the three main phases of the design based research paradigm (DBR) A total of 9 different prototypes of TLS for the three different target ages have been developed. In all cases, the process of

designing, implementing, evaluating and improving the TLS has been driven by science education researchers with the involvement of teachers and professional scientists.
Along these processes, we have been collecting data using participatory and non-participatory observations. This data has been analysed with retrospective analysis using the screening strategy (Plomp & Nieveen, 2013). Additionally, for the identification of potentialities and challenges to involve stakeholders in the process we have used post questionnaires especially developed for each profile of participants (Tena & Couso, 2019). Answers (n = 32) have been analysed following a constant comparative method for discourse analysis using both a top-down bottom-up approach.
For the analysis of when each stakeholder (teachers, professional scientists…) participation becomes a milestone in the process of designing, implementing, evaluating, and improving the TLS it has been adopted the Tena & Couso's (2023) theoretical and methodological framework for evaluating quality of a TLS. As it can be seen in the following figure (figure 1) this framework includes both the essential elements and crucial stages to develop a TLS (in grey in figure 1) and the specific dimensions and criteria that should be considered to evaluate its quality (in primary colour in figure 1).



2Figure 1. Tena and Couso's (2023) theoretical and methodological framework to analyze the quality of TLS in DBR paradigm. In grey color, the essential elements and crucial stages that TLS should include. In primary colors, the identified dimension: validity (in yellow), usefulness (in magenta) and reliability (in blue) and the evaluation criteria associate to each of them.

3. Preliminary results

The retrospective analysis allowed us to identify the key stages when each stakeholder contributes to the design, implementation, evaluation and improvement of the TLSs, which are almost the same in the three projects analysed. However, there are important differences among the participation of each stakeholder in terms of the stage and the contributions done.
Regarding the participation of teachers, results show that they have a crucial role in the evaluation and improvement of the TLS in terms of their usefulness (to what extent the TLS design and implementation allowed us to obtain both useful educational/ teaching tools and adequate learning outcomes in terms of their helpfulness to guide the implementation in standard classroom contexts) and reliability in terms of effectiveness at level 1 (to what extent the implementation of the TLS or what actually happens in the classroom is in agreement with the design). Regarding the usefulness, on the one hand, teachers' on-the-go analysis of the key activities to build the scientific ideas about pollution and the main challenges in each TLS prototype helped us to identify and improve the TLS practicality (to what extent the implementation could be considered feasible and fruitful). On the other hand, an important role for the teachers has also been granted to the identification and improvement of the TLS productivity (to what extent some teachers'/students' tools included in the TLS have potential for being applicable in other TLS and in standard classroom context). In this

sense, teachers have had a significant role, for example in the identification of the PaPER scaffolding tool (Tena & Couso, 2020) as having potential to guide the students' process of planning and carrying out their own researchers not only regarding the pollution phenomena but also in others. Moreover, they made essential contributions to the improvement of this tool (e.g. suggesting relevant questions to scaffold students' process, demanding the clarification of some of the parts…) based on the observations done during its implementation. Regarding the participation of professional scientists, results show that they have a crucial role to ensure TLS quality in terms of validity (to what extent the design of the TLS, in terms of both learning objectives and designed educational materials, is coherent with and based on current science education, pedagogical and professional science knowledge). In our case, for example, the analysis has pointed out the relevance of professional scientist focusing the idea of air pollution that students need to build, shifting from a general perspective of pollution to a view of pollution in terms of particulate matter (PM), along different prototypes. These changes were done in agreement with the current professional researchers' results on effects of different pollutants on health (Gignac et al., 2021).

On the other hand, the analysis of questionnaires about the stakeholders' perceptions of their participation shows that in all cases more potentialities than challenges have been identified, both regarding their collaboration with scientist and science education researchers. The analysis of teachers' answers has underlined benefits on both the improvement of their scientific knowledge on the topic, and the promotion of reflective practices about their own school practice:

"*It helps me to complement the pedagogical part (such as classroom management, time…) with the scientific part of the phenomena, how the air pollution phenomena are nowadays, current and high-quality information" (Post-quest_Teacher_1)*

"*I would like to use the same structure [of the project]: starting from relevant socio scientific issues and spending more time [with the students] doing authentic research activities. This means to reconsider some of the contents that are part of our school project"* (Post-questTeacher 2)

Moreover, scientists post-quest indicate that their participation helped them to identify the relevance of their research for the society and how to communicate it to the students.

"It has been helpful specially to explain our research and think what of what we do is actually relevant for them [students]… "(Post-quest_Researcher_3)

4. Conclusions

These obtained results reinforce, on the one hand, the idea that a participatory approach not necessarily implies the collaboration of all the stakeholders at the same level and in all parts of the educational design process (Hernández & Pintó, 2016); and, on the other hand, the necessity of identifying stages where the participation of a stakeholder is essential in order to improve the quality of TLSs both in terms of improving students' STEM stance and learning. In this sense, the preliminary results seem to highlight that while professional science have an important role in the first steps of the process of designing a TLS to ensure its validity, teachers have a key role in the implementation of the TLS and their evaluation in terms of the usefulness and reliability.

On the other hand, results related to stakeholders' perception highlights the potential of these initiatives to help teachers and professional scientist to improve their knowledge about the topic and to rethink their current practices.

In the following months, as part of the Multipliers project, it will be possible to include new stakeholders profiles (e.g. media, out of school experts, industry, policymakers, civil society…). Results of their participation will be analysed and included in the final communication.

Acknowledgements

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The Fieldwork Concept in STEM Education: International students' perspectives and expectations before an Erasmus+ course about climate change

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1. Introduction and theoretical background

Fieldwork, defined as out of classroom teaching where first-hand experience with the field is essential, is considered an important pedagogy in GEES (geography, earth science and environmental sciences) and STEM (France & Haigh 2018). However, fieldwork is expensive, requires organization, may be hard to fit in regular timetables, and schools worry about liability issues and inclusiveness. Remmen and Frøyland (2014; 2017) and Peacock (2018) state that effective fieldwork does not need lengthy traveling: it can take place on campus or in the vicinity of school. This kind of fieldwork can be particularly powerful when trying to overcome the distancing biases in climate change education.

Educating pre-service teachers in setting up fieldwork can therefore be an important element of improving climate change education. The EduChange projects (1.0 and 2.0), enabled by Erasmus+ partnerships (Panek et al. 2022; http://educhange.net), provided students in teacher training with different fieldwork experiences. The focus was on student-centered, enquiry-based methods (Oost et al 2011) which also applied photography, Virtual Reality, gamification, and place-based experiences. Participants were very enthusiastic about these different methods for climate change education through outdoor learning.
Previous research by Emstad et al. (2021) demonstrates that even intensive training in outdoor teaching (in a traditional Norwegian rural area) does not guarantee that newly graduated science teachers apply fieldwork in their teachings. Therefore, Emstad et al. (2021) call for further research involving transdisciplinary perspectives and diverse teaching arenas. The EduChange students got a broader transdisciplinary course about climate change, which also included a wider range of teaching arenas compared to the Emstad et al.'s (2021) study. In this study, we followed two cohorts of students that attended the field course to see how their perceptions of fieldwork evolved during the entire programme. We hope that our participants gain both enthusiasm and efficacy for doing fieldwork in their future lives as teachers. The EduChange programme does so by inviting students from four universities to an eight day residential field course with a focus on educational design for climate change education and various hands-on experience with a range of playful, field-based teaching methods, followed by the design and organisation of a teaching activity back home.

2. Methods

Two generations of EduChange participants shared their fieldwork perceptions, expectations, and experiences with us. This group may be self-selective, as climate change education and fieldwork were two important pillars of the course and of the information about the course handed out before departure. Students' fieldwork perceptions were collected at the start of the residential field course using sticky notes (n=18, 2022; n=30, 2023). We asked the students about their vision of fieldwork as a pedagogical concept and their desired and expected types of field education. The 2023 cohort also completed a supplementary questionnaire with questions regarding their prior experiences with fieldwork. An SDI, stepwise deductive – inductive analysis (Tjora, 2018) was used for analysis. Both during and after the residential field course, we made an inventory of which student groups applied fieldwork in the activities they subsequently designed as part of the EduChange programme.

3. Results

The outcome of the preliminary analysis gave three main themes of interest: *a) External conditions*: Students associated field work as an activity that is outside, in natural environment and they expected it to be about real-life experiences (codes: Outside, Natural environment and Real life/Situated); *b) Didactics:* Students perceived it to be active/doing things and they expected activities that connected theory and practice (codes: Doing, Connecting theory-practice), and *c) Field methods:* Students expect to use field methods to collect data, do observations and to use inquiry-based tasks (codes: Collect data, Inquiry and Observations). The analysis of their perspectives on fieldwork in future teaching ended in the same themes, with most statements related to didactics: exploration, activity, cooperation, frames, and discussions. All these results frame the students' associations and expectations into a sociocultural context with wishes for situated fieldwork practice. Although both cohorts of students mentioned similar themes, the 2023 cohort wrote much more elaborate answers on their sticky notes, that were similar in size to those used in 2022. Therefore, more codes were picked up from these notes.

4. Discussion

Students expected field work to be more than a guided tour, they also expected fieldwork to be inquiry-based, framed in a specific context and with the possibility to use science theories to solve practical assignments. These expectations are in line with authors such as Oost et al (2011) and Remmen & Frøyland (2014; 2017) that stress the value of student-centred approaches to fieldwork. This has implications for how pre-service teachers would see their own role as teachers: coaching students to be active learners, and how we develop our education towards enabling our students to actually implement field activities into their own future teaching.

Acknowledgements
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Sustainable Development, Environment and Open Tools in School

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Arduino in Education

Arduino is a platform for prototyping interactive objects using electronics that was designed so that anyone, without knowledge of electronics, can program interactive devices. Since Arduino applies the open-source model not only to the software but also to the hardware, the microcontroller board and the sensors and actuators necessary to work with it can be purchased at a very reduced price. This democratization of electronics has opened up a multitude of possibilities in the world of education, especially in STEM disciplines. Arduino can not only be used to learn concepts of electronics and programming, but through the programming of sensors and the design of electronic devices also allows for activities with which students learn scientific concepts in an entirely practical way with an Inquired Based Leaning pedagogical approach. We will also show how to use Arduino with a PBL methodology in order to build a prototype that will help society solving real problems like some of the Sustainable Development Goals of the United Nations 2030 Agenda. Combining these pedagogical approaches we are not only teaching STEM topics and problem solving but also some other "soft skills" like communicating with their peers, adaptability, critical thinking and time management since students will have to collaborate to reach their goals in the time given to do so.

In this presentation we will show several activities that illustrate the enormous potential of the Arduino platform in education. Specifically, we will focus on materials that can be used in the classroom to address the Sustainable Development Goals of the United Nations 2030 Agenda that are related to the environment.

Arduino and the Sustainable Development Goals

The Sustainable Development Goals (SDG) are a call to action by all countries to promote prosperity while protecting the planet. Among the seventeen goals set by the UN, four of them relate to the environment more or less directly. These are Goal 7 (Ensure access to affordable, reliable, sustainable and modern energy), 11 (Make cities inclusive, safe, resilient and sustainable), 12 (Ensure sustainable consumption and production patterns), 13 (Take urgent action to combat climate change and its impacts) and 14 (Conserve and sustainably use the oceans, seas and marine resources). Using these global goals as a basis, in this talk we will show practical activities that can be carried out in the classroom with Arduino to study different environmental problems. In them the students apply the scientific method and, after analyzing the results of the experiments carried out, they draw conclusions that they can pass on to the community (their school, neighborhood or city) to involve them in the protection of the environment.

The following activities are a sample of the materials that will be presented in more detail in the talk:

- Air quality: different sensors are used to analyze possible pollutants present in the air. With these results, a comparative study can be made between different areas of a city and conclusions can be drawn about the factors that contribute to poor air quality.
- Noise pollution: students make a sound level meter with which they measure the level of environmental noise to become aware of a type of pollution that is usually not given the importance it deserves.
- Energy efficiency: with a few simple experiments using a temperature sensor, students work on ways to improve energy efficiency when designing and building homes.
- Responsible energy consumption: to promote energy saving, students make prototypes with which they simulate the automation of the lighting of street lamps or the operation of a thermostat for heating.
- Global warming: to understand global warming, a greenhouse is simulated and the temperatures inside and outside are studied, as well as the effect of adding a source of carbon dioxide.
- Ocean acidification: The uptake of carbon dioxide by ocean waters and the consequent acidification of the oceans is addressed with simple experiments in which the acidity of the water is measured with a pH sensor.
- Weather Monitoring: a weather station is built to monitor climatic variables such as atmospheric pressure, temperature, humidity, rain and UV radiation.

Benefits of using Arduino in the classroom

Finally, we gather some reflections on the benefits of using Arduino in the study of environmental issues. First, the use of sensors and the design of electronic devices provides an alternative way to address environmental issues in education, so that students learn by doing. Arduino also adds a motivating factor, since it allows us to face the problems from a realistic perspective and close to the way in which scientists work. Since it is the students themselves who manufacture the measuring devices, we are also encouraging them to be creators, and not only consumers, of technology, in addition to promoting the use of open technologies. Finally it is important to note that Arduino and the sensors used are cheap. This means that students can buy their own material to do the experiments at home, so learning is not limited to the school.

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Teacher 'Transformations' of Mathematics Tasks from Project Materials to Classroom use: Looking beyond adaptations

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Educational institutions from across different countries work together on projects with the aim of designing and implementing programmes that seek to offer solutions to problems that are common to them (Vanden Broeck 2020). The European Union (EU), which is one of the main financial backers of these initiatives, tends to favour projects that offer professional development (PD) programmes to science, technology, engineering and mathematics (STEM) teachers with the aim of embedding inquiry-based learning (IBL) in classroom practices (Gray 2015). One of these EU-funded projects was Supporting Mathematics and Science Teachers in Addressing Diversity and Promoting Fundamental Values (MaSDiV) (2017-2020), which promoted IBL as a pedagogy that supports diverse and multicultural classrooms. The MaSDiV project included the design of a professional development (PD) programme for teachers. A key feature of this programme was the development of materials, or tasks, that were meant to guide and support teachers' implementation of the PD programme's aims inside their classrooms. In Malta, a multi-layered PD model was used to implement the MaSDiV PD programme with mathematics and science teachers. The underlying idea was to provide PD sessions to a group of teachers to become PD leaders while they support, even as they train, a small group of teachers in a school to implement and/or build on the MaSDiV materials in class.

We, the three authors, played a dual role in this study: that of PD organizers and researchers. Drawing on implementation research (Century and Cassata 2016), we explore in this presentation the implementation of the project's mathematics tasks inside Maltese classrooms. We shed light on how these tasks were 'transformed' by teachers from project materials to classroom use. More specifically, we look at changes in MaSDiV mathematics tasks that went beyond the context-induced 'adaptations' that did not jeopardise the core principles of the project (see Koellner and Jacobs 2015). As such, we focus on exploring the 'how' and 'why' of task transformations that we, as PD organizers, thought would jeopardised the project's core principles.

Opting for a qualitative case study methodology (Yin 2018) that incorporates elements of self-study research (see Hamilton et al. 2008), our understandings are based primarily on the experiences of the mathematics PD leaders in the project who were both trainees (i.e. by attending a course at university to familiarize themselves with the programme materials and learn how to lead a PD programme) and trainers (i.e. by leading the PD programme with teachers in schools) at the same time. Data was collected through: surveys; teacher portfolios; researchers' meetings; and focus group discussions. The data was analysed then using a thematic approach (Braun and Clarke 2006).

Findings suggest that the mathematics teachers in the project carried out tasks transformations that could be classified as 'adaptations' and others that went beyond this. While the former were actually encouraged by us, as PD organizers, the latter constituted interventions, which we had neither encouraged nor envisaged, that potentially jeopardised from our perspective the essence of the project. This development intrigued us both as PD organizers and as researchers with an interest in teacher professional development. Our analysis suggests that the tasks transformations that went beyond the notion of context-induced adaptations worked on two levels: task eliminations and task adjustments. In both cases, the overall effect appeared to be that although some teachers were participating in the MaSDiV project, the project tasks that they were presenting to students in class were still very similar to what they normally did in class. The main reason for this was that, in their opinion, the project itself and its materials did not meet, to some extent or other, their perceived needs. The implication here is that what PD organizers and other stakeholders perceive to be the needs of teachers might be different from what the teachers themselves perceive as their needs.

This finding is particularly useful to PD designers and organizers, and teacher educators in general. For it reveals the need of creating opportunities that give teachers ownership to adapt materials with the support of more knowledgeable others who can help them bridge the gap from their existing knowledge, practices and beliefs towards those promoted and encouraged by, for example, a PD programme. We argue moreover that teachers, empowered by these professional skills, would be better prepared to participate with profit in school-community-projects. For these projects, which typically apply school content knowledge to real life situations, are not that well-served with traditional school materials. Indeed, the notion of open schooling, which underpins school-community-projects, calls for the development and adaptation of materials that position learning as a communal activity not bound by the canons of traditional schooling. We think that having teachers who are willing and capable of developing and adapting such materials would be an important step in this direction.

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Core Organisational Structures for Sustainable Implementation of Open Schooling in Science Education: Lessons learned from the COSMOS project

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Thursday, 11 May 2023, 16:00-17:30, Live Science

1. The potential and challenges of open schooling

'Open schooling' has attracted attention from scholars and practitioners in recent years. Diverse conceptualisations of this approach to educational organization, curriculum, teaching and learning exist. Some emphasize the aspect of open *access* to education (e.g. Jenkins & Sadiman, 2002), others focus on instructional methods and student participation (e.g. Nikolaou, 2021), or perceive 'openness' in terms of the connection between the school and the world/communities beyond the school (e.g. Sotiriou & Cherouvis, 2017). Especially in light of the latter two interpretations, the open schooling approach has great potential to foster meaningful education through connecting science to students' everyday life and aspirations, and supporting them in understanding key societal issues related to science, as well as enabling them to identify and act upon possible solutions. Given that open schooling has been shown to promote more positive attitudes towards science, science career aspirations and active citizenship (Sotiriou & Cherouvis, 2017), especially toward addressing social-environmental issues, it seems to contribute to a more sustainable future. Science education through open schooling seems therefore promising yet challenging for school teams. These challenges are located both at the level of implementing the approach into teaching and at the level of school organization, i.e., sustainably embedding open schooling into schools' organizational structures and 'pedagogical DNA'. Examining and addressing the challenges of implementing open schooling at the intersection of student learning, teaching practices, and school organisation is at the heart of the COSMOS project. The aim of this presentation is to discuss the COSMOS approach to open schooling for science education, and report on lessons learnt from a first implementation round.

2. The COSMOS approach to open schooling

COSMOS (*Creating Organizational Structures for Meaningful science education through Open Schooling for all*) is an EU funded project in which higher education and societal partners collaborate with primary and secondary schools across Europe (The Netherlands, Belgium, Portugal, Sweden, Israel and the UK), to study how science education can be leveraged to move schools on a continuum from an *inward-to-outward* orientation to community-engagement. This movement toward an outward orientation is conceptualized in the COSMOS (2022) framework by reference to eight openness dimensions: community collaborations, inner-school communities, learning communities, shared governance, a dynamic curriculum, student participation, social engagement, and parental involvement (see e.g. Furman, 2002; Sotiriou et al., 2021). Each of these dimensions are considered as equally important as well as interdependent, and for each of them schools are positioned in a continuum. More specifically, the open-schooling approach to science education in COSMOS is realized by developing a community-based approach to SSIBL (socio- scientific inquiry-based learning, Knippels & Van Harskamp, 2018). The SSIBL pedagogy is centred around three concrete phases: allowing students to ask authentic questions concerning SSIs (ASK), enacting inquiry to build understanding and make sense of the issue (FIND OUT), and collectively finding ways to engage as active citizens toward a sustainable future (ACT). A community-based approach to SSIBL is understood as actively involving various stakeholders (e.g. small businesses, NGOs, local residents, community services) in any or all of the SSIBL phases.

3. Organisational structures to support Open Schooling

The COSMOS project specifically aims to create and examine organisational structures that support schools in their 'outward' movement, including the application of a community-based SSIBL pedagogy. To that end, a key concept that the COSMOS (2022) framework introduces is the CORPOS (*Core ORganisational structure for the Promotion of Open Schooling*). This structure functions as a professional learning community that convenes regularly to promote an open- schooling culture and practices. Ideally, the CORPOS is composed of both internal (school staff) members and external stakeholders, jointly discussing practical policies and practices to promote open schooling competences and behaviours across the eight openness dimensions. In the COSMOS project, focus is on employing the open-schooling approach in the context of science education, although a spill-over effect might occur beyond science education. Drawing from the field of school organisational theory, an effective CORPOS, which closes the gap between ostensive and performative organizational routines (Liljenberg & Nordholm, 2018), is characterized by teacher collaboration, staff professional and social networks, norms and procedures for decision making, and the continuity of roles within decision-making teams (Kaul, et al., 2022). Given the limited attention to such organizational structures in the open schooling literature, research on the initiation, viability, sustainability and impact of these structures is a major innovation of the COSMOS project.

4. Research focus and outlook to lessons learned.

The COSMOS project is centred around two rounds of implementations in practice (school years 22-23 and 23-24), throughout which we support schools to initiate and sustain a CORPOS and implement SSIBL. The central research questions we aim to answer are:

- What is the impact of the COSMOS open schooling approach on (a) the students' science attitudes, career aspirations and active citizenship, and (b) the schools' openness dimensions?
- How can a CORPOS support and sustain the impact of COSMOS? In particular we will study what mediates the initiation of a CORPOS in schools, which elements can be connected to implementation success, and how a CORPOS can lead to a sustained adoption of open schooling.

We deploy a longitudinal mixed-method approach, combining focus group discussions, interviews and surveys. At the time of the proposal submission, the first round of implementation is underway. At the ICSE/MOST conference we will present our core concepts, approaches to professional development and the research instruments developed to study them. We will also reflect on the intermediate lessons learned concerning the impact of our approach and, more importantly, the insights gathered concerning the nature and success of a CORPOS in the sustained implementation of open schooling.

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Hands-on Commodity Science

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Thursday, 11 May 2023, 16:00-17:30, Auditorium

1. Teaching Commodity Science

Learning with hands-on teaching has always been achieved the best learning outcomes. In times of Distance learning, science teachers tried to bring experiments into the households to enable science experience to students and their families.

Commodity Science is Applied Natural Science and essential for manufacturers innovation and consumers decision. In German speaking countries a four-step differentiation in Commodity Science is common. The three German words "Kunde", "Lehre" and "Wissenschaft" are all to be translated into the word "science".

Recently propagated Commodity Science 2.0 includes a modern view to the scientific field, to the development of new norms and a scientific projection of research into the future. (Cormode_G., 2008, Aghaei_S. 2012, MOOC 2016)

- **Commodity Science 1.0** is the knowledge base of the field of commodity science. It encompasses a traditional description of goods and their quality.
- **Commodity Science 2.0** (Zalewski_R 2014) stands for the knowledge of commodities, organized in a framework, which encloses the utilization and the description of the life cycle of all goods. Consumers benefit by new processes and technologies at POS, by high quality, safety and sustainability.
- **Commodity Science 3.0** is the further development including automatization, computer technology and facilitate production and everyday life by using machines.
- **Commodity Science 4.0** will be the development of artificial intelligence, including digitisation and robotics.

The modern commodities are personal data, merchandised as raw materials. It has to be discussed, if personal data have to be rated to CS 4.0 or if they even are a new category CS 5.0. (Regulation (EU) 2016/679)

Today at the same time information explosion is hard to administrate for both the producers as well as consumers. The huge quantity of information given in electronic media and the fragmentary information mediated by sales promotion is to require a "come-back to the roots". It will be necessary to merge all phases of Commodity Science evolution.

In all levels of education, the basic knowledge of commodities must be mediated. The goods must be understood in their natural manner. It is to learn the description of commodities, the testing, as well as the knowledge of sociological and ecological consequences of the commodities usage.

The suitable teaching methods for Commodity Science 1.0 – 4.0 have to implement the technical achievements of each developmental stage. This signifies, that teaching CS 3.0 or 4.0 has to use modern technical devices:

- transferring commodities from storage places to digitised eMuseums
- Using electronic devices: computers, tablets, mobile phones, digital cameras, as well as ebooks
- Interactive eLearning-platforms and tools: MOOCS, Moodle, LMS (Learning Management System), Apps
- Implementation of robotics and coding

2. Educating Commodity Science in times of distance learning

Especially in secondary vocational schools there is less time for practical lessons. Times of distance learning opens up new opportunities for practical teaching. Experiments must be organised with simple instruments and less material, that can be run at home.

Experiments can be reorganised, so that even microorganisms could be grown, or DNA can be extracted from fruits at home. Lessons must contain the following:

- Precise description by the teacher, given in video, in conference or in texts,
- Very precise safety instructions,
- Use of less materials and household appliances (such as candles, knives, spoons, glasses, vinegar, nutritional oil, salt, sugar, flour, rice, milk, spirit, food colourings),
- Complete documentation in reports, including text and photos,
- Debriefing via video conference and written feedback by the teachers;

Teachers are not allowed to assume adult supervision. Precise safety instructions are the most important part of experiments at home, especially when students work with water maybe nearby their computers, with heat or open fire. It is important to demand reports including photos to avoid copy and paste sessions.

In times of distance learning, success of the students was increased by 20 to 30 % compared to previous years, measured by the number of works submitted and the total number of points that could be achieved. Students had to study the experiments more intensively because of the preparation.

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MOST: Facing the Transfer of Theory into STEM Classroom: Teacher professional development in open schooling and environmental issues

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Thursday, 11 May 2023, 16:00-17:30, Tribune

1. Abstract

Teachers' professional development (TPD) is a fundamental aspect to implement and scaling up innovative teaching approaches. However, the reality is that there is a high diversity in TPD structures, with different levels of involvement in teachers' practice. This paper presents, from a structural dimension, the TPD carried out in Spain in the context of the MOST European project, which has made possible the transfer into the classroom of what has been worked in open schooling with respect to environmental issues.

2. Teacher professional development and its transfer into the classroom

The inquiry based learning (or teaching), socio-scientific issues or authentic contexts have shown to be effective in scientific literacy of citizens. However, competent teachers must, successfully implement these methodologies, into the classroom.

Teachers continuing professional learning is one of the two strands presents in OECD Education area in which it is underlined that "Continuing professional learning is vital for teachers to broaden and deepen their knowledge, keep up with new research, tools and practices and respond to their students' changing needs." (Boeskens, Nusche, and Yurita, 2020; p.6).

Thus, TPD becomes an object of research, and there are multiple specialized works that try to determine which are the characteristics of a TPD program affecting the learning of students (cited in García-García et al., 2020). At present, attempts are being made to spread forms of professional learning that can increase teachers' effectiveness, putting into practice school- based projects focusing on practices and sustainability over time (Boeskens and Nusche, 2021). In this context, the need arises to establish those essential characteristics or design principles that must be incorporated into TPD so that it lands in the classroom. Kennedy (2014) proposed a categorization in which professional development programs were classified according to their ability to change teacher practices, grouping them as transmissive, transitional or transformative. She indicates that the transformative model should join the range of different conditions required for transformative practice, like the existence of a community of practice engage in action research.

3. The MOST Project and its TPD approach

The MOST project is an international initiative involving 10 European countries that collaborate to improve STEM education and increase scientific vocations through open schooling and environmental projects, guiding teachers in the implementation in their classrooms of projects aligned with those subjects. The professional development experience followed by teachers in Spain is shown below.

In-service TPD in Spain has been carried out in teachers' centres funded by Regional Government, which offer optional TPD activities for in-service teachers. In addition, professional development is usually offered outside working hours, which, together with the bureaucratic overload of teachers, means that they frequently claim that "there are not enough hours a day!" In fact, the rate of participating teachers in formative actions is low and, even lower in actions that can be considered aligned to the transformative model (community of practice or similar). Specifically, teachers involved in training based on peer learning and coaching is 19% (OECD average 44%) and only 24% of teachers in Spain report participating in a network of teachers (OECD, 2019).

Thus, in this context, teacher training should be optimized. In Spain, the TPD associated with the MOST project has launched transformative training actions favouring a community of practice engaged in action research and guiding teachers to apply what they have learned in their own classrooms. Specifically, this training has been followed by 260 teachers. They were invited to investigate and design an school community project from co-creation with other colleagues and agents outside the educational community, to put it into practice in their classrooms, to share it with the rest of the members of the community of practice and, finally, to analyse it from the point of view of profits for their professional activity. Throughout all this time, face-to-face and non-face-to-face sessions of work in the classroom were interspersed over four months.

4. Results that justify the TPD approach

Once the TPD was developed, the teachers filled out a questionnaire, which was developed based on theoretical models from the specialized literature and previously validated instruments. The questionnaire analyses how teachers have perceived the experience in terms of its relevance for students' learning, difficulty for implementing SCP and cost in daily teaching, how they perceived themselves when implementing SCP in terms of self-efficacy and expectancies for success, teachers' enjoyment and anxiety and how the teaching and learning context has influenced their attitude to implement innovation.

The results show that a considerable percentage of the sample (c.a. 30%) shows obstacles when implementing school community projects on environmental issues in their classrooms, some of them related with personal aspects as nervousness and anxiety. Nonetheless, 83% of teachers value the experience during the implementation and development of environmental school community projects as "good or excellent". A more detailed analysis of the cluster and teacher profiles, taking into account the main dimensions of the questionnaire, will help us to analyze and have a more accurate information of this sample.

5. Final reflection

Society demands people competent in transversal skills and competencies in the scientific world, thus, teachers must be ready for it through transformative TPDs. The guided TPD action, implemented within the European project MOST, has allowed to generate a community of practice that has transformed their professional practice, applying the knowledge acquired about school community projects, STEM and sustainability to their classroom and therefore turning educational research to the last recipients of its beneficiaries, the children and young people of today's society.

Acknowledgements

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Subject Matter Didactics for Connections between the Components of STEM

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Thursday, 11 May 2023, 16:00-17:30, Tribune

1. Introduction

Undoubtedly, the parts of STEM (Science, Technology, Engineering, Mathematics) are closely connected to each other. To enable students to apply mathematics in STE, teachers need to anticipate and understand students’ difficulties and, if necessary, to simplify mathematics for the application purposes. In order to impart mathematical background, didactical considerations are necessary, and this leads to *subject matter didactics* (SMD, German “Stoffdidaktik”, f. e. Straesser 2014). In this paper, we will examine the significance of SMD for teachers by considering some examples of STEM teaching sequences. The aim of the study is to consider the following questions: (1) How can we characterize the application of SMD for the design of STEM teaching sequences? (2) In how far does SMD help to build and understand the connections between the components of STEM? (3) To what depth do teachers need scientific background, in relation to the lessons they intend to teach?

2. Theory

2.1 STEM and education

Livstrom et al. (2019) define the STEM approach as interdisciplinary for learning various scientific concepts combined or associated with real-world events. In modelling contexts, they perceive mathematics as the glue between STEM components. Ideally, teachers can select from a variety of learning models in order to support their students’ learning, in the sense of making it easier and more effective for them to comprehend and master the necessary skills (Cheng & So 2020). According to Hobbs et al. (2018), STEM is not only a combination of different disciplines, but “what is needed is a vision that is inclusive and interdisciplinary in nature and specific to school needs” (p. 134). Their reflections lead to the different models of STEM teaching shown in Figure 1. In models 1 and 2, the disciplines are separate, and teachers only need competences in one STEM component. In the other models, teachers need competences to connect and combine the different STEM components.

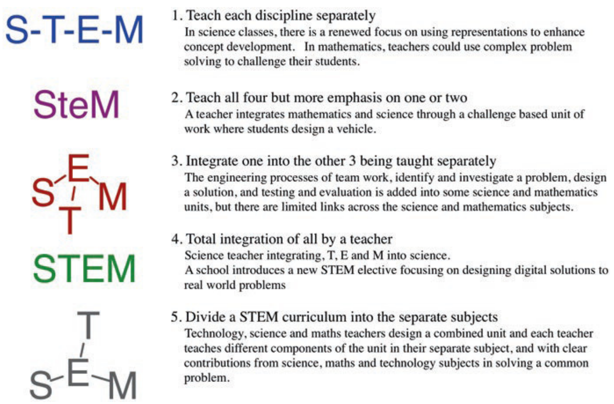

Figure 1. Models of STEM teaching in schools (Hobbs et al., 2018, p. 144)

2.2 Subject Matter Didactics

Hefendehl-Hebeker (2022) defined SMD as the part of mathematics education with expert knowledge as foundation and environment for the teaching of mathematics. To be able to utilize SMD appropriately, teachers need knowledge and understanding of mathematical background. The vast majority of scientists and mathematics educators regard SMD as fundamental for the education of mathematics teachers (e. g. Ball et al. 2008). The notion of SMD also applies to STEM components like chemistry or biology (Nerdel 2017), physics (Halloun 2006) and computer science (Modrow & Strecker 2016). According to Beswick and Fraser (2019), who point out the importance of mathematics, SMD should not be reduced to single elements of STEM, but should be regarded comprehensively, resulting in a need of SMD for STEM teachers.

2.3 Activity Theory

Cognitive processes can be examined with Activity Theory (AT), that “is the common lens that guides the analysis across multidisciplinary fields” (Núñez, 2009, p. 8). It can be described as a “psychological and multidisciplinary theory with a naturalistic emphasis that offers a framework for describing activity and provides a set of perspectives on practice that interlink individual and social levels” (Barab et al, 2004, p. 199). Leontiev (1978) and Engeström (1987) introduced significant frameworks for AT. Leontiev describes individual activities, whereas Engeström describes collective actions in his framework as an object-oriented, collective, and culturally mediated human activity, as illustrated in Figure 2. The *subject* component is defined as an individual or individuals, the *object* refers to the immediate goals of the activity. *Tools* are “anything used in the transformation process, including both material tools and tools for thinking” (Kuuti, 1996, p. 14). The *community* consists of people and groups whose knowledge, interest, states, and goals shape the activity, and *rules* represent norms, conventions or social traditions. How the work in the activity is divided among participants is referred to by the *division of labor*.

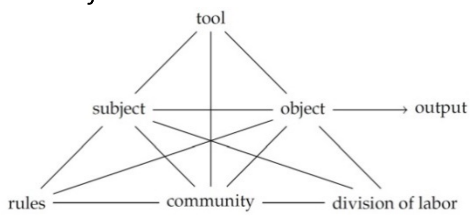

Figure 2. Model of an activity system from Engeström (1987)

3. Design of the study

3.1. Structure of courses

For the study we chose different courses of grade 9 to 12 at a German high school and in extracurricular academies for gifted students of grade 12. We planned, taught, and analysed sequences of lessons. Two topics addressed in the courses were (1) Chaotic Dynamical Systems and (2) Quantum Computers (QC), using postgraduate literature. The choice of topics was influenced by different STEM elements. Topic (1) includes nonlinear dynamics for systems over $\mathbb{R}$ and $\mathbb{C}$ up to the Mandelbrot set. The central component is mathematics, with connections to computer science. Topic (2) deals with mathematics, technology, computer science, and physics; we chose the IBM Quantum Experience.

3.2. Data collection and evaluation

According to Hobbs et al. (2018), there are several models for teaching STEM in schools (Figure 1). There can be more emphasis on one or two components (model 2), or one component is integrated into the other three (model 3), thus revealing connections between the STEM elements. We will analyse these connections in relationship to SMD via AT.

For the application of AT to SMD we interpret the components of the learning activity as shown in Table 1. Instead of interpreting the individual as subject, we specify the object in connection with the contents of the courses and their products (in the form of students' reports). Therefore, rules, division of labor, and objects should also be understood in connection with students' report. Here, the tools are taken as teachers' SMD, and the community is understood as an activity from teachers towards students (Figure 3).

Table 1. Learning activities in connection with SMD (teacher's activity, students' activity)

Subject	students' ambition, formulate questions for teachers
Tools	subject matter didactics
Rules	students' scientific knowledge, search for working material
Community	imparting to students
Division of labor	presentation of solution process and interim results to students
Object	students' solutions and competences

SMD is understood as a tool of a learning activity. As described in section 2.2, SMD is important in connection with scientific backgrounds. It builds the foundation for the teachers' ability to support students in the application of mathematics in their projects. Without SMD, teachers might be unable to sufficiently support students in their projects, for example to help them find a suitable topic for their project, reduce background complexity appropriately, and support them by finding apposite literature. During the project work teachers can help students to present interim results to the other members of the course.

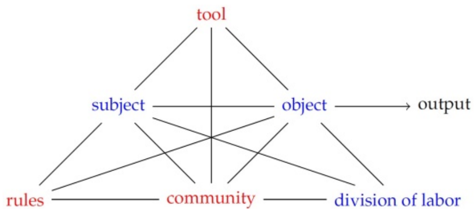

Figure 3. Model of AT in connection with SMD (teacher's activity, students' activity)

4. Contents of the courses for teachers and students

(1) In the course on Quantum Computers, the structure of the Mandelbrot Set $\mathcal{M}$ and Julia Sets J_c with $c \in \mathbb{C}$ were examined. From a topological perspective, J_c is either connected or a Cantor set. Actually, $\mathcal{M} = \{c \in \mathbb{C}: J_c \text{ is connected}\}$, and J_c is a Cantor set, iff $c \notin \mathcal{M}$. The teacher needs background knowledge in topology and must be able to reduce this knowledge for application by students, e. g. via graphs of J_c and $\mathcal{M}$ subject to c by means of a computer algebra system.

(2) The course on Quantum Computers used the *IBM Quantum Experience*, https://quantum-computing.ibm.com/. A suitable goal for students is its application in the context of computer science. Operations with Qubits $\alpha|0\rangle + \beta|1\rangle$ are described with the states $|0\rangle, |1\rangle$, $\alpha, \beta \in \mathbb{C}$ and $|\alpha^2 + \beta^2| = 1$. These become visible with the Bloch sphere shown on the website. Transformations of quantum waves can be described with $|\psi\rangle = \cos\left(\frac{\theta}{2}\right)|0\rangle + e^{i\varphi}\sin\left(\frac{\theta}{2}\right)|1\rangle$. Quantum gates, which are given e. g. by Pauli-matrices like $Y = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}$, are depicted by special symbols. Operations of the matrices are performed via the tensor product. Here, teachers need background knowledge about $\mathbb{C}$ and linear algebra, whereas students can manage with elementarizations for their projects.

Obviously, teachers must master these topics on a different level, as compared to their students
We described the two levels of students and teachers. Ideally, the teachers should be familiar with all components of SMD shown in Table 1, in order to decide about possibilities and ways to address these topics in their courses and adapt them individually for their students.

5. Conclusions

As our elaborations show, AT helps to realise and understand the structure of projects reports. In particular, it shows the importance of teachers' competences for the design of projects for students, and for watching, noticing, and supporting students when working on their projects. Clearly, teachers need SMD to fulfil these tasks. This gives an answer to research question (2).
The description of the courses yields answers to research questions (1) and (3). It becomes obvious that background knowledge of the topics is indispensable for teachers. Teachers need deep background knowledge to overview possible goals, difficulties, knowledge necessary to comprehend descriptions of topics, and their foundations in application and/or theory.
In sum, we can say that teachers need a stable background in SMD in order to provide students with the learning opportunities offered by complex STEM topics. For further research objectives, we recommend to extend the study by examining the learning processes of individual students, in order to gain insight into how to apply SMD to optimise the learning experience for students.

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Fostering learning on socio-scientific issues with escape games

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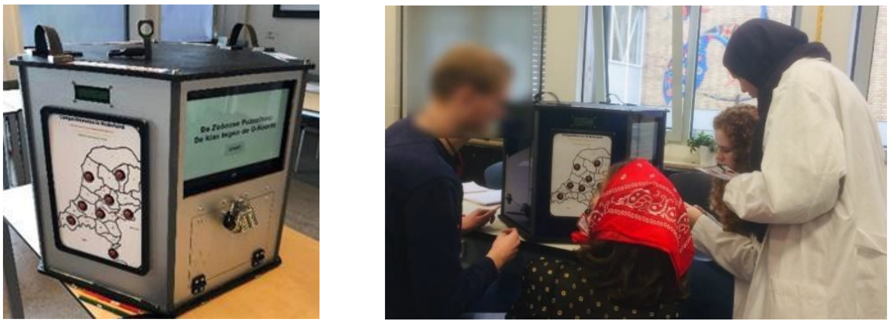
Thursday, 11 May 2023, 16:00-17:30, Tribune

STEM teachers implement escape games (EGs) to foster learning in authentic contexts such as laboratories or outside world contexts which out of reach or potentially dangerous. Students and teachers perceive that students are more engaged and learn more compared to regular classes. However, a systematic review shows that outcomes on the acquired content knowledge are disappointing (Veldkamp et al., 2020b). As the educational EGs are mostly copycats of recreational EGs and not grounded in theories, there is room for improvement.

In this study, the escape game was developed using a design-based approach and a framework grounded in theories on game-based learning. The framework focusses on the three main challenges for the use of educational EGs, 1) the participants' transition from the real world to the game world, 2) the alignment of game design aspects and educational aspects, and 3) the transfer from attained experiences and knowledge back into the real world. This study aims to explore how educational game design elements related to each of the challenges foster learning in the socio-scientific context on the joint control of a zoonosis. In other words, how do immersion, collaboration and debriefing contribute to the appreciation of and learning with an escape game?

The developed escape game was an escape box with changeable fronts, see Figure 2. The fronts offer various tools, such as a laptop screen, a magnet board, and hatches with locks. Puzzles placed on each side of the fronts put players face to face with each other.

Figure 2. The escape box featuring on the left front buttons linked to an embedded microchip, and an LCD screen



for the question and feedback. The right front shows the laptop screen with an interactive PowerPoint. b. Students dressed according to their role, playing the game (Veldkamp et al., 2020a).

A mixed-method study was carried out. The activity was played with a total of 126 pre-A-level students, aged 16-20 yrs. To determine whether learning actually took place, a pre-test/post-test was deployed. To study how the game design elements influence learning in an EG, various data sources were used: experience questionnaires, interviews with students and teachers, and classroom observations.

Students answered positively on the question on the appreciation for the game (4.5/5 Likert scale). The means of the pre-test/post-test scores are M_{pre} =7.8, SD = 3.5; M_{post} = 15.0 (14.95), SD = 2.8, showed that learning actually took place (Wilcoxon's Z= -9,8, $p < 0.0001$). The Spearman's rank correlation test indicated a small positive correlation between the knowledge gain during the activity and the student's appreciation of the activity. In addition, the appreciation of the activity correlates positively with the appreciation of each of the game design elements. This indicates that the appreciation not depends on one of the design elements, but all contribute.

Although students' collaboration was successfully fostered and 76% of the time spent on the content knowledge, it scarcely led to collaborative learning during gameplay, due to lack of discussion and reflection needed for deeper understanding. Based on the results, most accountable for the knowledge gain during gameplay is immersion, scaffolded by the roles and boxes, resulting in a constant focus on tasks. It might be possible that immersion is a threshold element of the learning process, fostering mostly individual learning during gameplay, but not unlimited. More immersion in the game leads only to higher game scores, but not to higher science learning outcomes (Cheng et al., 2015). Finally, the developed framework could help educators in creating immersive games which not only confront learners with biology-related authentic contexts or socio-scientific issues but also give learning gains.

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Make It Open

Kafri, Roey Bloomfield Science Museum, Israel

Thursday, 11 May 2023, 16:00-17:30, Live Science

Abstract

"Make it Open" aims to develop an open schooling infrastructure in Europe based on the pedagogy, content, processes, and tools of the maker movement and citizen science. It promotes innovative STEAM activities and provides support for schools and local communities to form new partnerships, in which schools are transformed from traditional educational institutions into community partners and become agents of community well-being.

How it relates to the overall conference theme

"Make It Open" project aims to use the philosophy of the maker movement to develop a transformational approach to STEM education. The project focuses on empowering students to become active participants in their learning and community through hands-on and inquiry-based methods, explicitly focusing on open schooling initiatives related to environmental issues. The project aligns well with the conference theme of professional development in STEM education, as it emphasises using innovative approaches, such as the maker movement and citizen science, to improve STEM education. Conference attendees who work in the field of STEM education will find valuable insights and practical takeaways from the case study of the project's implementation in European schools.

In the project, tools such as the *Make it open Navigator* and *Learning scenarios* have been developed in co-design with teachers to create learning environments and experiences that are accessible and inclusive to learners of all abilities and levels, using the concept of "low floor, wide walls and high ceilings" for themselves and the students.

From which perspective it will address the topic

"Make it Open" project develops a set of actions, tools, and resources for the education community to use or attend. As part of the project, ten open schooling hubs have been established in European countries

to empower schools and provide local support. The case study presented at the conference will focus on the Israeli hub and provide insight into its challenges and benefits.

How it relates to one or more of the dimensions in the call, and Which of the questions raised in the dimension descriptions will be addressed.

"Make It Open" project relates to several dimensions of the ETE conference call, including re-thinking learning boundaries, empowering learners, innovative approaches, and sustainability education. It promotes open schooling, transforming traditional educational institutions into community partnerships and allowing for a more flexible and personalised approach to learning. It emphasises empowering students to make choices about their learning and become active participants in their communities through hands-on and inquiry-based learning using maker education and citizen science.

The content of the planned presentation

The presentation will provide an overview of the project, its implementation in European schools, challenges encountered and its impact on student learning and engagement. It will also provide practical takeaways and recommendations for educators and policymakers and address questions raised in the dimension descriptions, such as "How can we re-think learning boundaries to enable learners to acquire the competencies needed for the 21st century?" and "How can innovative approaches such as maker education and citizen science empower learners and create culturally tailored learning?"

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Additional information can be found on the project's website: https://makeitopen.eu/

Kazakhstani Middle and High School Girls' Attitude About STEM Career Interest

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Friday, 12 May 2023, 9:00-10:00, Live Science

1. Introduction

Major universal policy documents state rather unequivocally that all children, regardless of gender, ethnicity, ability, or age, have the right to an education. However, multiple studies have demonstrated that one of the major challenges concerning the school system is gender disparities (Dubrovskiy V D et al. 2022).

STEM is one of the educational fields that requires further investigation in terms of gender equality. According to a UNESCO (2016) report, despite increasing female involvement in higher education, the proportion of women entering STEM education is still decreasing. Labelled as the “leaky STEM pipeline” the phenomenon of women leaving the STEM disciplines has been a major reason for concern in academia (CohenMiller A. et al.,2021; Mim S A 2019).

1.1. Kazakhstani context

Factors that contribute to females' underrepresentation in STEM are prevalent in many countries of the world, including Kazakhstan. It is a unique landscape, being a post-soviet country with a historically and culturally oriented society that strongly affected women’s perception of STEM. Those historical and sociocultural factors unavoidably influence female students’ decision to pursue STEM studies. Such factors have been pinpointed in the qualitative study conducted by Almukhambetova A and Kuzhabekova A (2020).

It was discovered that the STEM profession is clearly biased against women. The key factors influencing female to major in STEM are classified into three levels of significance. Each level appears to be linked to others, making an eventual solution more complex and challenging. Further research is required to determine the impact of each level, to assess girls’ interest in STEM careers, and measure societal perceptions of girls in STEM in order to contribute to eventually solve the problem of underrepresentation of females in STEM.

1.2 Carrier interest

Career interest was described by Osipow S and Fitzgerald L (1996) as a person's propensity to engage in particular activities that provide them happiness and fulfilment.

Considerable research has been undertaken to demonstrate the significance of investigating students’ career interests from many perspectives in order to provide adequate guidance on STEM occupations, examine influencing factors, improve career counselling, and reduce STEM pipeline leakage.

Recent studies have focused on a number of factors that influence students’ career interest. For example, Hazari Z et al. (2013) investigated five common factors that may influence female students' career interest in physical science: single-sex physics classes, female scientist guest speakers, a female physics teacher, discussion of female scientists’ works, and discussion of women’s underrepresentation in science.

2. Methodology

In this study, we aimed to find out Kazakhstani middle and high schools girls’ attitudes toward STEM careers interest. We determined girls’ interest using the STEM-CIS survey (Kier M V et al. 2014) and recorded how it changed according to type of school and grade level, along with locating the correlations between their interests and their end term marks in each STEM subject.

A convenient sampling method was used to determine the participants from ten girls’ schools in Almaty city in Kazakhstan. 522 girls from grades 7th to 11th provided answers to the “STEM Career Interest Survey” which was administered online. Collected data was analysed to see how girls’ STEM carries interest change according to the type of school and grade level, along with locating the correlations between their interests and their end-term marks in each STEM subject.

3. Findings

MANOVA analysis showed that girls’ carrier interests in different STEM subjects are changing for different school levels across types of schools. Through ANOVA analysis we showed that only girls’ math interest significantly changed across school levels. The post-hoc analyses indicated that seventh level students’ interest in math was statistically higher than eighth and ninth level students. For the school type variable, ANOVA analysis showed that only girls’ technology and engineering interests were significantly different across school types. In other words, girls in NIS schools were significantly more interested in technology and engineering careers than public school girls while for science and mathematics there was no difference between the two types of schools. Additionally, at the 8th and 11th school levels NIS girls have a higher interest in science while at the 10th level public school girls have higher scores. Finally, we detected significant correlations of modest amplitude between girls’ STEM carrier interest and their achievement in physics, math, chemistry, and biology.

4. Conclusion

This study will allow supporting teachers and school administrators in their efforts to encourage girls to pursue STEM studies and careers, and we hope it will also help researchers to orient their efforts in providing them with fertile and durable solutions.

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Challenging girls to engage in STEM activities in the context of an online summer school

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Friday, 12 May 2023, 9:00-10:00, Live Science

1. Introduction

Digital transformation is on growth and impacts many life facets. However, the lack of interest among girls to pursue studies in ICT and STEM continues to be a major problem (Kaleva, et. al., 2019). Even though girls and boys have similar interests and competence in digital technologies, only some girls keep on building this interest in their studies or in their careers (National Center for Education Statistics, 2012). Merging the gender gap is vital for completely incorporating the value of the digital revolution. Towards this goal, in the summer of 2021, in the framework of a European-funded program (ERASMUS +, KA2), the Greek participating team in the project (Department of Mathematics, National and Kapodistrian University of Athens) had to organise a summer school in STEM fields for girls aged 13-15 years old. Encouraging examples, role models and support to defeat stereotypes are crucial for girls and young women in recognizing that they, too, can succeed in ICT and STEM. These were our starting points for planning and designing the summer school.

As the pandemic effects and restrictions remained even during 2021, the comparative lockdown impacted more than 1.5 billion learners as teachers and students (Brunetto et al., 2022), and online education forced teachers to change how they taught (Hodges et al., 2020). In the education field, a new term, "pandemic pedagogy", has been introduced in educators' vocabulary, most of whom may have never used remote or online learning (Daymont, Blau, & Campbell, 2011; Donham et al., 2022). Emergency remote teaching, different from online teaching, which is designed to be delivered remotely, is the core option; however, when deciding to deliver online teaching, the concerns are several and diverse (Lewis & Abdul-Hamid, 2006; Edwards, Perry, & Janzen, 2011; Baran, Correia, & Thompson, 2011; Keengwe & Kidd, 2010). One of the main concerns is the quality of learning. Online learning is accused of being of lower quality compared to in-person learning (Hodges et al., 2020), although the last decade's research on online education has proven different results. Therefore, even though the initial plan was to carry out this summer school face-to-face, the restrictions forced the Greek team to deliver it online. The concerns encountered were numerous and various, such as on the level of competencies of instructors and participants in online learning, the pedagogy to be used, the transformation of activities for the online context and the role of instructors and students. Thus, two challenges were accepted: 1) How could a STEM summer school for girls be adapted to the online context regarding pedagogic approach and activities? 2) What are the learning outcomes for girls in an online STEM summer school?

2. Methodology

Before starting the planning process, specific standards common for all the summer school activities were set:

The duration of each activity: 90-minute workshops were considered as a practical timeframe, which could be either divided into 3 phases of 30 minutes or 2 of 45 minutes, if necessary, but in any case, it was assessed as sufficient time for the presentation of the relevant STEM field and cooperation between the participants.

The maximum number of participants was 20 students per activity, considered a manageable number, especially for the online format to divide them into rooms but also to have time for everyone to take the step and interact with the instructor and the rest of the participants.

Structure of content: It was decided to have a theoretical part in the activity so that all participants have the same level of knowledge regarding the subject, but also practical application through game in an effort to combine interaction, inclusion and fun with learning and keeping the students' interest high during the activity.

During the planning of the online activities, we followed the steps below:
Step 1: we considered which STEM fields we wanted to highlight and which house object students could use for the activities. We tried each activity will have a different STEM field because we wanted girls to have an integrated STEM experience
Step 2: we designed the activities, presented them to the rest of the group, discussed them and improved them.
Step 3: we made a list of the materials or links students will need and planned to send them by post or email to the participants' parents. We ensured they were as simple, functional and easily accessible to everyone as possible.

Considering all the above, among other activities, an example of an online activity in Biology (entitled: "Decrypting DNA") designed for a 90-minute workshop is described below. The workshop consisted of 3 phases. First, there was a presentation of the theory of DNA decryption by the instructor, followed by an online game in which the participants applied the knowledge of DNA decryption presented. Then, they simulated their own DNA chain according to their personal characteristics (eyes, hair, height etc.) with materials sent to them before summer school inception. Finally, there was a session with a biochemist research scientist, who connected online from her laboratory. The lab was about pharmacological research for the diagnosis and/or therapy of various diseases. Through a virtual visit to it and to its equipment, girls could ask anything they were curious about. The scientist answered all questions, underlining the close connection between biology and chemistry.

The number of participants was kept at an average of 20, manageable for the instructor to give the floor to all participants and interact with them through discussion and questions. A combination of practice and inquiry-based pedagogy was adopted. The session was interactive as after a small presentation by the instructor, the participating students posed questions and explored the field through creative activities and games. The instructor encouraged the girls to collaborate with peers to achieve the activity's goals. The activity combined synchronous and asynchronous communication since the students could complete the activity after the end of the online session and send photos of their creations to the instructor.

3. Results

There were many concerns about the outcome of the online version of this summer school in general but also for the specific activity. The quantitative evaluation of the overall image of the summer school showed encouraging and positive results. The summer school was assessed by the completion of a digital questionnaire by the participants before and after the summer school. The data from the questionnaire (N=63) after the summer school showed that the students enjoyed themselves and had a good time at a fairly high percentage (Figure 1).

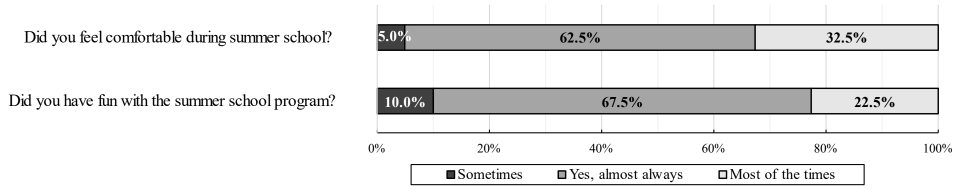

Figure 3-Perceptions of participants on their feelings during summer school

Furthermore, from Figure 2, it is evident that the summer school influenced the participating students to start thinking differently about science in general.

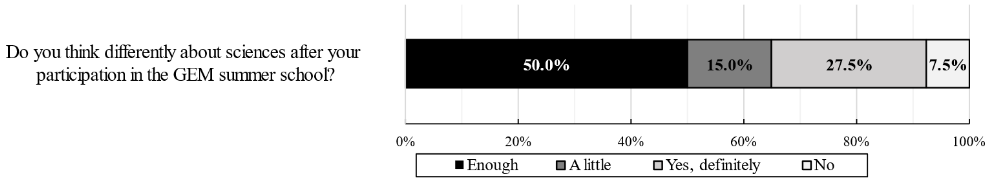

Figure 4- Question "Do you think differently about sciences after your participation in the summer school?"

This is made clearer by Figure 3, which shows the change in girls' perceptions in a remarkable percentage to certain statements before and after summer school (N=38).

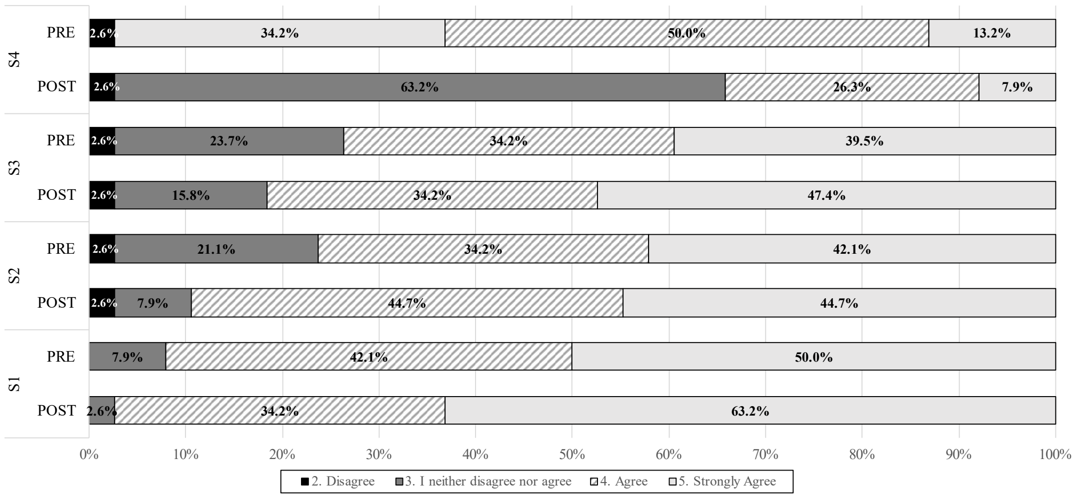

*Figure 5-**S1**: I enjoy learning about STEM; **S2**: The effort I put into my STEM courses is so worthwhile because it will help me in the profession I want to follow later; **S3**: What I learn in STEM courses is valuable to me because I need it for what I want to study later; **S4**: I consider STEM easy.*

The qualitative results for the evaluation of the specific activity in Biology implemented online were also positive and proved that the activity operated effectively. The students were thrilled by the activity. *"It was an unforgettable and unique experience. If given the chance I would participate again! […]"* one of the students writes on the padlet of the activity while other points out that *"I feel lucky that I was able to participate in this program. It was truly a unique and valuable experience. It provided me with a lot of knowledge and helped me understand that I am very interested in the field of Biology and Chemistry […]"*.

According to the instructors' views and experience of the online summer school, although they felt strange not teaching in person and pursue the most direct communication with the participants, one of them comments: *"I really enjoyed the activities the girls got involved in and the interest they showed! In fact, some* *girls had a special talent and interest!"*, though other points out that: *"Of course, I would prefer it to be live because a lot of girls didn't participate at all or we had a hard time identifying their needs through webex."* The instructors did not expect that the young girls would be so concerned of the stereotypes connected to girls and they were impressed how much obvious this is to female students. They found out during the labs that girls were not self-confident in the activities and realized that this creates gaps.

4. Conclusion

The starting idea of this presentation was not only to show that girls can embrace STEM but also that when certain restrictions arise educators have the ability not only to adapt their teaching methods but also their teaching activities. When a STEM summer school is delivered online could have equal benefits and create equal enthusiasm to the participating students as if it was in person. The maximum of communication and interaction with students may not be achieved and the possibilities in the implementation of some activities may seem limited, but the benefits and positive points are evident. On the one hand, it enhances and encourages the development of digital skills, and, on the other hand, it allows for autonomy and flexibility of participation from different parts of the country, as in the case of the Greek summer school, for both participants and educators. It is essential, when planning and designing the activities, to consider that it will be performed online, in order to use the appropriate tools to achieve the combination of pedagogies and to better describe the role of the educator in achieving effective STEM education.

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Let's build gender-inclusive STEM culture!

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1. Abstract

Despite the similar performance of girls and boys in science, the drop of STEM engagement among female students is evident leading to a striking under-representation of women within STEM sectors. This drastic loss of talent hinders science from showing its stunning power as a tool to solve key challenges of society fulfilling each and every person's needs. Here we present a successful case about how to face this issue which requires gender- sensitive pedagogies and teachers training as the way to achieve a sustainable STEM education that, by definition, must be inclusive.

2. Out-of-school initiatives as a way to support girls in building STEM identity

Non-formal education refers to learning experiences lived outside the classroom, during out-of-school hours, such us museums, summer camps or science parks. In the case of STEM, several authors point out that non-formal education undoubtedly contributes to create a STEM culture education providing positive experiences and meaningful participation in science (Wang et al., 2021). Effective STEM out-of-school initiatives provide a suitable scenario for the design and implementation of educational proposals that often cannot be offered from a formal context (National Research Council, 2015): a) It allows to dismantle scientific stereotypes when showing the variety and heterogeneity of real issues addressed by the STEM world; b) usually, non-formal education contexts count on a wide range of material, resources and spaces lacking at schools; c) it offers the chance to learn science in an applied way to solve real life problems without curricular constraints; d) it is an opportunity to show the fun side of science and create a positive experience for students; e) it can promote teamwork and fully collaborative ways of learning, increasing the feeling of STEM community; f) these initiatives can involve not only students but also their families, friends and other members of society, so their impact is expanded; g) the participation of students is voluntary which reinforces their commitment and positive effect on their learning, h) it is possible to freely ask doubts and fail without penalty building a comfortable learning environment.

These strengths not only provide a perfect opportunity to fight against the barriers in closing the gender gap in STEM described by Bilgin et al. (2022) but also to pursue the quality education required to reach the Sustainability Development Goal 4 (SDG4). In fact, some authors as Campbell et al. (2022), elaborated about how STEM education for sustainable development is perfectly aligned with gender-sensitive pedagogies as SDG4 seeks to ensure inclusive and equitable quality education providing lifelong learning opportunities to achieve a better and more sustainable future for all.

3. GEM summer camps for STEM girls in Spain

A successful implementation of these guidelines are the summer camps for girls organized in 11 European countries in the frame of the GEM project (https://icse.eu/international- projects/gem/). In the Spanish context, the main purpose of this intervention was to offer a positive personal experience to girls through an immersion experience in research with female mentors acting as inspiring role models that not only share their professional career but also their personal experiences showing how they successfully develop their identity as female professionals in an exciting STEM field. The two editions of the summer camps (2021 and 2022) lasted five days and combined research in small groups with mentors along with workshops to develop digital and entrepreneurial skills and social activities. Research projects offered deal with real-life issues such as sustainability, ICT to improve society, health or endangered species. These activities have been specifically designed to engage girls in STEM by: 1) discovering inspiring close women with an outstanding career in STEM; 2) getting immersed in STEM research and feeling competent and empowered while doing and applying STEM; 3) becoming aware of their own STEM, digital and entrepreneurial potential and 4) realizing to what extent STEM can contribute to improve people's lives. Finally, both summer camps editions ended with a Final GEM Conference in which girls shared the experience lived during the week in an open-doors event which highlighted the feeling of empowerment and sense of STEM community.

4. Findings from research in the framework of the GEM project

Findings from the analysis of the pre-post questionnaires distributed among participating girls show gains in items related to the future job orientation towards STEM and the degree of difficulty associated to STEM (after the experience they perceived it easier than before). In addition, after the Summer School, students reported a conceptual change about STEM as they realized the applied, useful and enjoyable facet of science. Extended results from the 2021 GEM summer camp are reported by Quesada et al. (2021).
Participating girls highly valued mentors as female role-models, social activities related to science and the applied and hands-on concept of the sessions that they found better than school courses. Therefore, this target-group initiative posed some lesson learned and teaching recommendations that could be transfer to schools in order to rise girls involvement in STEM fields. These suggestions comprise teachers training about the relevance of role-models in STEM to fight against gender stereotypes, working in small groups as a way to encourage girls to get in front and take the initiative, providing practical activities to connect STEM with everyday life making the experience personally meaningful. In fact, some of the activities carried out during the GEM summer camp have been adapted to learning units freely available such as https://www.fisme.science.uu.nl/toepassingen/29138/.

5. Future directions

Bridging formal and non-formal STEM education is key to transfer best practices to rise girls' STEM interest directly to schools. Necessarily, this requires the inclusion of gender- sensitive pedagogies and informal science experiences in the context of teacher professional development, but also the collaboration between researchers, teachers educators, teachers, students, families, companies and policy makers to achieve a sustainable STEM education for all.

Acknowledgements

Our deepest gratitude to the participants in GEM summer camps in Spain (students, families, mentors and lecturers) for their high commitment and dedication to the summer camp. We also acknowledge the UJA's Scientific Culture and Innovation Unit (UCC+I) and International Union of Biological Sciences (IUBS) for their support to organize the camp and for valuing the relevance of this action. This initiative has been funded by the European Union under the grant agreement nº LC- 01380173 (GEM project).

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Use of new technologies for the challenges of the future

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1. **Smartfeld_St.Gallen: Tackling SDGs, future skills and physical computing in co-creation with active teachers and influenced by start-up spirit.**

Smartfelds new project “Use of new technologies for the challenges of the future” (TecforFuture) combines STEM-education with education for sustainable development by fostering the experience of self-efficacy in the combined fields of new technologies and SDG-based challenges.

Smartfeld itself is an interdisciplinary initiative of the innovation network Startfeld, Empa, GBS St. Gallen, the University of Applied Sciences of Eastern Switzerland, the University of Teacher Education St. Gallen and the University of St. Gallen with the aim of promoting creativity and future competencies as well as making children and young people fit for the challenges of the digital age.

Within TecforFuture, the cooperation partners of Smartfeld, active teachers and their students combine their experiences and co-create new learning offers/workshops together, which benefit from the fact that (a) the interdisciplinarity, (b) the necessary expertise and (c) the necessary resources (time, finance, locations) are available and stimulate new exciting formats to arise (Falloon et al., 2020).

The implementation of the workshop is carried out in the Switzerland Innovation Park Ost where start-ups work and make their ideas fly. This unusual, authentic location additionally contributes to the inspiration for students and teachers.

2. **Co-creation of student and teacher educational settings with partner schools**

The project aims at two different target groups, (a) students (Sek I, Sek II) and (b) their teachers.

Students: Most students in Switzerland are forced into career decisions within Sek I, latest Sek II, but in-school educational offers for self-efficacy experiences in the field of technology, entrepreneurship and interdisciplinary problem solving are still (very) rare. With this highly interdisciplinary project, students shall generate a broader view on the possible impact of STEM-competences and creativity on the SDG-challenges of the future.

Teachers: In contrast to Sek II, teachers of the swiss Sek I are multidisciplinary educated, but most lack resources and/or sufficient IT/physical computing knowledge to integrate its potential into their lessons (Iwata et al., 2020). Furthermore, some teachers shy away from the apparent complexity of open learning sessions often associated to student-centred computer-driven STEM-tasks. Within the project`s spiral model, teachers are supported to improve on their own physical-computing skills, thus encouraging shared ownership.

3. **TecforFuture: Problem statement and approach**

Our problem statement:

Four out of ten students in Switzerland cannot explain climate change (Balmer and Cornehls, 2022). In an international comparison, the awareness of global issues of Swiss students is also low (OECD, 2020). But already in 2015 17 Sustainable Development Goals (SDGs) where defined as an urgent call for action by all countries in a global partnership (United Nations, 2015).

To tackle the SDGs, innovative solutions are needed on a broad scale, translating into numerous creative and diverse minds working efficiently together, with an interdisciplinary understanding of the challenges and a mindset that individual capabilities can shape a powerful team. The pool for these diverse minds is represented by the future key-stakeholders (and the future mindset) for the creation and implementation of these innovative solutions: the young people.

Our approach:

With TecforFutures, Smartfeld expanded its innovative portfolio with a focus on using new technologies for the challenges of the future. Based on the SDGs, challenges are addressed by students by developing initial solution concepts (prototypes) with the help of new technologies.

The goal is, on one hand, to enable learners to experience self-efficacy in the field of new technologies and to gain their own experience in implementing solution ideas, and on the other hand, to acquire methods and a mindset for solving problems and to recognize the resulting benefits of the generated application. This goal shall enhance the understanding of technologies' broad potential to support solutions for the SDGs (Nguyen et al., 2020). However, a more generalized but in the context of the SDGs equally important goal is that as many young people as possible (Sek I, Sek II) shall experience for themselves in new learning settings that they already have what is the raw material of the future due to its "nonautomatability": Imagination and problem-solving skills that will make the difference for a more sustainable future.

The effective solution to achieve this goal lies within Smartfeld's specific DNA, as a proven and highly motivated incubator for innovative education created by strong partners.

We will present a) the project, b) its current implementation and c) lessons learned from the co-creative development- and implementation process from the view of Smartfeld as well as from the participating teachers.

Smartfeld at a glance:

In St.Gallen, the higher educational institutions have created a common lab to fuse technology and creativity for STEM-Education: Smartfeld. Smartfeld reaches out to 3500 pupils per year. Backed by foundations, it started in 2022 to develop, implement and run its new open source-workshop "Use of new technologies for the challenges of the future" by combining the creative potential of its partners and active teachers in a co-creative approach based on the OECD-Learning Compass 2030 (OECD, 2019). In short, it tackles SDGs, future skills and physical computing in co-creation with active teachers and influenced by start-up spirit.

Smartfeld's feedback loops represent a shortcut between teacher-education and students' educational system, thus "lessons learned" as well as established good practices can rapidly be distributed and discussed between relevant stakeholders as well as disseminated e.g. via teacher training events, conferences and research-based formats.

Acknowledgements

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MOST: Context-based teaching for students' sustainability consciousness

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1. Introduction

This presentation relates to Topic 2 (Material dimension) and addresses to the question: "What materials do teachers need to run open schooling projects?" Our study is conducted within the context of the Horizon 2020 project MOST (Meaningful Open Schooling Connects Schools to Communities), which intends to open up school education by initiating school-community projects (SCPs) across Europe. Within a school-community-project, schools and community members work together to find regionally implementable and scientific approaches to sustainable issues. The focus on this paper is on waste management, more specifically, we follow a 5th grade class in Norway when exploring chewing gum waste in their local context and investigate the importance of context-based teaching on students' sustainability consciousness.

As teacher educators within the MOST project, we have developed an SCP manual and SCP pedagogical guidelines for in-service and pre-service teachers. Our aim is twofold: Firstly, to equip future science teachers with knowledge about open schooling and competencies in teaching using this approach. Secondly, by working with prospective teachers, we hope they will continue implementing SCPs in their day-to-day science teaching once they finish their education. Thus, we aim at spreading the materials at national level. The SCP-materials developed in MOST is meant to be used by teachers and teacher educators, hence the relevance to the overall conference theme (Educating the Educators) and to Topic 2. Our presentation will be addressed from a target group-specific perspective, i.e., primary students' outcomes. We intend to use the oral presentation format.

2. Theoretical background and rationale

Context-based teaching is often highlighted as a means for students to experience the teaching as relevant and close to reality (Gabrielsen and Korsager, 2018; Sinnes, 2020). Context-based teaching uses authentic learning contexts as a starting point for learning. This study is based on an authentic context from the students' everyday life and uses this context as a starting point for learning about sustainable development (SD).

SD has been promoted in Norwegian school for a long time (e.g., curricula from 1922, M74, L97, LK06). With the new curriculum from 2020, SD was introduced as an interdisciplinary topic in all subjects (Kunnskapsdepartementet, 2017). Although SD is not a new concept, there is little research on the implementation and prioritization of SD in schools (Boeve-de Pauw et al., 2015; Sinnes and Straume, 2017; Bjønnes and Sinnes, 2019). Smaller investigations may indicate that even if SD has been part of school for a long time it has not been prioritized, and the focus has been on students' theoretical understanding of the subject (Bjønnes and Sinnes, 2019). Focus on the theoretical understanding of environmental and climate challenges in schools can lead to students being overwhelmed and paralyzed (Hicks and Bord, 2001). Although many young people show an interest in and have knowledge of these global problems, it is common to feel frustration, fear for the future and to feel helpless (Ojala, 2012). It has therefore been argued for not only to teach about challenges we face, but also convey success stories and show students that they can make a difference. It is then important that students develop action competence to ensure that SD becomes part of their everyday life (Olsson et al., 2016; Scheie and Korsager, 2014).

The concept sustainability consciousness is closely linked to Breiting and Mogensen's (1999) definition on action competence; knowledge of possible action alternatives, belief in one's own ability to influence and willingness to act (Olsson et al., 2016). The term is intended to reflect students' action competence within each dimension of SD and therefore implies knowledge (K), attitudes (H) and actions (H) within the environment and climate, economy and social conditions. Sustainability consciousness involves a more holistic approach to SD than action competence as it includes both cognitive, affective and knowledge-based components (Olsson et al., 2016). In this study we lean on Gericke et al.'s (2019) operationalization of the concept sustainability consciousness that includes knowingness, attitudes and behaviors within the three dimensions of SD.

The research question guiding this proposal is: How can context-based teaching influence students' sustainability consciousness? The sub-questions are:

1. *How have students' knowledge, attitudes and behaviors changed as a result of implementation of a context-based teaching unit?*
2. *How do students experience to work with a context-based teaching unit which aims to influence their sustainability consciousness?*

3. Context: Description of the implemented SCP

The teaching unit was designed based on MOST SCP Pedagogical principles: 1) Features of SCP ways of working: student-centered, collaborative, dialogic and interactive, respectful, value mistakes as learning opportunity, multi perspective approach of problem, attentive to girls' interest and motivation, 2) Features of SCP problems: authentic and co-created, shared ownership, motivation, environmental related Socio Scientific Issues (SSI), meaningful and relevant, scientific or technological strategies required. The SCP, which lasted for about one month, started with an excursion to the local city center where students had to look for problems. The students then decided which problem they would like to learn more about and find a solution to. This coincides well with Sinnes's model (2020) where the goal is to develop hope and find solutions to the problem. The class decided to work with chewing gum which is thrown to the ground. They explored the topic chewing gum, why this is a problem, what can be done to solve the problem and decided that separate bins for chewing gum could be a good solution. Family members, citizens, researchers and municipality members were involved.

4. Materials and methods

The study design is of a mixed method approach including a pre-post student questionnaire (N=17), and a focus group interview with a small sample of students (N=3). The questionnaire focused on three indexes of sustainability consciousness: knowingness, attitudes and behaviors, inspired by Gericke et al. (2019). The results were analyzed using descriptive statistics.

Of those who completed the survey, students were selected via opportunity sampling to take part in a focus group semi-structured interview. During the interview they were asked to elaborate on their own sustainability consciousness (knowledge of the possible action options, believe in their own ability to influence, willingness to act), and their experiences of working with the context-based project. Interviews were subject to thematic analysis (Braun and Clarke, 2006). Students were in 5th grade, 10-11 years old.

5. Results and discussion

The results from our study show no statistically significant change in the students' sustainability consciousness after completion of the context-based project. Descriptive statistics from the analysis of the pre-and post-tests show a slight decrease in students' knowledge and attitudes. The students' attitudes were characterized by seriousness and concern. It might be that the lessons to a large extend focused on challenges and developing students' knowledge of the problem. As Hicks and Bord (2001) show, a too high focus on the theoretical understanding leads to students being overwhelmed and paralyzed by action. In the interview it emerged that the students had a lot of knowledge about SD, but it seemed that the students directed their focus towards everything they did not know. This may indicate that the students have gained more knowledge and became more aware of how extensive and complex issues related to SD are. The tendency to decrease in students’ attitudes can also be explained by the fact that the students' proposals for solutions were not taken seriously by the municipality, leading to the feeling that they didn’t have a real influence.

Results from the thematic analysis of the focus group interview indicate that the students themselves believe that they, and people in general, lack knowledge about the subject in question, and as a consequence they express concern about sustainability issues, as expressed by one of the students: “It was kind of interesting for me when I saw how many people came to our exhibit point, where we showed many people [what we did]. They didn’t know much, and lots of people came. Even our parents didn’t know. And if that many people didn’t know [about the problem] then, what does the world know?” On the other hand, the students express a desire to make a change and express that they need to be given the opportunity to do so: “We can make a difference if we are given the opportunity to”. The students contacted the local municipality and suggested solutions to how the problem can be solved, but they were demotivated by not getting a good enough response from the municipality: “We spoke to the municipality, but we didn’t get much. We had a meeting with them halfway through and then they said, “we will take it into account”, and then we will see what happens and we haven’t heard back from them”. They experienced that they were not given the opportunity to contribute and felt that they were not heard. It emerged that they were worried about the future and believed that people in power, such as politicians, were not doing enough to promote SD.

Regarding behaviour, there is a slightly positive trend, where the students have become more neutral to the questions about actions. In the interview, the students conveyed that their habits, associated with chewing gum, had changed. It also emerged that the students enjoyed both the working methods and the content of the teaching unit. When it came to measures that can be taken to contribute to SD, the students had many suggestions, mainly linked to changes in own consumption habits.

Despite the limited number of participating students in our study, the limited time frame for the project and non-significant results, we would argue that context-based teaching can have a positive effect on students' sustainability consciousness if the focus is on *solutions* to problems that are taken from the students' immediate environment, so that students *experience personal relevance* and are able to *influence decisions* regarding their own lives.

Acknowledgements

This proposal is based on work within the project Meaningful Open Schooling Connects Schools to Communities (MOST), which has been co-funded by the Horizon 2020 programme of the European Union under grant agreement n° 871155. We appreciate the effort of students that participated in the survey and interview and the financial support from our Department at Norwegian University of Science and Technology.

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Integrated STEAM practice in Teacher Training: Get to know your Rubbish

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Friday, 12 May 2023, 9:00-10:00, Auditorium

1. Introduction

Integrated STEAM Education (STEAM-Ed) is a methodological approach that promotes the integration of academic subjects through Project Based Learning (PBL). It is becoming a worldwide movement that aims to promote students' core competencies while enhancing and providing them with a deeper understanding of the curriculum (see Belbase et al, 2021, for an updated review on the topic). This model presents teachers with opportunities to connect the curriculum, not only with other subjects but even within each subject itself. On the other hand, this integration may jeopardize some topics and ideas that need a more abstract setting and/or deliberate practice. To accommodate these two valid, research-based, but opposing views, we need to establish boundaries about when, where, and especially how STEAM-Ed is the appropriate way to develop certain competencies.

In this paper we focus on how STEAM-Ed can reach Higher Education to build both a more integrated view of the curriculum and the experience of a new methodology that can be applied in the future. The connections arise from the fundamental theme of Environmental Education, which underpins our proposal where students' reflections on this topic are accompanied by the quantitative reasoning and analysis they need to develop as future mathematics educators.

2. What is "Get to know your Rubbish"

The models with which we have been educated are the essential reference for the models we will use when we become teachers (Beswick, 2006; Rivero et al., 2011). For this reason, the lack of personal experience of the methodology is one of the factors that make it difficult for teachers to implement PBL in their classrooms. Since we must offer examples and experiences to teachers in training in those educational methodologies that we intend to find in their future practice, we have involved students in an Integrated STEAM proposal. At the same time that the students have gone through this process, they have been introduced to the main aspects of the methodology, always seeking coherence between the experience and the theoretical foundations of STEAM-Ed.

Get to know your Rubbish is the result of merger of two electives for 7th semester Teacher Education students. Environmental Education and Mathematics Education meet in a Project Based Learning STEAM approach, where our students gained first-hand experience of the methodology, advancing in the curriculum for both courses while working in an open school setting.

Our PBL proposal starts from the general topic of Sustainability, in particular rubbish generation and recycling, to raise awareness of our own effect on the environment. This proposal seeks to answer the question of how to teach preservice teachers to develop and implement open educational projects that allow students to learn science and mathematics in a meaningful, open and hands-on environment. The collaboration between the two lead-teachers has allowed us to challenge the students from both disciplines, melting the boundaries between them in terms of the schedule, curriculum, and regular assignments.

3. Description of the experience (Outline of the presentation)

3.1. Context

The experience took place between February and May 2022, with a small group of 8 trainee teachers in their 7th semester at the Faculty of Education in Segovia (Spain). Elective subjects of Environmental Education and Mathematics Education, each with a workload for the students of 6 ECTS (approximately 4 face-to-face hours and 6 non-face-to-face hours per week).

3.2. Entry point: The 'Get to know your Rubbish' challenge

The activity began with a news item about the largest landfill in Europe, located in Madrid, less than 100 km from our classroom. During the first 4 weeks the students were introduced to the environmental problems, in particular the greenhouse effect, created by this garbage. Divided into two groups of four students each, they were asked to do further research on this topic as they went through a process of collecting data on the garbage discarded in each of their 8 homes, which was then represented and analyzed. This research was guided by the lead-teachers through formative assessment.

The students were then challenged to make a contribution that could raise awareness of this issue outside of our classrooms, particularly for primary school teachers or trainee teachers. One group chose to create an art installation to show how much trash the community produced in a day (paper, packaging and mixed waste). The second group, on the other hand, proposed to record video tutorials of various DIY ideas for self-made school supplies from recycled plastic.

The main difficulties for the students were the choice of the specific topic they wanted to address, teamwork and time management. They had to learn to manage this situation of great freedom and autonomy, to which they are less accustomed. At the same time, during the classes, they reviewed the types of plastics, the management of urban waste, the use of spreadsheets, the types of variables and the elaboration and analysis of graphs.

3.3. Development: Making a contribution

During the following 4 weeks, the students had to put their ideas into practice. Each group had a different final product in mind and, therefore, interactions between the two groups decreased during that time and each group focused on different aspects, depending on the chosen objective.

As they had never developed a project before, engineering strategies such as Scrum and Kanban were introduced (Figure 1). Teamwork was - as expected - complicated and the tensions arising from the sudden innovative environment were analyzed and discussed in their dual role as students and future teachers. While the students worked in an adequate and committed manner during these weeks, the classes did not result in clear notes specifying a list of topics to be learned for an exam and, although they knew the competencies to be developed in both courses, the students had an expectation based on the content that caused some trepidation.

At the end of the allotted time, the art installation was displayed at the entrance of the main building of our campus and the video tutorials were promoted on social media (Figure 2). The art installation was surrounded by posters and QR codes explaining the project, providing additional information on waste generation and disposal, and linking to the video tutorials.

3.4. Assessment of the process and learning auto-assessment

Every student reflected about their own learning process in the group; about the PBL methodology, and about the two subjects. They filed a three-column table: in the middle column the learning objectives had been included by the lectures, their project areas for improvement at left and learning notable aspects at right. They wrote things like:

To improve: "It did not occur to me to compare the data with other Spanish citizens to see if our consumption was normal or if we were more or less aware. Also, this should have been extrapolated to other countries"; "To break down activities that may block the main tasks into sub-tasks"; "I would like to get involved with more associations and in the future, as soon as I have more time, I will do so in order to share and give visibility to all that I have learnt".

Notable aspects: "I understand how and why the process of statistical inference is performed and I think I could replicate it in a similar project"; "Through data collection I have become aware of the amount of waste we generate in our households"; "We integrate the plastic arts in the activity that we propose to carry out in schools, in addition, the assembly of videos, infographics and our social networks, follow a striking model capable of being interpreted in a visual way and that captures the attention of many people while taking care of the aesthetics".

Figure 1. Students group working

Figure 2. The Education Degree students preparing the art installation.

4. Final reflections

The actual implementation of this idea gave us a better understanding of the tensions that arise when first experiencing PBL as a student in Higher Education, as well as the advantages of this integrated approach. We believe the experience has been very positive for us as lead-teachers, since we have also gained practical experience on a methodology that, up to that moment, we had only experienced as mentors of several primary school teachers with whom we have worked for the last 6 years.

Regarding our students, we think the experience made them improve on all the competences that we had planned to include, of course, to get acquainted with this methodology from a personal viewpoint. The share and formative assessment of the process was key, as well as collaboration between the two groups to raise the goal in time. The emotions flow through the project. The insecurity at the beginning, the joy at the creativity stage, some frustrating moments for the students that they had to manage, because they couldn't obtain the result they had dreamed of, and finally, joy again when the public exhibition took place, and they received feed-back and questions.

We think that some of the tensions that arose were not originated by the STEAM-Ed or PBL approach themselves, but because of their lack of experience with how competency-based assessment is conducted. It is important to note with respect to this issue that Spanish law has applied this approach since 2006, but its reality is content-based testing and our best students tend to be rather competitive with their grades.

This teaching experience can be transferred to other settings taking into account organizational issues such as having the same set of students in both courses as well as the greater dedication to face-to-face teaching, since co-teaching has been necessary in certain parts of the experience.

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MOST-event in Norway for Primary Education

Cramp, Rachel, Birralee International School, Norway
Lewis-Jones, Caroline, Birralee International School, Norway
Friday, 12 May 2023, 10:10-11:10, Auditorium

1. Abstract

This presentation will examine how the MOST Project and the Sustainable Development Goals can be implemented through the curriculum so that it can be embedded into the life of the school. It will include an examination of how the approach to learning of the MOST Project is compatible with the IPC Curriculum. The

IPC Curriculum promotes a holistic approach to learning with the subjects being tackled through a theme rather than teaching each curriculum area discreetly.

There will be consideration of the practicalities of Open Schools for schools and how this can best be fulfilled through different approaches. The basic tenor of the MOST Project is Open Schools which encourages students to work as co-creators with people outside school over an extended period of time. Within the framework of a school this can be a high aspiration which is largely unattainable because of the constraints involved in timetabling, meeting curriculum requirements and the time commitment that is required from the outside contributors. Finally, there will be a reflection on the MOST Project at Birralee International School.

2. The MOST Project at Birralee International School, Trondheim, Norway

The MOST Project has been implemented at Birralee International School for two academic years. The first round was during November/December 2021 and the second was December/January 2022/23. In the first round, it was decided to run the MOST Project in Years 4, 5 and 9 and this year we have just focused on Years 4 and 5.

It was very important that the MOST Project complimented the curricula that our students follow rather than being an 'add on' since this would give greater meaning to the activities that the students would complete and it would provide the students with much deeper learning opportunities. In addition, through integrating the project there is greater opportunity for making the MOST Project more sustainable and with greater longevity.

3. The IPC Curriculum and MOST

The IPC Curriculum is constructed in such a way as to easily accommodate the MOST Project because of the way in which it is structured. The Curriculum Guide outlines the vision, philosophy and aims of the IPC in the following terms:

Vision: The vision of the International Curriculum is to inspire learners to be active and reflective thinkers who lead their own learning now and in the future.

Aim: The International Primary Curriculum (IPC) aims to improve learning in schools by supporting teachers and leaders through the provision of contemporary, internationally researched curriculum materials and engaging, age-appropriate units of learning.

Philosophy: Central to the IPC is the belief in, and commitment to, the holistic development of learners through enjoyable and connected academic, personal and international learning that prepares them for opportunities and challenges now and in the future. (IPC Curriculum Guide 2020-2026, p. 7)

According to the MOST Draft Manual for Work Package 3 the INCREASE Trail Map steps were included to guide teachers as to the methodology involved in the MOST Project (2020, Manual to Plan and Perform SCP Draft Version, p.4). INCREASE involves the following steps:

INVITE: Invite anybody, who has a certain level of interest.
CO-CREATE: Try to bring different stakeholders and community members together. ACT: Decide on a topic, set a concrete timeline, and develop a strategy with milestones and objectives to reach
SHARE: Communicate your project; use all possible channels to disseminate your project
EVALUATE: See if you reached your goals!

This has been used and incorporated into the IPC Learning Process which is fundamental to the curriculum:

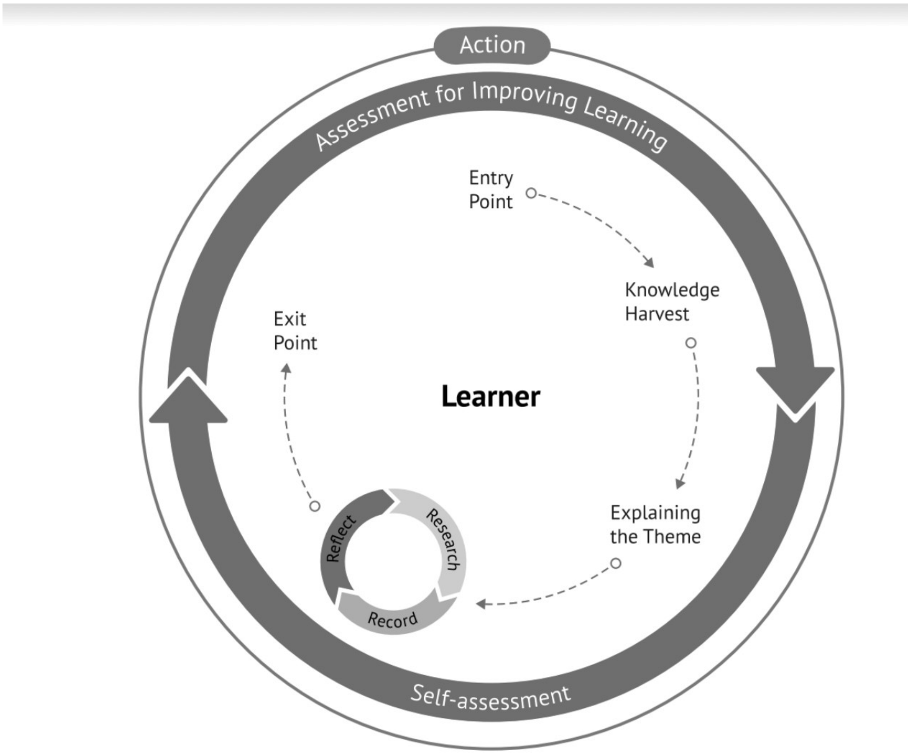

Figure 1: The IPC Learning Process to facilitate learning (IPC Curriculum Guide 2020-2026, p. 18)

It has been important that the MOST Project becomes part of the IPC Learning Cycle since there is also a requirement from the IPC that at least once every two years students complete a Sustainable Development Goals Unit.

3.1. The MOST Project at Birralee International School

The MOST Project has been run at Birralee International School for two academic years. It has proven to be most appropriate for students in the Upper Primary years (Years 4 and 5) although it has also been run with Year 9 students (first year of IGCSE).

In 2021/2022, Birralee International School, like all other schools, was still working within a framework that had been adjusted due to Covid-19. This meant that there were limitations on what could be done, most notably in terms of inviting people into the school. This meant that collaboration and co-creation with people outside of school was rendered even more difficult than it would normally be.

This academic year, there are no restrictions, however, there are a number of things that must be considered which included:

1. Safeguarding- anyone who works with our children
2. The ability for members of the wider community outside school being able to commit more than a couple of hours of their time for such a project.
3. Organising visits when there is a timetable to consider which includes specialist subjects such as Music, PE and Norwegian which are led by subject specialists
4. The skills that are required to work with primary school students. Often people who come into school have no experience of making materials accessible to younger students.
5. There are still many people working from home and there is still some concern about contracting Covid.

This has meant that as a team working with the MOST Project we have chosen to continue to have an Open School through the use of ‘experts’ rather than one person being with the group throughout the project of approximately 5 weeks. This made the project much easier to manage, particularly with the students in Years 4 and 5.

Those students who took part in the MOST Project in Year 9 found this project more challenging because they were only able to devote one and a half hours a week to it. Additionally, to make the project more meaningful and to integrate it into the examination syllabus, the students completed it as a Personal Project which is required by the IGCSE Global Perspectives syllabus (Syllabus Cambridge IGCSE Global Perspectives 0457).

3.2. General Outline of the Two Projects

The first MOST Project (2021) ran through three different Year groups in the school. Year 4, Year 5 and Year 9. The initial project was 'kicked off' by an introduction to the students using the Sustainable Development Goals. This was a new concept of learning and what teachers used to underpin the learning based project. The projects began in the same way for all three of the year groups and then quickly fractured into separate identities as students took the learning in the direction that they desired. In order to 'formulate ideas and thinking' visits and tours of the local area were included in the planning and immersion phase of the project. After this point, community involvement was sought and the projects continued.

The second MOST Project (2022) ran in only two Year groups (Year 4 and Year 5) but used the same staff as the previous year. The initial planning and immersion phase was structured differently using the staff's experiences from the first project. The project was 'hung' on a unit of learning from the IPC Milepost 3 curriculum and has been designed to allow staff to trial collaborating on an 'across age phase' style of teaching and learning for the first time in the school. The project 'kick off' was held back this time as we dedicated time to allowing the students to gain vital knowledge and skills in the subject area. This was very successful and staff felt that it gave students more context and the ability to make an informed decision about their research area.

3.3. Reflections

The MOST Project was a daunting prospect for teachers to begin with. The internal structures of the project and the Manual to Plan and Perform felt a difficult and at times almost impossible task for teachers to implement, especially in a post-covid classroom. It was imperative that agencies and stakeholders from the community were involved and maintained a presence in our projects, but this proved very challenging.

Having been part of the MOST project for two years has allowed staff to have the confidence and insight to allow students to direct their own learning more effectively in the second project and the 'constraints' have felt less constricting.

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MOST: What Are The Skills Teachers Need To Implement Open Schooling Projects?

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1. Introduction

Communities face global challenges and their effect to themselves in today's world. If communities are to be actively and responsibly involved in decision-making, they need to have a better understanding of science and technology. In this context, co-operation between formal, non- formal and informal education providers, business and civil society should be enhanced to ensure relevant and meaningful participation of all societal actors in science and to increase participation in science studies and science-based careers to improve employability and competitiveness (Commission et al., 2015).

Considering the needs and objectives mentioned above, it can be said that open schooling embodies an understanding that can make significant contributions. Open schooling involves the understanding that schools are places that influence the welfare of society in co-operation with other stakeholders, that families are encouraged to be stakeholders in school life and activities, and that experts from businesses and society actively bring real life projects to the classroom (Commission et al., 2015). In more general terms, it includes the understanding of education in co- operation with relevant stakeholders by opening the school doors to the outside.

Open schools

- support co-operation with non-formal and informal education providers, businesses, parents and local communities to ensure relevant and meaningful engagement of all societal actors in science and to increase understanding of science studies and science-based careers, employability and competitiveness,
- becomes a tool for community well-being,
- supports partnerships that promote expertise, networking, sharing and application of science and technology research findings, thus bringing real life projects into the classroom,
- focuses on effective parental involvement,
- supports science learning for girls (Sotiriou et al., 2017).

School community projects (SCP) offer effective educational opportunities in carrying out activities in the context of open schooling. With school community projects, problems related to the welfare of the society are investigated and solved through co-operation [www.icse.eu/most/]. Indeed, co-operation between teachers, students and stakeholders in science-related subjects offers exciting ways to bring real-life problems with ethical and social issues into the classroom environment and can also help problem-solving skills (Commission et al., 2015).

We focus on the skills teachers need to implement open schooling projects. In line with this focus, the study's research question is "What are the skills teachers need to implement open schooling projects?"

2. Method

The study was designed as a narrative study of qualitative research. The participants in this study were the teachers who are science or math teachers in different middle schools in Turkey and carried out school community projects in their schools.

Research data were obtained in three ways. In the first way, the form which has open-ended questions was used. The form contains questions for each stage of a school community project and provides the teachers with the opportunity to explain their activities and experiences related to the project process. In the second way, the videos of the co-creation stage were examined. Lastly, the personal observations of the researchers were used.

3. Finding

As an early result of the analysis, Table 1 was determined as the skills teachers need when conducting school community projects.

Table 1. the skills teachers need to implement open schooling projects

Stage	Skills
Opening lecture	• Supporting argument construction • Using instructional techniques (Brainstorming) • Providing a democratic environment (ET) • Giving appropriate feedback to determine the subject • Creating a discussion environment • Making a presentation
Invite	• Effective communication skills • Communicating
Co-create	• Ability to use online platforms • Organising planned activities • Using instructional techniques (Brainstorming)
Act	• Skills for inquiry process • To be able to continue the process of ensuring students' motivation
Share	• Creating a slogan • Making a presentation • Creating visual tools (table etc.)
Evaluate	• To be able to evaluate the process • Being able to recognise mistakes

Conclusion

Teachers need to use various skills in the stages of school community projects. These skills are mainly independent of the nature of the subject matter. In general, teachers need skills in managing student-stakeholder and student-student interactions and managing inquiry-based research processes and evaluations.

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Promoting teacher competencies towards sustainability conducted through STEAM interventions in IndagaSTEAM Escuela Project

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Friday, 12 May 2023, 10:10-11:10, Auditorium

1. School Culture supporting STEM Education

Education improves constantly, so lifelong learning and continuing education/professional development are a way of being updated on almost every innovative knowledge approach and learning strategy. STEM education contributes to scaffold a holistic educational framework curriculum. In this line, to establish School Culture supporting STEM education is relevant to foster an education reform at all levels.

Place-based learning STEM approach in real-life contexts provides school subjects meaningful elements either for teachers/professors or students. Furthermore, when implementing constructivist teaching-learning approach, problem-based learning, and connections with real world items in the classroom, STEM approach is very efficient, specially using inquiry-based strategies. However, STEM Education goal refers to a holistic integration of STEM areas across the curriculum, although it seems to lack specific scientific literature related to how STEM acronym (and disciplines) should be implemented, because the whole is greater than the sum of its parts (Aguilera et al., 2021).

2. What is IndagaSTEAM Escuela Project

Professional development programmes can simultaneously explore mechanisms for integration across STEM and non-STEM disciplines, and help existing teachers develop a deeper understanding of the subjects they teach. (Margot & Kettler, 2019). They involve a shift from the teacher's role as a transmitter of knowledge to a facilitator of knowledge, helping students to identify and use relevant sources to solve real-world problems. Sustained professional development programmes could have a positive impact on teacher teaching and student achievement. These programmes may also use a mentor or peer coach, allowing teachers to apply their learning in the classroom with the support of a peer coach. (Cotabish et al, 2013).

IndagaSTEAM Escuela Project is an experience to promote transfer of learning for students during their teacher training at schools -for compulsory education- to develop students' key competencies, conducted through cooperation between schools and universities by mentoring interventions (Lupión-Cobos et al., 2021).

Moreover, the following points are taken into account when designing the project programme: a) Teacher/Student centered approach, b) A curricula reform, new organizational system and new teaching materials, c) HE & School projects implementing inquiry-based learning and place-based learning (Morrell et al., 2020; Author, 2021), d) Teaching and activities selection and design for Professionals and Students, and e) Activity impact evaluation to aim the goal. In particular, several didactic aspects of the training process were addressed:

4 Teaching as examining one's own practice in the classroom/reflecting as a professional: Teachers as managers of change and transformation in schools.

5 The systemic nature associated with the change that it implies as an innovation in teaching practice requires consideration of different influencing elements (curriculum, school organisation, professional development or teaching materials, among others).

6 School projects, using inquiry and contextualising strategies, have been identified as helpful training scenarios for applying STEM education objectives (Morrell et al., 2020; Author, 2021), which clarifies educational purposes and guidelines for its treatment.

7 Activities to be used and how they fit in. The teaching skills to select and design them allow to formulate coherent and solid proposals with the intention of the proposed model. Its identification and design thus becomes a training objective that also articulates an expectation of professional practice.

8 Systematically evaluate the impact of actions (interventions) and provide evidence/research evidence to guide improvement.

The program professional development of participants (teachers) is mainly focused on empowering and motivating learners to become active sustainability citizens, fostering critical thinking, and participating in shaping a sustainable future (Leal Filho et al., 2019). Thus, the project articulates teacher sustainability competences (Rieckmann, 2019). This proposal describes teacher sustainability competences through a project design and its implementation to stablish relations between them: a) PBL STEAM "How can I improve my environment" (Topic 2 "material") and b) sustainability competences by the teacher (Topic 1 "personal").

3. PBL STEAM "How can I improve my environment" for teaching competences associated to Agenda 2030

The school project was designed and implemented in primary schools (6-12 years old children) by primary school teachers during 2020-2021; 2021-2022 course. It was developed in 6 weeks (from 2nd half of April to May), divided in three phases (1 = Initial, 2 = Development y 3 = Final) which includes 7 work sessions with activities for students who were working in a Class Group (CG) and in Small Groups (SG)).

In phase 2, the teacher helps pupils to develop their understanding of the world as an interconnected whole, to look for connections in the social and natural environment, and to consider the consequences of their actions, by visiting a natural environment located close to the school. Its design is planned as a work project tackled from a transdisciplinary approach, with STEAM areas being its backbone.

At every session, collecting data tools are used to evaluate results (which are likely to be used either for students or the project).

Initial phase starts with a CG kickoff workshop introducing the topic environmental awareness & sensibilization and reflect about 2030 Agenda for Sustainable Development Goals (SDGs), enabling students to focus the problem to be addressed (environmental pollution), using thinking techniques (Word-Idea-Phrase). Activities design and implementation allow teachers to initiate a wide range of competencies related to sustainability at each phase of the project, which are categorized according to Rieckmann's description (2019) (Figure 1).

Figure 1. Sustainability competences for teachers expressed in phase 1 of the project

Phase 2 & 3, foster the sense of understanding our interconnected world (with teacher support), searching links among social and natural areas, bearing in mind how the consequences of one action's would affect the environment. Furthermore, a nearby natural site is chosen for a scholar visit which needs a former inquiry. Students (CG) search for information and draft an "Environmental Eco-audit" which allows them to know and contrast "in situ" the environmental location and its characteristics. Moreover, students are asked to explore future alternatives and use them to deliberate about how they might change their behaviors to support sustainable development, driving their work to elaborate an "Eco-Tourist Guide", to design "Informative-persuasive signage to promote good habits", and a proposal at the school for "Creation of vertical gardens with native aromatic plants". In addition, critical thinking related to non- sustainability actions are launch by the teacher fostering sustainable awareness and the need of a societal change, from a receptive and inclusive perspective, reinforcing their sustainable believes and values. In Phase 3, SG presents their Final work to CG, by oral presentations using murals, posters and/or digital resources.

The whole project implements transdisciplinary lines, especially using STEAM as main axis, fostering creativity and proactive decision making, so as strength students to critically evaluate the reliability of environmental management models, accepting responsibility for their work acting prudently and timely.

Sustainable competences for teachers described by Rieckmann (2019) are always bearded in mind (Figure 2).

DEVELOPMENT PHASE (2) ⇨

- **SYSTEMS**
- **FUTURES**
- **PARTICIPARON**
- **ATTENTIVENESS**
- **EMPATHY**
- **ENGAGEMENT**
- **TRANSDISCIPLINARITY**
- **INNOVARON**
- **ACTION**
- **CRITICALITY**
- **RESPONSABILITY**
- **DECIVENESS**

FINAL PHASE (3) ⇨

- **ATTENTIVENESS**
- **EMPATHY**
- **ENGAGEMENT**
- **TRANSDISCIPLINARITY**
- **INNOVARON**
- **ACTION**
- **RESPONSABILITY**

Figure 2. Sustainability competences for teachers expressed in phases 2 &3 of the project.

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MOST: Instructions for schools on how to organise School-Community Projects

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Friday, 12 May 2023, 10:10-11:10, Live Science

1. Introduction

Europe is facing major challenges in various areas, one of which is the shortage of skilled workers in STEM professions that has existed for years. Exacerbated by Russia's war of aggression and the pandemic, the call for well-trained people is getting louder. In addition to the general shortage of skilled workers, there is a shortage of female skilled workers in scientific professions because at a certain point they lose interest in a career in the STEM field (Reinking 2018). To prevent the resulting gender gap, it must be countered at an earlier stage to encourage girls' interest in science (Penner 2008). According to a 2018 study, only 17% of employees in the technology sector are female (COM 2021) whereby an immense potential of possible skilled workers is lost. To address these challenges and to change traditional ways of thinking and acting, innovative and collaborative strategies are required to encourage students to strive for STEM related careers.

2. How to support teachers in carrying out OS-Projects

Individuals, single institutions, or single governments can´t address these challenges. They demand collaborative action amongst stakeholders and ask schools to create learning environments that inspire young people to exploit their full potential. The Open Schooling approach, therefore, supports students to acquire real-life knowledge by getting in touch with STEM-related subjects and topics in their community (OSS 2017).
The MOST project (Meaningful Open Schooling Connects Schools to Communities) aims to promote students' interest in science fields through School Community Projects (SCP). The interaction between students and community members from STEM fields leads to the promotion of students' motivation and interest to pursue similar career paths (Reinking 2018). In addition, the open schooling approach leads to a suitable networking system between schools and their communities, which supports meaningful cooperations between different stakeholder in the region (Dalton 2007).

The MOST project intends that private individuals, companies, and associations work together on strategies to overcome current environmental and social problems. The collaborative work leads to a broader understanding of scientific processes and intends to promote the scientific knowledge and transversal skills of the society in the long term.

In order to support SCP leader in the implementation of Open Schooling projects, we have written a handbook within the framework of Workpackage 3, "Instructions for schools on how to organise SCP", which, based on the INCREASE Trail Map (Fg.1), leads step by step through the individual phases of a School Community Project.

Figure 1. The INCREASE-Trail Map for School-Community Projects (S. Kapelari, 2021)

INCREASE stands as an acronym for INvite, co-CREate, Act, Share and Evaluate and represents the skeleton of a 5- step process aiming to engage stakeholders in co-creation activities and implement joint projects. The manual describes in detail which goals are aimed for in the individual phases.

By describing important steps that should be taken into account by SCP leaders when carrying out a school community project, the manual aims at teachers, headmasters, and other possible SCP leaders to support them in carrying out School Community Projects. Containing best practice examples and experiences from 10 different countries all over Europe, it is a valuable and useful document, which can be seen as a guideline to successfully go through Open Schooling projects. It helps with the question of which teacher, which classes and students are possible participants in such a project, and how to come up with an appealing, socially relevant, the region concerning, topic, as well as the framework within a school community project, can be carried out at schools.

The handbook benefits from a series of interviews with HEI representatives from the MOST project, as well as occasional other partners who have been involved with the project over the past two school years. The interviews were held online, and the questions follow a guide that leads step by step through the INCREASE trail map. In this way, we received individual answers for any single phase and learned about the needs of schools and the problems teachers and SCP leaders had to deal with. The results of the interviews will be integrated into the manual in the coming weeks, which will give us the opportunity to present best practice examples and conclusions from 2 years of Open Schooling projects at the ETE IV in May 2023.

Acknowledgements

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Methods of Increasing the Attractivity of the Teacher-profession for Pre and In-STEM Teachers through Professional-Development and Career Advice

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Friday, 12 May 2023, 10:10-11:10, Live Science

1. Overview

To counteract the upcoming shortage of teachers, measures must be taken to make the teaching profession more attractive. This is exactly where the project 3C4life comes in. An online platform was developed within the framework of the 3C4Life project. There, on the one hand, professional development opportunities are presented through career options for teachers, and, on the other hand, innovative teaching materials are presented that intended to improve the teaching-quality of teachers and thus increase their enthusiasm for their own profession. The effects of this platform are examined in the form of a quantitative and a qualitative study.

2. Teacher-Shortage in Europe

Europe is facing teacher shortages. Besides, STEM education systems lack the capacity to support teachers to make the best of their life as teachers. As a major reason, the ET2020 Working Group on Schools identified that teachers do not perceive teaching as an attractive career option anymore (Carlo et al. 2013; Katsanova 2019). This leads to increased teacher turnover (Thorburn 2020). To raise the attractiveness of the profession, a positive image of the teaching profession must be established, among teachers as well as among society. Furthermore, the teaching profession must be perceived as a lifelong development process, including the use of innovative teaching approaches. Collaborative practice and professional learning communities must be promoted and anchored and teachers must receive support from the beginning of and throughout their careers to allow for professional growth.

However, there are still major gaps to be filled: Career guidance for teachers across Europe is rare. Teachers do not see a need to develop teamwork competences and collaborative approaches are hardly applied. Furthermore, teachers have problems in adopting new teaching methods and professional development offers do not meet their needs.

3. The Project 3C4Life and the teach4life Platform

As part of the EU-funded 3C4Life project, an online platform (teach4life.eu) was developed to counteract the causes of the shortage of teaching staff. The intention is to support teachers at all stages of their career and profession. The platform offers information about career opportunities (i.e. videos of interviews and career description for each partner country), a digital network for STEM teachers and impulses for innovative teaching including detailed descriptions and solutions with a strong focus of inquiry-based-learning, socio-scientific issues and real-life contexts.

In this project the causal link between the motivation for long-term involvement of STEM teachers in occupational advancement programs and three elements of the online platform will be analysed. The research hypotheses are:

1. A sequential arrangement of motivational triggers increases the involvement of STEM teachers in occupational advancement programs.
2. Multi-directional advancement perspectives raise teachers' motivation to shape their best personal path as a teacher.
3. Targeted community-building features increase teachers' participation in Communities of Practice.

The impact of the platform is examined in three ways. In a qualitative study, five participants per country (total n=30) are interviewed and asked about the effect of the platform on their attitude towards the teaching profession. In a quantitative study, at least 120 participants per country, (total around n=600), complete a pre-post-follow-up questionnaire. This will be used in particular to investigate attitudes towards the teaching profession and self-esteem. In addition, user behaviour is investigated through AI-based tools.

4. Content of this Presentation

After a short presentation of the impending or already incipient teacher shortage in Europe and how this can be counteracted, the concept and the core elements of the online platform teach4Life are presented. The platform offers attractive career options for STEM teachers, serve as a platform for collaboration and exchange with teachers across Europe and gives you inspiration for your teaching. The aim of the platform is to increase the attractiveness of the STEM teaching profession in Europe by initiating dialogues between STEM teachers and connecting future and practicing STEM teachers.

A special focus is on the presentation of the teaching materials with three examples of innovative teaching approaches. The concepts of inquiry-based learning, socio-scientific issues and real-life contexts are introduced. They highlight why and how they can further develop sustainable STEM education by scaling up innovative teaching approaches.

In addition, preliminary results are presented from the conducted study and relations to sustainable education are made.

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A Professional Development session on Environmental socio-scientific issues and its impact on Prospective mathematics teachers' task designs

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1. Introduction

The literature review suggests that there is a need for developing a Professional Development (PD) model to prepare European prospective mathematics and science teachers to integrate Environmental socio-scientific issues (EnvSSIs) in science and mathematics classrooms (Maass et al. 2019). It seems that this integration raises many challenges and dilemmas for teachers due to their ill-preparedness in leading debates on controversial discussions and dealing with the uncertainty of students' solutions (Evagorou2011). In the context of mathematics teaching, many researchers admit that environmental crisis provoked questions about the role of mathematics education at the level of research and practice in facing this crisis (Boylan and Coles 2017;Owens et al. 2019). In addition, Hauge and Barwell, (2022) propose the following principles when designing Professional Development (PD) courses in order to support mathematics teachers to deal with the dimensions that EnvSSIs are related to: exploring meaningful situations of risk and uncertainty and incorporate both scientific/mathematical concepts and societal perspectives. Furthermore, according to Vos, (2018) the environmental issues seem to possess the two essential authentic task characteristics: a) the out-of-school origin and b) the certification of originality, thus they could engage students in authentic, meaningful and context-driven mathematics tasks that address issues of societal concerns (Yaro et al. 2020).Thus, exploring ways of enacting a PD session addressed to PMTs, in order to support them in designing tasks relevant to EnvSSIs; and the impact of this session on PMTs designs could be of interest in the field.

The present study took place in the context of a European Project (ENSITE, https://ensite-project.eu/) aiming to enrich prospective teachers' competences for designing and implementing Environmental Socio-Scientific Issues (EnvSSIs) in mathematics and science classrooms. In the context of this project, several modules were designed and piloted in many European Universities.Particularly, four Greek Teacher Educators (TEs) designed and enacted short Professional Development (PD) sessions to support prospective mathematics and science teachers to include in their teaching practices tasks on EnvSSIs. This paper reports on one of these cases.

This study explores a TE's actions while enacting a teaching session on EnvSSIs for Postgraduate Mathematics Teachers (PMTs) and the extent that this session could support PMTs' exploitation of these issues. The research questions are:

RQ 1: What are the TE'sactions aiming to support PMTs to teach EnvSSIs in mathematics classrooms?

RQ2: What is the impactof TE's actions on PMTs' exploitation of EnvSSIs in their task designs?

2. Context and Methodology

The PD session we study here was part of the undergraduate course entitled 'Teaching through Problem solving-Mathematization' based mostly on parts of the modules developed in the ENSITE project and lasted for 7 teaching hours. In the course's final assignment, 47PMTs (working in groups of 2-3) were asked to design a mathematical problem that concerns an EnvSSIof their choice;present the relevant socio-scientific issue; provide the sources used in their design. The data for thisstudyare a) the TE's lectures and teaching materialsand b)selected PMT's assignments. The TE's lectures were analysed in terms of her teaching actions and goals. In this way we responded in our first research question. For the selected specific PMTs' assignments the following steps emerged: 1st step: all PMTs' assignments (22)were analyzed by focusing on four dimensions: a) the authenticity of the environmental problem they are referring to; b) the emphasis ofsocietal aspect of this problem; c) the emphasis they placed on the controversial aspect; and d) the identification and further use of mathematical tools needed for solving the suggesting problem; 2nd step: we characterized each assignment according to the extent it addressed the above dimensions (less, medium, high); 3rd step: we selectedfive characteristic examples of PMTs' assignments to illustrate the diversity in terms of the above four dimensions of the emerging PMTs' answers.

3. Results

3.1 TE's actions enacting the PD session.

a) Inviting four PMTs who participated in an online ENSITE Multiplier event to introduce EnvSSIs to their classmates. The goal of this action was to familiarize PMTs with EnvSSIs and their controversial side.

b) Discussing parts of the project modules involving mathematical activities such as interpreting big data on climate change and ecological footprint, diagrams related to a Lake drainage and the power production of wind generators versus the use of windmills to the past.The goal of this action was to specify mathematical aspects of specific EnvSSIs.

c) Implementing an online survey quiz with the question: "Paper or plastic bags, which is better for the environment?". In this activity, PMTs had to read several resources and provide an argument for the one or the other choice. Subsequently, PMTs were asked to analyse their classmates' arguments by using the Toulmin's framework. The goal of this action was to support PMTs' evaluation of arguments.

d) Using a digital calculation tool to engage PMTs in counting their ecological footprint with the goal to sensitize them on relative issues.

Thus, TE emphasised on the controversial characteristics of EnvSSIs (Actions a and c); raised PMTs' sensitivity to such issues (Actionsand d); and supported students to acknowledge the mathematical aspect of these issues(Action b and d).

3.2 PMTs' exploitation of EnvSSIs in their task designs.

Amonga number of PMTs' interesting answers, five proposed assignments indicate PMTs' exploitation of EnvSSIs.

(a) The *Fire fighting* task*:* the students had to develop ways to prevent forest firefighting, explore the main causes and make the better choice of trees for reforestation.

(b)The *Railway* task:the students had to decide on /the expropriation of a piece of land to benefit from a new railway track.

(c)The *Fashion Ecological Footprint* task: the students had to explore ways to lower the ecological footprint from clothing production.

(d)The *Sinking Village* task: develop ways to rescue a sinking village in Indonesia.

(e)The *Donation* task: choose the best way to recycle plastic for making a donation to a disabled person.

Some extracts from PMTs' tasks are: 'Study the energy consumption of trains versus cars and state the benefits from each choice' (*Railway*); 'where would you put the factory, if you wanted the least CO_2 emissionand the lowest production cost?' (*Fashion Ecological Footprint*); 'Argue on the following question: Pine tree: just a beautiful tree or real bomb*?'*(*Firefighting*); 'Save the village ofTimbulsloko by creating a protection zone planting bamboo or mangroves trees. Which is the best choice*?'* (*Sinking Village*).

Mathematical tools needed to solve the above tasks were mostly simple calculations (e.g., *Firefighting; Sinking village; Railway*) orthe use and interpretation of statistical representations (e.g., *Firefighting*); or engage students with arithmetical progression models (*Railway*).

The societal aspect was also ascertained in all the above tasks. We can list for example,the reference to a recent and catastrophic Greek fire that caused many people deaths (*Firefighting*);the priority of rescuing a cemetery (*Sinking Village*);the promotion of the value of volunteering (*Donation*); andthe sensitivity to global self-awarenessabout the planet climate change (*Fashion Ecological Footprint*).

The controversial character was ascertained in only two tasks (the *Firefighting* and the *Sinking Village*)while the negotiation in terms of profit and cost was present in the *Sinking village*, the *Railway* and the *Fashion ecological footprint*.

Finally, all of the above tasks maintained authentic characteristics since they were different from these that the TE presented in her lectures and they were based on authentic resources such as:national data (*Firefighting*, *Fashion ecological footprint*, *The sinking village*); onlinearticles,newspapers and magazines(*Firefighting*, *Donation*, *Sinking village*);sites aboutenvironmentalissueshttps://adoptabeach.wwf.gr/schools (*Donation*),https://climate.nasa.gov/vital-signs/sea-level/ (S*inking village*); World Resources Institute: https://www.wri.org (*Fashion ecological footprint*); andresearch papers (*Firefighting, Sinking village, Fashion ecological footprint*).

4. Conclusion

This study provides an example of introducing global realities to PMTs through the design of a short PD session based mostly on high quality and ready-to-use materials that were developed in the context of the European Project ENSITE.

The Teacher Educator emphasized on the controversial characteristics of EnvSSIs; try to raise teachers' sensitivity to such issues; and supported students to acknowledge the mathematical aspect of these issues. Five characteristic examples of task designs are selected to illustrate the diversity in terms of the above three dimensions of the emerging PMTs' answers. The analysis of the above five tasks indicates that the controversial characteristic cof EnvSSIs was integrated less among the problems so, the TE needs to develop more or different actions to stand up for her students to learn how to integrate this aspect into their designs(Evagorou 2011; Hauge and Barwell 2022). Also, the mathematical challenge in PMTs' designs was relatively low and the students seem to need more support to design challenging mathematical problems. On the contrary, the authenticity as well as the societal dimension were intensively present among all the above tasks. Maybe TE's actions supported the authenticity of tasks due to the various resources she used in her lectures.

This study suggests that if these short PD sessions become functional parts of specific undergraduate courses in the upcoming years it could be the start of supporting sustainable education in respect to EnvSSIs for prospective mathematics teachers (Maass et al. 2019).

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Poster Presentations

ARSTEAMapp Project: Fostering Scientific Vocations through Augmented Reality about European Cultural Heritage

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ARSTEAMapp addresses the challenges of improving the teaching of STEAM disciplines in the 12-16 age group, designing an innovative way to connect these disciplines with the educational context in a meaningful and feasible way.
An augmented reality (AR) educational application will be developed that will clearly reflect the connections between STEAM disciplines on 10 buildings that are symbols of European cultural heritage (Burgos Cathedral/Spain, Hagia Sophia/Turkey, Colosseum/Italy, Eiffel Tower/France, etc.).
As an example of the intended application, students will scan the façade of the Burgos Cathedral using a tablet or smartphone; then, through a virtual tour, students will learn aspects related to science (type of rock used), technology (tools used in its construction), engineering (successes and failures in its design), mathematics (structure) and art (historical context in which the cathedral was designed and built; social and cultural significance of the cathedral), while making explicit links between STEAM disciplines content. Students will also be expected to answer some questions related to the knowledge they have learnt in practice.
This project aims to develop a pedagogical framework to guide secondary school teachers to implement the STEAM approach through an AR educational application and a comprehensive handbook.
The specific aims of the project are:
(1) to promote the adoption of an integrated STEM approach by establishing a clear link between landmark buildings of European cultural heritage and the contribution of STEAM disciplines to their design and construction through the development and implementation of STEAM-based AR.
(2) Facilitate teachers to implement the integrated STEAM approach through AR resources, thanks to the development of a constructivist-based pedagogical model. Thus, the pedagogical design, implementation and guidance of the created tools will be realised based on the educational curricula of the different countries of the participating partners (Turkey, Romania, Portugal and Spain).
The ARSTEAMapp project (2022-2025) is also an Erasmus KA220SCH project. So far, we have piloted the project, which has been trialled and highly appreciated by teachers and academics in partner countries. In the coming period, the pilot application of the project will also be tried by students. Studies will be carried out in the remaining 9 symbol buildings and will be applied to students. At the end of the project, all these works carried out over a period of 3 years will be explained to all stakeholders in Spain in an event with great participation.

Changes of Components of Reflection and practice of Novice Facilitator in Context of Co-Designing Mathematical Trails

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Despite of the recommendations of national curricula and several years of support, transmissive classes seem to be prevalent in Slovakia. Most teachers do not have experience with posing and solving open modelling problems. Mathematical trails seem to provide reasonable activity for students where they spend time outside by solving mathematical problems related to real objects (Čeretková and Bulková 2020). Posing problems related to real objects allows designing the problems dealing with socio-scientific and environmental issues.
MathCityMap is a system for designing and enacting math trails with the support of technologies (Barlovits and Ludwig 2020). Collaborative designing and enacting of mathematical trails offer various affordances in professional development of in-service as well as pre-service teachers (Haringová and Medová, 2022), e.g.

during the planning teachers pose and formulate new problems related to social-scientific issues, formulate hints in order to provide scaffolding for their students; during the implementation of trail teachers observe their students during problem-solving. The involvement in co-design put special requirement also on the teacher educators.

Methodology

In this self-study we identify opportunities to learn and changes in various aspects of work of professional development of novice facilitator. Silvia (the second author of the poster) started to work with MathCityMap trail when she was in year 3 of her initial teacher education. She got very excited by the idea and dedicated her master thesis to posing problems with MathCityMap and their enactment out-doors and in remote conditions caused by measures related to Covid-19 pandemics. Just after finishing her master's degree in mathematics and informatics education she did not become a teacher but applied for and was accepted for doctoral studies in mathematics education.

In order to describe the changes in the various aspects of Silvia resources, goals and orientations we used the double level framework by Karsenty (2020). Deductive analysis of the transcripts of the webinar was used. Each of the sentences was categorised using the Six Lense Framework to enable the accessing of changes in Silvia's identity as a teacher and Meta-Lences Framework in her identity as professional development facilitator.

Results

Her thesis should be focused on co-design of materials for inquiry-based classrooms. As she was so keen on MathCityMap trails, she adopted the lesson study model to work with teachers on posing problems, designing the MathCityMap trail, enacting the trails and reflect on the activities. Silvia has supervised more than 15 MathCityMap trails with teachers around Slovakia and led several workshops about designing the MathCityMap trails in Czech Republic and Slovakia. She was actively involved as supervisor of students during solving the tasks in MCM trails, so she gained also an experience as a teacher in this settings. Each activity for teachers was followed by a mentoring session with her supervisor.

There were two webinars led by Silvia. One was organised during last months of her master study by the institution providing the professional development for in-service teachers in April 2021. The second webinar was held in October 2022 after all the mentioned activities and was organised by the Department of Mathematics. According to enactivist paradigm "knowing is doing and doing is knowing" (e.g., Brown & Coles, 2011) we can observe the development of novice PD facilitator based on her enactment of the two webinars. Her developed expertise should be observable in this action.

The most obvious change was in the number of sentences addressed directly to the attending teachers. She expressed here goals as a facilitator more explicitly. In her journal she reflected on her perception of the two webinars as follows "*we want to take students outdoor and show them how they can use mathematics in the real-life world, because mathematics is all around us*".

During posing and enacting the MathCityMap trails Silvia got the knowledge and experience not only with work with teachers, but as an unexperienced teacher also with work with pupils. It influenced the PD agenda and ideas, as the focus of the first webinar was on the technological particularities of the MathCityMap portal, whereas during the second webinar the pupils' behaviour and experiences with enacting the trails were addressed.

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Healthy beverages factory. Integrated STEAM project for Primary School

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1. What is “Healthy beverages factory”

The learning project that is presented was developed in a Primary School center. The didactic proposal is based on Project Based Learning (PBL) and the STEAM approach. It was designed to enhance student's learning from an integrated perspective. This mixed methodology allows the teacher to develop an open teaching-learning process that integrates all the students (Kim, 2021). It was implemented in a context where it was relevant to integrate some students with special educational needs.

PBL encourages commitment and motivation that students need to solve real world tasks. The process leads to a final product that allows them to develop skills and knowledge for real life (Cheng & Yong, 2019). It is also known that the STEAM approach helps students to acquire either skill for solving real world tasks and creativity (Perignat & Katz, 2019). The convergence of both methodologies benefits the creation of a solid and integrated curriculum, which can substantially increase the engagement of PK-12 students for learning (Bequette & Bequette, 2012). From this perspective, this project sets an interesting material for Primary School teachers.

This proposal proceeds from the general topic of Sustainability, in particular sustainable production, and pollution, to reflect on how we can transform our environment and create sustainable products. The project tries to bring the students' context to reflect about sustainable production, renewable energies, healthy consumption, and the necessity to preserve the natural environment. The curricular integration has allowed students to develop skills from different disciplines as math, science, arts, and social science, learning by thinking and solving real life problems (Brown, 2017).

2. Description of the experience

2.1. Context

The project took place during April and May in 2022, with a small group of 12 students (ages between eleven and twelve) from a public school based in Segovia (Spain). In the group there were four students with special educational needs, and the project sets a new approach to facilitate their integration. It lasted three weeks during which ten sessions of variable duration were held. During the project the students worked in four heterogeneous groups.

2.2. The develop of “Healthy beverages factory”

The general topic of the project was the creation of a sustainable factory that produces healthy drinks. While the factory was fictional, the students came to elaborate a real drink in the classroom. During the process the students had a digital diary where they registered the progress and learnings they were doing. The project had four phases with different steps.

The first phase consisted in the explanation of the project. After it was exposed, it started the second phase, which consisted in the research of information. The first step was to carry out surveys in the school, to know flavors and kinds of beverages that would be interesting to produce. The second step was to investigate the production sectors, and to deduce how each one will contribute to the production of a drink. It was said, for instance, that it will require some fruits and milk, and energy for the factory. The next step was to investigate energy, looking for a renewable one that can be used to elaborate the beverages in the factory. Then, in a different session, they must propose solutions to decrease the impact that the factory could have on the environment. Then, the next step consisted in the elaboration of the beverage. They first had to investigate substances, materials, and blends, and to design the first recipe for the drink. After that, they properly created the beverage in the class and tasted it until they found the flavor they really wanted. To finish this phase, students had to find an NGO that works for sustainability, and to think about how they would collaborate with them.

The last two phases consisted in the organization of the materials to create a poster and an advertisement to announce the beverage and their work. Each group creates their own video, their beverage, and their poster, that were held in the classroom. To conclude, there was an evaluation process after all the materials were presented to the class.

3. Final reflections

The implementation of this project has benefited global learning. All the class improved their performance on the final test. Motivation towards learning increased in almost all students. Some positive ideas about health and sustainability grew up in the class, while students develop relevant skills on math, science, digital art, creativity, and entrepreneurship.

Students reflect in their personal evaluation that they prefer to learn by practice instead of writing. Specifically, they found that the activities related with energy were excessively theoretical. On the other hand, the surveys were considered very positive, and the results opened new lines of activities in the school.

The groups worked properly in general terms. However, there were occasions when a person had to work more than their mates. While some groups worked in a balanced way, others needed the teacher´s order to work to succeed in the practices. This shows the importance of designing balanced groups with students that can cooperate using different skills.

To conclude, the project presented can serve as an example that other teachers can adopt in the context of STEM education. It provides a framework for incorporating STEM concepts and skills in a real-world, project-based approach that engages students and promotes their learning. The project also focuses on the pedagogy employed and includes a reflection about it. The reflection highlights the successes and challenges of the project, as well as the lessons learned by the teacher as an educator. This reflection can help other teachers to adapt and improve upon the project in their own teaching context.

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Primary Students’ Visions Regarding Key Factor to Promote and Constrain Biodiversity in Specific Environments

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1. Overview of the study

The present study is part of a larger research project with the main goal of understanding how primary students conceptualize biodiversity, the main factors of biodiversity loss and which collective and individual actions could promote an improvement of biodiversity. For the purpose of this research, the main aim is to describe and interpret which factors are taken into account when primary students think of the biodiversity of particular environments.

This study is framed in an educational innovation project called PATIS BIODIVERS (BIODIVERS SCHOOLYARDS) which has two major goals. It wants to promote the authentic inquiry practices and to use empirical data collected from schoolyards to develop scientific research. Last year, in a pilot project, the materials of the project were created collaboratively from an interdisciplinary team of researchers from Universitat the Vic – Universitat Central de Catalunya (UVic-UCC), with the support of more than 40 teachers, from 13 different primary and high schools of Vic.

2. Rationale of the research

Many studies cite biodiversity loss as one of the major problems facing our society. The World Wild Fund points out that our planet's ecosystems are shrinking drastically, leading to a sharp decline in biodiversity. Teachers should bring this topic into schools as a challenge, as it is an excellent way to contextualize biology instruction (Weelie, Boersma, 2018). Not only to give children the chance to participate in our society and become aware of what is happening around them, but also to take action on the Sustainable Development Goals, as biodiversity is one of them.

In this respect, learning about biodiversity is seen as a key element of this strategy, which is based on four main arguments: a) emotional, creating personal meaning through discovery and experiencing biodiversity; b) ecological, understanding the global interdependencies between the different elements of the ecosystem; c) ethical, dealing with values and taking a moral stance in environmental issues; d) political, making choices and developing action competence (Weelie, Wals, 2002).

Therefore, learning about biodiversity is not only related to learning facts from different sources of information, but also must be considered as experiential learning, involving participants in community, hands-on activities and contact with nature (Navarro, Tidball, 2012). Understanding the factors of the environment that can promote or restrict the establishment of species in it could be useful to inform individual and collective actions to promote biodiversity. In this respect, a previous study to predict the viability of the wolf population in the Pyrenees (Jiménez, Amat, Codony, 2020) showed how primary students only took into account a few factors in the environment to support the wolf establishment.

3. Research dimension

Knowing children's perceptions of the factors that constrain or enhance biodiversity not only helps teachers determine in which aspects they should focus during the activity’s development, but also helps children improve their knowledge of biodiversity and define their actions. In this study, data was obtained from 49 of primary school students, from three urban schools. The data collected will be analysed through a Qualitative Content Analysis approach (Mayring, 2000) using a deductive category development strategy. Our results show that students consider humans as one of the main factors for the lack of biodiversity. As for the most biodiverse environments, forests and jungles were most frequently chosen by the children. They described them as suitable areas because there is so much peace, vegetation, water, humidity and so on, while they consider deserts and polar areas as unsuitable places for survival, mainly for the lack of vegetation.

4. Acknowledgements

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Sustainability-related personal values of pre-service biology teachers

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1. Relevance of Teachers’ Personal Values

The likelihood that teachers are able to successfully implement Education for Sustainable Development (ESD; UNESCO, 2017) in their everyday teaching largely depends on their professional competence (Dunn and Hattie, 2022). However, the broader set of personal values teachers hold may also play a crucial role in the successful adaptation of ESD to their classroom (Corrigan et al., 2020). Values are cross-situational goals that guide individuals or social groups and vary in importance (Schwartz et al., 2012). If a value, such as sustainability, is of particular importance to a person, he or she is more likely to choose those attitudes and behaviors that are preferable according to that value (Rokeach, 1973).

Different authors have already argued that and how teachers’ personal values may affect their teaching (e.g., Simon and Connolly, 2020). A study by Harland and Kinder (1997) showed that perceived mismatches between teachers’ personal values and those embedded in the curriculum decrease the likelihood of implementing specific instructional approaches and taking appropriate time to teach relevant topics. However, teachers’ values are important for a second reason: According to the socio-emotional domain of ESD (UNESCO, 2017), the acquisition of values conducive to sustainability is explicitly named as a learning objective. Indeed, values develop and change through learning experiences, the environment, and ongoing adaptation to new situations and lifestyles (Rokeach, 1973).

It is therefore crucial to take a closer look at teachers’ sustainability-related personal values to evaluate whether these are congruent with ESD or whether specific learning opportunities may be required for the targeted modification of any value mismatches that may exist.

2. Research Questions

1) Does a sample of pre-service biology teachers (PBTs) show higher levels of sustainability-related values than a reference sample (71% university students of different majors; 29% adults) that was surveyed 10 years ago?
2) Is there a positive association between the number of ESD-related learning opportunities in biology teacher education (operationalized by semesters of study completed) and the level of sustainability-related values, even after partialling out the influence of the PBTs’ age?

3. Methods

We conducted a cross-sectional survey including *N* = 151 PBTs from a university in Germany. We specifically selected this group as ESD in German curricula is mainly covered by the subject of biology.

The operationalization of sustainability-related values was based on Schwartz et al.'s (2012) refined theory of basic values, which covers 19 discriminable values that can be assessed using the Portrait Value Questionnaire – Revised (PVQ-R). A closer look at the PVQ-R reveals that the three universalism values covered are almost congruent with the key ESD goals: (1) *Concern*: Commitment to equality, justice, and protection for all people; (2) *Nature*: Preservation of the natural environment; (3) *Tolerance*: Acceptance and understanding of those who are different from oneself.

We asked our participants to answer the universalism-related PVQ-R items (three items per value; scale range from 1 [min] to 6 [max]) as well as sociodemographic questions to assess their age and semester of study.

Research question (RQ) 1 was answered by comparing our sample to the PVQ-R norm sample that was surveyed by Schwartz et al. in 2012. We calculated Hedges' *g*, which accounts for different sample sizes and can be interpreted analogously to Cohen's *d*. RQ2 was answered by calculating partial correlations.

4. Results

Regarding RQ1, our results show that, compared to the reference sample, our sample of PBTs shows higher levels of all three universalism values (medium effect sizes; Table 1).

Table 1. Differences in universalism values between a reference sample (Schwartz et al., 2012) and our sample

Universalism value	Reference sample (*N* = 3,261)		Analysis sample (*N* = 151)		g_{Hedges}
	M	*SD*	*M*	*SD*	
Concern	4.72	0.78	5.25	0.70	0.68
Nature	4.02	0.87	4.65	1.06	0.72
Tolerance	4.61	0.71	5.10	0.65	0.69

Regarding RQ2, we found a low, but significantly positive partial correlation ($r = .16$, $p < .05$) between semesters of study and the level of the nature-related universalism value. With respect to concern- and tolerance-related values, however, there were no significant correlations.

5. Discussion

Overall, our results show both positive aspects and possible starting points for action. Regarding RQ1, we cannot be sure whether the higher scores of our sample of PBTs are a result (a) of a general trend over time or (b) of the fact that their major is biology or (c) of a mixture of both. However, considering the fact that the maximum PVQ-R scale value is 6, we still interpret the result favorably. A clearer need for optimization is revealed by the correlational results. Although university teacher training in biology seems to be significantly positively associated with the development of the nature-related universalism value, other sustainability-related values do not seem to change in a similar way, although teacher education offers a lot of potential in this respect.

Empirically, it has been shown that university students' intention to engage in sustainable behaviors considerably depends on what they perceive to be the social norm. In this respect, university professors, CEOs, and politicians are seen as most important benchmarks regarding sustainable behavior (Swaim et al., 2014). Thus, particularly at the level of attitude formation, educators can have a great impact as role models. And this is even more important because attitudes toward complex issues like sustainability are less fixed and therefore easier to modify (Linville and Jones, 1980).

In order to effectively promote the acquisition of values conducive to sustainability among pre-service teachers, it may be beneficial for professors involved in university teacher education to consistently bring up their own sustainability-related values (e.g., in brief anecdotes) and, of course, to behave accordingly (e.g., ride a bicycle to work). In addition, community-based learning should not be forgotten in university teacher education, as it has been shown to encourage reflection on one's own civic responsibility (Ibrahim, 2010).

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When the Line met the Circle

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1. Introduction

Didactic fairy tales designed for academic purposes in primary and secondary schools and higher education institutions are gradually becoming an essential tool for teachers (Kucheriavyi, 2022). The storyline method contributes to pedagogical content knowledge for teaching school mathematics, and students experience an entirely new way of learning (Karlsen et al., 2020). This is a proposal for a project for inclusive mathematic classes. Participants will join in a Didactic fairy tale environment in which they will explore the circle, the line and the square experientially through constructions, motions, drawings, theatre, observations, debates and more. It is based on the theory that the various kinds of creativity aim to acquire emotional experience of fundamental physical laws, formulas, and abstract definitions (given in textbooks) of the essence of concepts of Mathematics (Kucheriavyi, 2022). The didactic fairy tale “When the Line met the Circle”, originally conceptualised and created by our group, is a novel, unpublished and original literary work which uses a fictitious plot to reveal individual phenomena and specific laws of nature as elements of mathematics.

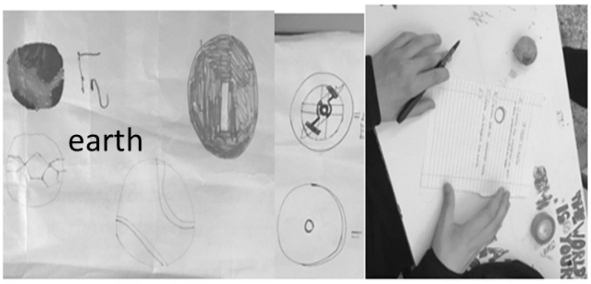
2. Aim of the project

Our purpose is for all students to be part of a math fairy tale, to experience the geometric characteristics in the way they choose, and be linked with the environment. It is an open schooling project since participants study the schemes, nature and the environment through vivid interaction and collaborative work for co-creation and sharing ideas and results. They are invited to develop research and innovation projects to address relevant local challenges, contribute to community development, and promote an active global citizenship attitude. Students debate about the «perfect scheme» but are also concerned about diversity, inclusion, friendship, and justice through creativity, art, and logical thinking. It perfectly addresses all disciplines of STE(A)M since it orchestrates studying the environment (nature, classroom) and materials (elasticity, structure, properties) by prompting participants to delve into concepts and connections of scientific objects. The fairy tale heroes are features from Geometry (Mathematics) which the participants will visualize either by constructing them (Engineering) or by representing them by drawing, dancing, or music (Art) or by exploring them in nature (Science). The project is also designed to implement computer-related activities for digital study and visualization (Technology). So, it is a STE(A)M fairy-tale open schooling project for an inclusive and environmental mathematic classroom.

3. Design of the project

This project is perfect for mixed-ability teams since students have been shown to prefer this kind of grouping together (Vasilopoulou & Triantafillou, 2022). In one mode of its implementation, no external aids and materials would be involved, prompting the students to use their body to represent the shapes and their properties. Nevertheless, to strengthen the inclusive nature of the activity, it would be of an added value to have the activities organised in stations of multiple tools in the space with direct access to the students. For example, we suggest paper, pencils, paints, plasticine, ropes, ribbons, musical percussion instruments, and bricks. Furthermore, the activities can take place outside so the children can connect with the Environment. By observing nature, deconstructing the image and delving into the shapes, they may "see" the Square in flowers, the Line in the sea, etc. The value of connecting the Environment with mathematics in the teaching of mathematics has been highlighted by research (Le Grange, 2010).

The Line and the Circle are the two fairy tale's principal heroes. The problem begins when the Line asks the Circle to become friends, and the Circle refuses because it believes that it is the perfect scheme. They appeal to Square for help after an intense debate. They are asked to show off their characteristics and skills, but in the end, they will find a way to collaborate and become friends. Individuals collaborate to get ideas for what a circle or a line can make and try to visualise their ideas using Art (drawings, photos, bodies), Engineering (constructions), Mathematics (properties), Science (delving into concepts and connections of scientific objects, e.g., elasticity, structure, properties) or Environment (exploring nature for lines and circles). They can also use Technology (pc for digital study and visualisation). In the end, all groups collaborate to find a solution with a line and a circle together, to a problem in their neighbourhood. For example, 10th Grade students in a Public Greek High School argue that the Circle is the better scheme, invoking the Earth and the Astrolabe (picture 1). On the other hand, the "line team" thought that a line could turn into anything "maybe line is not a shape, but it can become any shape it wants". But they all agree that it needs a No Entry Road sign, which is a line and circle together, on the road in front of their school, to make sure that no more car accidents.



Picture 1: Students' Visualisations

4. Conclusion

The key strength of our fairy tale project proposal is that is gives the opportunity to every student to participate and have an equal chance to experience the pleasure of achieving and understand fundamental mathematic concepts in their own individual unique fashion. In this proposal, Pupils have several ways to express their ideas, collaborate, and expand their knowledge regardless of level, skills and background. The "When the line met the circle" project has powerful possibilities for collaborative, learner-centred and research-oriented learning with flexible access, which influences the classroom culture and fosters students' learning. We anticipate this project to become a booster of experiential learning and will be a creative and inspiring tool in teachers' hands, for Inclusive open STE(A)M schooling classrooms.

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Use of school's local natural environment in outdoor education in ecology for promoting sustainability

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1. Long-term inquiry-based outdoor education project in ecology as Open Schooling for Sustainability Education

Environmental education research clearly states that learning experiences in the natural environment are important in developing students' connectedness to nature, environmental knowledge, attitudes, affections, consciousness, and responsible actions for environment (Ballantyne and Packer, 2002; Palmer and Suggate, 1996; Chawla 2018; Waite 2020). According to Uitto et al. (2006), outdoor nature experiences are the most important factor connecting with interest in biology. This poster presents a partial study of my ph.d-project which explores how reflected observations and inquiry-based, systematic learning activities in local environment, combined with a science and literacy approach in the classroom can support primary school students development of science process skills and collaborative knowledge building in ecology and in own local environment. Developing a relationship with nature, learning to make observations, understanding the key ecological systems, and understanding the dependence and interactive relations between human and nature is an important precursor to understanding issues in sustainability.

2. Pedagogical strategies supporting open inquiry and the use of local natural environment in ecology and sustainability education

This poster suggests what kind of structural changes in the ways of working in the primary classroom level (10 -11 years) are needed to consider when implementing a long-term, inquiry-based ecology outdoor education program in the local natural environment. The meaning is through this poster to present a purposeful way to integrate outdoor ecology lessons activities with classroom teaching, and thus guide a way for purposeful fieldwork and follow-up classroom activities as a regular activity of formal science education. During the program students are building their knowledge about biodiversity of invertebrates and winter birds in their natural habitats in the schools' immediate environment. Inquiry-based learning activities outdoors in local environment are systematically combined with a scientific literacy and inquiry strategy called Science Writing Heuristics (SWH) (Hand and Keys, 1999). Both these practices (outdoor education and scientific literacy activities) are widely valued but challenging to integrate in science classroom teaching on a purposeful way (Osborne, 2010; Dillon, 2013; Waite 2020).

During the program students are learning to use their local outdoor environment as an information source for their inquiries. Understanding the local environment helps young students later to understand and relate phenomena happening further away. In the outdoors, students can have direct experience with natural phenomena that can be sensed by vision, sound, touch, and smell. The multifaceted nature of the outdoor environment together with many variables in natural and build environment are affecting phenomena observed by students. Learning to react on phenomena and making directed observations is an important part of the program. Several opportunities to visit and investigate local environment give students possibility to interpret and see the phenomena or tasks from different perspectives and in different times. During the program students have several opportunities to reflect and review their observations and learn to make sense and meaning from their experiences, present their observations, share their knowledge at school, and connect their experiences and learning to students' families and homes.

The program uses an open inquiry approach with purposeful, prolonged observations and inquiries based on students' prior knowledge, self-selected problems and research questions, and own reflected, first-hand experiences and observations in the local environment as important elements. Learner-centred pedagogical strategies fostering meaningful and authentic learning are used to increase motivation and interest (Ausubel, 1968; Braund and Reiss 2006; Monteira and Jimenez-Aleixandre, 2016; Stroupe et al. 2019).

The study is guided by the following research question: What kind of strategies and practices must be considered so that elements mentioned above, and the use of local outdoor environment as a source of information, would become a natural part of learning in ecology and sustainability education?

3. Perspective and dimension

The poster is presented from initial teacher education perspective as well as teacher professional development perspective. According to Wolf (2022) pre-service teachers should already in their initial teacher education be provided with basic knowledge, skills, and methods for teaching curriculum-based content outdoors. The poster will address the Topic 3: Structural dimension of educating educators. The poster will focus on classroom practices and responsibilities that must be changed and reorganized to offer students possibilities and freedom to use local environment for their inquiries in environmental and sustainability issues. The poster will also focus on possibilities to engage students in open inquiry activities where the goal and activity are personally interesting and motivating, have relevance in every-day life, and serve a possibility for students to build their own knowledge-based environmental relationship.

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Mangualde STEM Academy – An innovative place-based curriculum development project from pre-school to year 10

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1. About the project

The Mangualde STEM Academy (Ribeiro and Fernandes 2021) is a project of the Municipality of Mangualde, in partnership with the Mangualde Schools' Cluster (all the 20 schools of the municipality) and the Teacher Training Center Edufor, funded since 2018 by European funds through the Intermunicipal Community of Viseu Dão Lafões to "Support Successful Educational Contexts and Pedagogical Practices". This Academy, through a Pedagogical Innovation Team, develops and supports place-based STEM curriculum development, promoting the use of project-based and other research-based pedagogies for active learning, collaborative and interdisciplinary teacher' work, contextual and reflection-in-action professional development, innovative educational technology and alternative school' organizational structures to improve teachers' and students' agency and skills (OECD, 2018, 2019) in solving local environmental (UNESCO et al. 2015, UNESCO 2020) and community relevant problems. With the collaboration of local companies, ambassadors from leading schools and universities in the country, the Pedagogical Innovation Team has developed and applied more than 150 lesson plans and projects from pre-school to year 10, shared in social networks, newsletters, local and regional media, multiplier events and paper and digital publications freely available on its website https://academiastemmangualde.pt/pt. The project has been invited to present and share its work in several national and regional level events related to STEM and innovation in education.

2. Methodology

In this project we focused on three dimensions: Structural, Personal and Material. At the Structural level, we needed to create the ideal conditions for the Personal and Material dimensions to work in an articulated way. The following table summarizes the work carried out in the three dimensions.

Table 1. Dimensions and practices of educating educators for innovation in the Mangualde STEM Academy

Dimension	Practices
Structural	- Specialized external teams hired to work together with schoolteachers in terms of professional and curriculum development (STEM), supporting teaching practices; Students' schedules organized to create interdisciplinary subjects (Natural Sciences, Physics and Chemistry, Maths, ICT); - Teachers' schedules organized to facilitate collaborative work, peer teaching and professional development; - Involvement of partners (Directorate-General for Education, local companies, higher education institutions, others) in both curriculum and professional development, in some cases acting as Ambassadors from different areas (experts in assessment for learning, critical and computational thinking)
Personal	- Informal working sessions between the external team and the teachers involved in the Project with informal professional development related to the learning activity being developed; - Formal workshops held at the school with invited experts (e.g. in assessment for learning, critical thinking, robotics, etc.) and end-of-year events based with expert's seminars (in the STEM area) and workshops.
Material	- Conception of STEM Learning Activity Guides divided into: a) Brief introduction of the activity, with the respective curricular framework, based on the

	competences foreseen in the Students' Profiles by the End of Compulsory Schooling and Essential Core Curriculum (Portuguese educational guidance documents); b) Teacher's Guide, with methodological suggestions, questions, materials, equipment to use, technologies and supporting web applications, student assessment, extension activities, bibliography, among others; c) Student Guide, with materials and instruments to support the activities to be carried out by the students. - Careful acquisition of innovative technology required for the designed learning activities; - Creation of pedagogical graphic novels (Fernandes 2017) that are representations of the designed teaching and learning activities with photos and text, that make explicit the pedagogical rationale, the practices and the results of the said activities for reflection-in-action.

3. A brief analysis of an exemplar learning activity developed in the project – A Patinter truck driver's trip

This activity, designed for 7th grade students (13 to 14 years old), was originally developed in a collaborative way with one of the partners of the Mangualde STEM Academy, Patinter, a large logistics company based in Mangualde, with a fleet of about 1000 trucks.

Students worked with direct proportionality, for example, kilometers and distances traveled, fuel consumption and additives ("environmental protectors"), constant, real and average speed, among other data (Maths) using the context of a truck driver's trip to England, planning his money exchange needs; analysed photos sent by the truck driver during the trip to identify and characterize different types of landscapes (Natural Sciences); Visited the Water Treatment Plant in place in the company headquarters characterizing physical and chemical operations (Physics and Chemistry).

In an interdisciplinary way, from the CO_2 emissions provided by the company for this trip, the students calculated the capture potential and the area required to plant trees of a certain species to offset the released carbon, presenting their findings to the board. To do that, they had to study the best tree species to plant, out of the four options presented, and calculate (estimate) how many trees would be needed, taking into account the CO_2 emissions of the entire fleet of trucks (monthly and annually). Then, the students wrote a letter to present the results to the company and, simultaneously, to the municipality of Mangualde to find land that could be reforested taking into account the results obtained in the study. The company, interested in the problem, would support the acquisition of trees to reforest the area identified by the municipality.

4. Reflection-in-action – Results of a self-assessment characterizing the practices of the Pedagogical Innovation Team

In the end of the school year 2021-2022, 9 teachers were invited to, anonymously, characterize the Organizational, Pedagogical, Assessment, Inclusion, Parents Engagement, Training and Monitoring Practices, following the framework on the recently published (2022) Monitoring Report of Curricular Autonomy and Flexibility by the Ministry of Education. These results were publicly discussed with the Academy Ambassadors and the project stakeholders, including students, to define an improvement plan now in practice.

Annexes

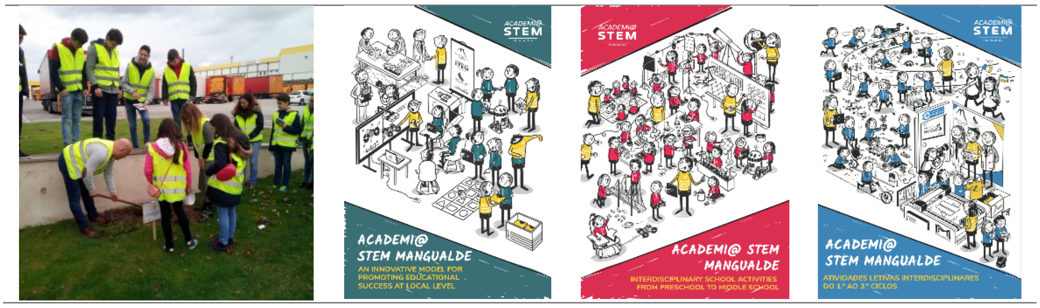

Figure 1. Students and Patinter staff planting the first tree in the company headquarters to offset CO_2 emitted by the truck fleet and covers of the Mangualde STEM Academy publications.

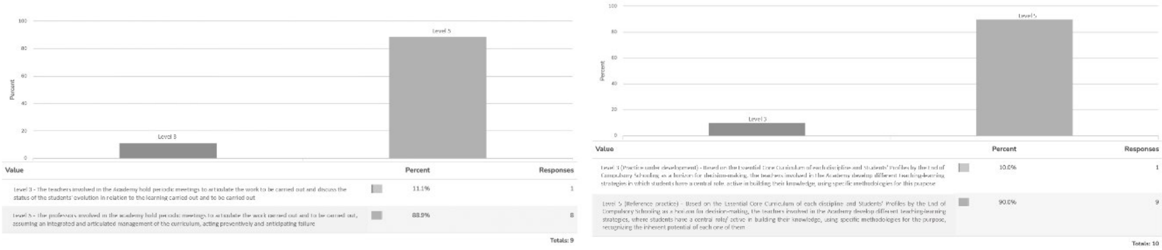

Figure 2. Excerpt from the answers given by the respondents in the Organizational, Pedagogical, Assessment, Inclusion, Parents Engagement, Training and Monitoring Practices' Report: Collaborative teacher work and organization of classes and active learning methodologies in the Academy.

Acknowledgements

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CENTRO 2020 PORTUGAL 2020 UNIÃO EUROPEIA Fundo Europeu de Desenvolvimento Regional

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CYANce: Climate Creativity – Youth for Alpine Needs Establishing a sustainable co-creative climate lab and launching an “education-research-industry” network for co-creation and inquiry-based-learning in Tyrol

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Larl-Zögernitz, Bettina Klasse!forschung, Austria
Färber, Vanessa Klasse!forschung, Austria

1. Introduction

The NPO klasse!forschung is a platform for non-formal STEAM education in Innsbruck, Tyrol, Austria. It unites up to 40 research organisations and enterprises ranging from universities and technical colleges, as well as innovative start-ups to well established, international industries into a network spanning from industry to research. It aims to develop and provide authentic, real-life scientific educational activities for schools and is a central hub and connecting element between schools/teachers, research organisations and companies in Tyrol.

This poster will illustrate the implementation of a new co-creative learning space in the Austrian region of Tyrol.

2. CYANce

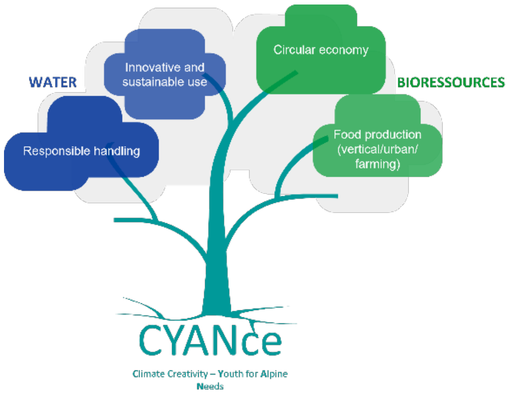

Figure 1. CYANce Tree

The project CYANce: Climate Creativity – Youth for Alpine Needs (project start: 01/12/2022) aims towards giving children and young people, from the ages of 6 to 19, an unprejudiced space to research topics and needs of the alpine habitat. The name – being a word play on science and the colour cyan as a combination of the colours blue and green – symbolises the two main research themes water (blue) and bio-resources (green).

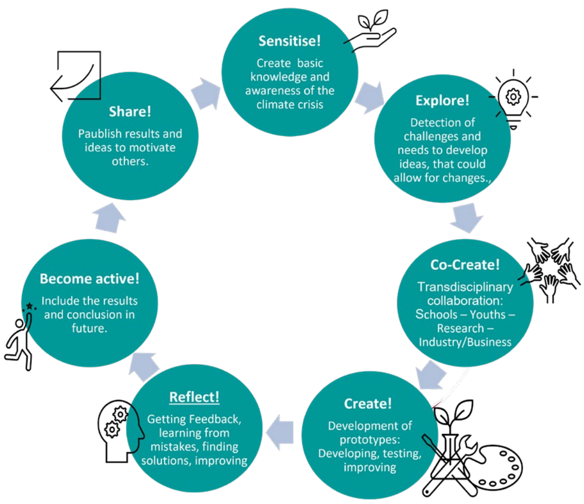

Figure 2. Didactic Concept

CYANce's didactic concept (Fig. 2), partly grounded on the concept of design thinking, consists of at least seven modules that can run in different sequences but always should start with a thematic introduction (sensitise!) and should include loops of reflection.

Schools as places of learning and teaching are often limited due to various reasons, CYANce aims to break down some of those limitations and offer open-minded spaces for learning and co-creative processes.

Together with experts from science, research and industry the kids and youths use co-creative methods to find solutions for climate protection, climate change adaptation and mitigation and the use of renewable energy resources. The main object of the project is to create and increase the awareness that the climate crisis can only be challenged by working together and through the interaction of a reflected approach, as well as the efficient use of our resources and the development of forward-looking technologies.

Through CYANce's wide, interdisciplinary partner network, the project displays the possibility to deal with a selection of topics in the context of water and bioresources in an interest-led and interdisciplinary way, following the STEAM idea. Variable infrastructure, tools and methods promote individual young talents: Biolabs in the Micromondo+ Science Center and at the universities enable a scientific approach in authentic working environments, digital fabrication labs enable an approach via technology and handicraft, participating architects, work teachers and microbiologists combine natural science with art and design and enable an approach via creative and artistic work, digital learning games enable a linguistic approach to deal with the topics and to understand interactions and control mechanisms. Variable, stationary and mobile laboratories distributed throughout Tyrol allow access even in remote regions.

This poster will illustrate this first phase of CYANce and the co-creative development of activities and workshops with and for kids and youths.

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Acknowledgements

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MOST in Czechia – Best Practice Example of Waste Oriented Project

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1. Introduction – Sustainable development and responsible consumption

Sustainable development concept represents an alternative model of societal development reflecting the natural environmental limits to economic growth. One of the most challenging goals of the sustainable development is to change consumption patterns and expectations that are deeply entrenched in most societies and cultures (Meyers et al., 1997). Worldwide consumption and production still rest on the use of the natural environment and resources in a way that continues to have destructive impacts on the planet. However, resource decoupling and impact decoupling are needed to promote sustainable consumption patterns and to make the transition towards a greener and more socially inclusive global economy. Circular economy is emphasised as one of the current sustainable economic models (UNEP, 2017).

Circular economy is based on three main principles: eliminate waste and pollution, circulate products and materials and regenerate natural systems using renewable energy (Kirchherr et al., 2017). The transition to this kind of economy is dependent on how the companies, organisations, as well as individuals learn to use what they have learned in the real World. Thus, education play vital roles to ensuring students are equipped the key skills and knowledge to apply circular thinking and reasoning in their everyday lives and carriers.

Open schooling can be one of the approaches to introduce students to the principles of the circular economy in a natural way. In our study we present best practice examples of Czech open schooling projects dealing with reducing waste.

2. Open schooling approach

Open schooling is an approach that puts the schools (students and teachers) in the role of agents of community well-being. In order to become these agents, they must work with the wider local community, i.e. families, professionals from enterprises, non-governmental organizations, universities, local governments – politicians and policy makers, etc. The main goal of the open schooling is to bring real-life projects to the classroom and expand so opportunities for science and sustainability learning.

It is expected that this learning approach will motivate students to be more interested in science oriented themes, will support their scientific understanding, will show them the relevance of science topics, will contribute to their better awareness of science and sustainability themes, and will provide the students with knowledge and skills to make informed decisions and choices in the future.

Horizon 2020 project "MOST – Meaningful Open Schooling Connects Schools To Communities" introduces School-Community-Projects (SCPs) – based on open schooling approach – as a purposeful implementation instrument with the capacity to universally serve as an implementation instrument that connects schools to their community members in the context of science education. The SCPs implemented in project countries deal with the important circular economy themes – waste and energy.

3. Best practice example from the Czech Republic

In the Czech Republic, we focused on those topics of the circular economy that are linked to the Sustainable Development Goals established by United Nations in 2015 (UN, 2015), in particular on Goal 12 - Ensure sustainable consumption and production patterns. Since there is a big theme in the Czech Republic – food and packaging waste, the schools implemented SCP called "food waste in school canteen" and "without packaging".

About 75 % of students in the Czech Republic eat in the school canteen because the meal is subsidized. Funding for school meals comes from three main sources: Parents pay the food costs, the state finances the salaries of school canteen staff and the municipality pays all operating costs (energy, cleaning, etc.). Thus, the meal seems to be cheap to the students and they are used to waste it. The purpose of the project was to find out in cooperation with the staff of the school canteen how much food, by type (meat, potatoes, butter, etc.) is wasted in one day. Students converted the amount of wasted food into monetary units, calories and used the Nutritional Food Calculator to assess the impacts on the environment (Nutristopa.cz, n.d.).

The second topic was concerned to packaging waste. Students worked in proposals and realization how to reduce packaging waste and with big success they produced own shopping bags distributing in the environment of their schools.

Acknowledgements

This work was supported by the Horizon 2020 project no. 871155 - MOST "Meaningful Open Schooling Connects Schools To Communities", and by the Charles University Research Cooperatio "General Education and Pedagogy".

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The Impact of Integrated STEM Professional Development in Interdisciplinary Teacher Design Teams: A Longitudinal Study

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1. Introduction

Globally, STEM education has become a subject of interest of ministries of education since STEM related competencies are seen as vital for economic growth and are needed to level up the future workforce to a standard that can compete globally (Kennedy & Odell, 2014). Economical and societal changes, predominantly driven by technological advances, are changing occupational demands (Schleicher, 2019) and are ushering in a fourth industrial revolution (i.e., Industry 4.0). To promote enrolment, 'STEM' is often used to imply something innovative and exciting, yet it may remain disconnected subjects (Wang et al., 2011). Integrated STEM education aims to remove the perceived barriers between the four disciplines (i.e., science, technology, engineering and mathematics) and encourages students to understand the relevance of STEM to solve various technical and social problems in real life. However, the concept of integrated STEM education is complex and challenging, as integration of subjects is more than parallel treatment of different subject areas (Knipprath et al., 2018). As the benefits of an integrated STEM-approach are clear (Becker & Park, 2011; Roberts, 2013), practice isn't always in line. Moreover, Thibaut et al. (2018) emphasized creating meaningful connections between STEM disciplines as it requires an iterative act of matching and reorganizing learning goals between the different disciplines, searching an appropriate alignment for these goals and incorporating new learning goals. This challenging task is an obstacle many teachers experience in adopting a more integrated STEM methodology (Margot & Kettler, 2019). Therefore, professional development plays a crucial role in improving the quality of STEM education and classroom practices (Loughran, 2014).

Currently, the 'iSTEM inkleuren' project aims to translate scientific knowledge on integrated STEM approaches into practice and builds on research conducted under the 'STEM@School 'project (Knipprath et al., 2018), which provides a framework and lesson materials to facilitate an integrated approach. Because short interventions have been shown to have a limited impact on teaching practices (McConnell et al., 2013), the project adopts a more demand-driven model for teacher professionalisation (i.e., interdisciplinary teacher design team, TDT, with guidance from teacher trainers of 'iSTEM inkleuren'). A TDT can be described as a group of teachers who (re-)design curriculum materials together (Handelzalts, 2009). A distinctive characteristic of TDTs is the sort of design task at hand (e.g., an integrated STEM project). There is growing evidence about the potential benefits of TDTs for the professional development of teachers (e.g., Voogt et al., 2015), but the sustainable impact of these interventions in the context of interdisciplinary teams and integrated STEM education remains underexplored. 'iSTEM inkleuren' also encourages the TDTs to integrate computer science in their projects, especially computational thinking, a skill demanding adequate professional development (Bocconi et al., 2016).

2. Our study

To investigate the sustainable impact of the TDT intervention on teachers we opted for a longitudinal study with three measuring points (i.e., before, just after, and 2 months after the intervention). The instrument used (e.g., questionnaires) measures teachers' self-efficacy based on the TPACK framework (Chaipidech et al., 2021), perceived relevance of iSTEM, STEM implementation, and school context (Thibaut et al., 2018). As the 'iSTEM inkleuren' project is an inter-association of Flemish universities and university colleges and is funded by the Flemish Council of Universities and University Colleges (VLUHR) and the Flemish Ministry of Education, the study focuses on secondary school teachers in the Flemish education system, teaching STEM-related subjects. Data collection takes place from September 2022 until February 2023 and aims to include 200 teachers divided into approximately 40 teams. Data triangulation will take place using structured interviews of approximately 20 teachers participating in the TDTs.

3. Conference Poster

Our poster will depict an overview of the used methodology in the 'iSTEM inkleuren' project and report scientific findings on the impact of interdisciplinary TDTs as professional development on integrated STEM. As integrated STEM requires a unique approach (e.g., Ellis et al., 2020; Thibaut et al., 2018), it can be considered an innovative teaching approach in STEM education. Moreover, in our study, we focus on the professional development of STEM teachers regarding these approaches using TDTs. It would be ideal to further discuss our approach and the outcomes of our study in the personal dimension category and therefore hope to present our work at the international Educating the Educators conference *'Educating the Educators: STEM & Open Schooling for Sustainability Education'.*

Acknowledgements

'iSTEM inkleuren' is funded by the Flemish Council of Universities and University Colleges (VLUHR) and the Flemish ministry of Education.

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MOST: The implementation of School-Community-Projects in school and community

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Doorman, Michiel Utrecht University, The Netherlands

1. Background of the study

In Europe, the development of science disengagement among students in secondary education is an often-seen phenomenon (Howard, 2017; Osborne & Dillon, 2008; Sjøberg & Schreiner, 2019). As many European countries already experience a shortage of specialists in scientific oriented disciplines, it is of importance to get people motivated to pursue a carrier in science to keep up with the rapid growth of the science sector (Archer et al., 2013; STEM Alliance, 2017). Furthermore, societies face complex science related problems, such as global warming, floods, droughts and water and air pollution. As these problems, also known as Socio- Scientific Issues (SSIs), are becoming more and more present in our society, it is important to give attention to these issues in the classroom. This enables students to develop their civic competences, such as science-informed decision-making (Zeidler & Nichols, 2009) and therefore become better prepared to face these problems in their future.

One of the initiatives that helps to bring real-life problems such as SSIs into the classroom are School-Community-Projects (SCPs). The goal of a SCP is to establish partnerships between schools and their community, whereby relevant SSIs for the community are the subject of the project. Students are asked to use inquiry-based working methods to find a solution to a yet unresolved chosen SSI by working together with members of the community and other stakeholders to give students a better understanding of the application of science in society and motivate them to engage in science (ICSE, n.d.).

As implementing an SCP in a school structure asks for a change in the curriculum and effort of the people involved, it is valuable to identify supportive elements and hindering factors for implementation of such a project for long term use. For example, involving and maintaining contact with all (external) community members and stakeholders can be challenging for (internal) school members (such as teachers and school leaders) that are involved in the project (Mathie & Wals, 2022) and therefore asks for attention.

2. Relation to the conference theme and dimension

As School-Community-Projects are based on open schooling approaches and are built around environmental issues, this research will be suitable to fit the overall theme of this conference. The findings on the research question can be of help for teachers and other school members that want to implement and sustain open schooling approaches in their curriculum. In addition, similar projects arising and searching for a long-term impact will benefit from the outcomes of this specific research. Therefore, the findings will mostly be related to dimension 3, the structural dimension. The topic will be addressed from the perspective of the external community members and stakeholders an to give students a better understanding of the application of science in society and motivate them to engage in science d internal school members that are involved.

3. Set up of the study

The research question of this study is: *What are supportive elements and hindering factors for the school organization and the community for implementing a School-Community-Project about energy management for long term use?* Currently, the study is set up and a SCP for approximately twenty 15-to-17-year-old pre-university students is designed. Besides students, other participants of the project will be external community members (such as family members and people from the neighbourhood) and other stakeholders (such as from businesses or governments), and internal school members (such as teachers, and school leaders). To define the support that is needed for the participants to join the project, questionnaires will be filled in by all approached people (also people that won't participate in the project). Also, a focus group with at least one teacher, one school leader, and two external stakeholders or community members will be set up and semi-structured interviews will be performed before and after the project. The interview before the start of the project is meant to allow the participants to indicate their needs to successfully participate in the project. The interview at the end of the project will be performed to evaluate the indicated needs, gather suggestions for change and identify what is needed for participants to stay involved in the long term. The results of the questionnaires and the focus group interviews will be presented on the poster.

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50/50 PROJECT: HOW TO SAVE ENERGY AND WATER THROUGH RECYCLING

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Abstract

An educational experience carried out in a Spanish educational center is presented in which the entire center is involved in providing open schooling for sustainability education through the 50/50 project. The involvement of the Center is facilitated by its membership of a teacher learning community that stands up for cooperative work and active methodologies that favour the acquisition of knowledge, values and responsibilities by students that allow the acquisition of appropriate attitudes and skills for sustainable development.

Teacher Learning Community

The educational community of Marcelo Spínola School in Jaén (Andalusia, Spain) belongs to Spínola Foundation, an educational network made up of 15 educational centres throughout Spain. The Foundation is committed to educational processes of pedagogical innovation with a series of lines that range from multiple intelligences and critical and creative thinking, to spiritual competence and social commitment. In this sense, we are immersed in a process of continuous training in different areas (ecosocial, energy, Sustainable Development Goals...), a process that we consider fundamental in order to be able to respond to the needs and concerns of our students, thus achieving more significant learning and bringing up people increasingly committed to sustainable development.

Sustainability Education with 50/50 project

Among the actions that we carry out in our school, promoted by the Foundation, we highlight the 50/50 project, which constitutes an experience to promote energy saving through measures proposed by members of the educational community and which become habits for efficiency in the use of resources and care for the environment. The methodology of the project has the students as protagonists and becomes a valuable learning about the value of natural resources and the impact of human beings on the environment. The savings, both economic and in gas emissions into the atmosphere, have an impact on educational centres and, beyond, on our planet.

The objective of the 50/50 project is to raise awareness, promote sustainable habits and empower educational communities to achieve a change in behavior in terms of energy and water consumption. The methodology was created for the first time in public schools in Hamburg (Germany) in 1994, with the sole objective of increasing energy awareness and the active participation of the population in caring for the Earth. The project is based on a common motivation: to work together to improve our energy consumption habits. From the individual commitment of each member of the educational community, we assume a work method that is based on the analysis and study of the situation, cooperative work and collective effort for a result of transformation.

To carry out this project, a team is formed with representatives of all groups in the educational community: students and teachers of all courses, families, services such as cleaning, dining room or maintenance, extracurricular, religious and management team. This group has a maximum of 30 members and 2 over 3 will always be students. The energy team is in charge of carrying out a monthly follow-up in its meetings on the expenditure of resources, it studies and proposes saving measures and motivates the entire community to reach established objectives.

The fact of not wasting resources supposes an important economic saving, at the same time that the environmental impact is reduced, also reducing CO_2 emissions into the atmosphere. But the benefits go further: a transformation occurs in our habits. A behavior that goes out of the classrooms to the homes and also to our closest social environment.
50 percent of the amount saved is invested in continuing to improve the centre's energy efficiency. The other 50 percent of the saving goes to the school project which community decides.

School Community Project

During this academic year we have decided to go one step further and open this project to our closest environment, involving neighborhood associations, businesses and nursing homes in our neighborhood. We have framed our proposals and actions within the philosophy of the MOST project and for this, we have developed a series of actions aimed to make the population become aware of the importance of recycling as an effective procedure to avoid the overexploitation of resources and, at the same time, save water and energy.
Among the actions we have carried out we can consider the following:

- Preparation of an interactive map of the neighborhood in which the recycling points are identified. The objective of this action is to make available to the entire population of Jaén, especially the residents of our neighborhood, the points where the recycling containers for plastic, glass, paper, batteries and oil are located, in order to facilitate the Recycling process
- Preparation of a leaflet with information on recycling (what can and cannot be recycled in each type of container), using QR codes. These leaflets are available to all residents in shops, bars, restaurants..., as well as on the websites and social networks of our school, neighborhood association, nursing home...
- Elaboration of musical instruments with recycled materials, carried out by the elderly people of "Fuente de la Peña" nursing home. Our elders visited our centre to present our students with the instruments made and explain how to make them.
- Production of videos by pre-school students presenting recycling actions, within the "Guardians of the Planet" project.

We believe that this type of projects allows us to work on contents related to recycling and energy saving, work that translates into an awareness on the part of the people involved, which translates into a change in habits that allow us to build a more committed society in terms of care for the planet.

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MOST: A Smart Pandemic Classroom: School-Community Project

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Sardag, Metin Hacettepe STEM and Maker Lab & Van Yuzuncu Yil University, Turkey

This study is a practice of a school community project carried out within the scope of the Meaningful Open Schooling Connects Schools to Communities (MOST) project. The roadmap developed for school community projects, which includes the stages of "invite", "co-create", "act", "share", and "evaluate" [www.icse.eu/most/], was used in this study.

When designing the school community project, the following reasons concerning the communities are the main elements shaping the project topic. As we move towards a world of energy efficiency, designing and using new systems that consume less electricity and illuminate large areas with the required light according to the lighting conditions are essential for reducing power consumption. In addition, almost 90% of people spend most of their time indoors for their daily needs. When the amount of CO_2 level in the environment exceeds the 1000 ppm limit, it causes headaches, drowsiness, and stagnation in people, while when the CO_2 level exceeds 2000 ppm, it is stated that it causes an increase in heart rate and many other diseases. Frequent fever measurement, which has entered our lives with the pandemic, is usually done after entering the classroom. This situation both increases the risk of contamination and brings extra workload as it requires the use of a staff member. For the current situation, automatic lighting, ventilation, and measuring fever in the classroom have become necessary. In the project, a study was carried out to eliminate the problems in existing situations.

The study was carried out with 25 6th-grade students from a public school in Turkey, and stakeholders who would contribute to the project in this field were *invited* to the study. An online meeting was held with stakeholders and students to *co-create* energy efficiency and human health ideas. In line with the ideas discussed in the meeting, the students *acted* and designed a smart pandemic classroom using an Arduino Uno programming board, LDR light detection sensor, HC-SR501 Adjustable IR Motion Detection Sensor, Mq-135 Gas sensor, MLX90614, EM18 RFID Reader and Ultrasonic Sensor LED display, Breadboard and Jumper's cables were used. The effect of the system created was investigated. The project results show that energy savings can be achieved by providing a lighting control and a ventilation control system in the smart classroom, and precautions can be taken against the risk of contamination with the temperature measurement system.

Finally, the results were *shared* on social media accounts, and the project's success was *evaluated*.

Teaching Sustainable Development Goals through Socio-scientific Issues: Teacher Candidates' Pedagogical Content Knowledge

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1. Objective of the research study and its relevance to the overall conference theme

The intended sub-study for the poster presentation is part of a larger PhD project which aims to reach a better understanding of science teachers' competencies and their training needs to teach sustainable development goals (SDGs) by incorporating socio-scientific issues (SSI). The sub-study itself focuses on characterization of science teachers' pedagogical content knowledge to teach SDGs through SSI.

Education for sustainable development (ESD) aims to empower everyone to make evidence-based decisions when it comes to social, political and environmental issues (Buckler & Heather, 2014). However, teachers struggle with identifying an appropriate method when they are asked to implement ESD in their lessons (Burmeister, et al., 2013). For this reason, this study aims to provide science teachers with the framework of SSI in order to teach SDGs. The interconnectedness between the eight criteria derived from ESD research in the Netherlands (Wals, 2006) and the framework for SSI (Sadler, 2011) provides evidence for the use of SSI as an efficient tool to teach these goals. SSI does not only enable teachers with a concrete framework to address environmental issues, but it is also recognised as a sociocultural response to STEM education (Zeidler, 2016). Unlike STEM education, SSI contributes the development of Vision II and Vision III on scientific literacy which have a greater focus on informed decision making regarding ethical, moral, and economical dilemmas (Van Der Leij, et al., 2022).

Professional development programs, such as *professional learning communities*, foster teachers' PCK of SSI (Minken, et al., 2021; Bayram-Jacobs, et al., 2019). For this reason, the first author of this proposal and

6 teacher candidates from three disciplines (physics, mathematics, and computer science) will form a *professional learning community* through which the teacher candidates will develop a lesson module for sustainability education. Using SSI to develop students' citizenship skills is not a new strategy but getting teachers to design SSI lessons in a *professional learning community* setting through iterative cycles is a new approach. Therefore, the teacher candidates' knowledge regarding this new approach will develop through collaborating and playing an active role as "learners", "designers" and "reflective practitioners" (Henze & van Driel, 2015). Additionally, the design of this sub-study will enable the first author of this proposal to touch upon the roles in the educating the educators perspective thanks to their role in the *professional learning community*. The first author will provide information and guidance for the teacher candidates about the research conducted in the field of sustainability education and the use of SSI as an approach for ESD. Therefore, this poster presentation will address "Topic 1: personal dimension".

2. Perspective

This poster presentation will address the topic from the perspective of science teacher candidates who aim to incorporate ESD in their lessons by providing them an appropriate approach to teach not only the content of science but also the skills necessary for scientifically literate citizens.

3. Content

According to the research plan of this study, by May 2023, the first author will be in the process of data analysis. Therefore, the content of this poster presentation is the four stages of educational design research followed during the *professional learning community* meetings: exploration and analysis of the problems, development of solutions based on existing designs, iterative cycles of testing and refining, and reflection (see Appendix, Figure 1). Literature review and collaboration between the researchers and the science teacher candidates will provide input for the exploration and analysis of the problems in terms of identifying the links between the SDGs and the learning objectives of the Dutch science curriculum.

Acknowledgements

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Appendix

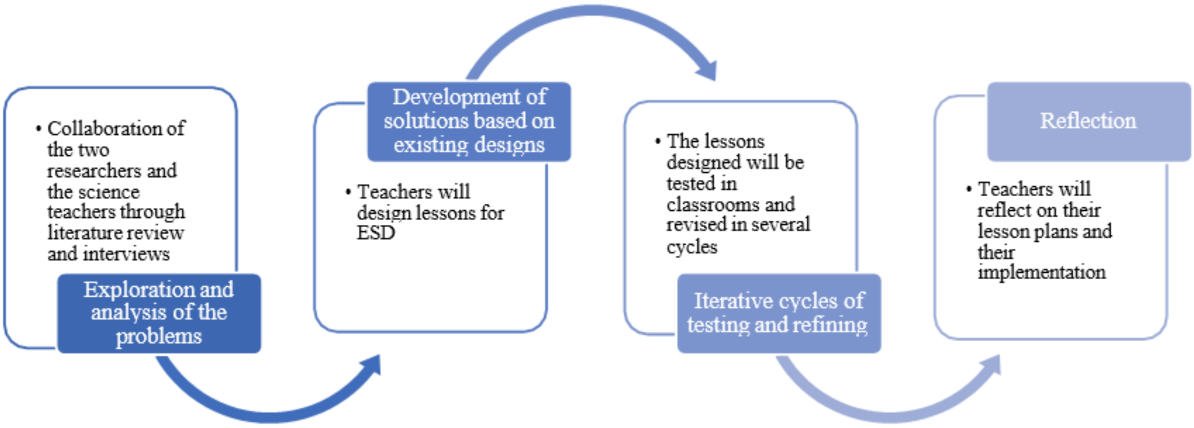

Figure 1. Four stages of the sub-study intended for the poster presentation

MOST SCP – Charlottenlund lower secondary school

Gangstad, Geir Charlottenlund ungdomsskole, Norway
Skjulsvik, Jon Erik Charlottenlund ungdomsskole, Norway
Semmingsen, Amund Sand Charlottenlund ungdomsskole, Norway
Haugen, Trude Stokkan Charlottenlund ungdomsskole, Norway

MOST - Forskning - Institutt for lærerutdanning - NTNU

https://www.ntnu.no/ilu/most

The school and project overall goal is aimed at benefitting the community as a whole and making schools agents of community well-being. The work presented on the poster will show examples of the work done at Charlottenlund lower secondary school. The poster will be presented by STEM-teachers from the school and put into the context of the MOST-project in Trondheim/NTNU

Competence Aims from national curriculum (8. – 10.th grade)

- explain energy conservation and energy quality and explore different ways of converting, transport and store energy
- discuss how energy production and energy use can affect the environment locally and globally
- explore, understand and create technological systems that consist of a transmitter and a receiver
- explore, understand and make technological systems that have a transmitter and receiver
- explain energy conservation and energy quality and explore different ways to convert, transport and store energy
- explain how energy production and energy use can affect the environment locally and globally

Learning objectives

- explain how forces work, and how they transfer and transform energy
- calculate speed, acceleration, forces and energy
- describe how energy is transferred as work
- explain and use terminology; electric current, voltage and resistance
- account for the transfer of electric energy in electric circuits
- explore and describe electric circuits
- explain how electric energy is transported from power plant to consumer

External stakeholders/partners in the projects are

Trondheim municipality	http://trondheim.kommune.no/
Trondheim Science center	https://vitensenteret.com/en/
Statkraft	https://www.statkraft.com/
Power house	https://www.powerhouse.no/en/

Project contents

1. Renewable energy. Solar panels
   a. Build your own solar panel (DIY solar cells)
   b. Experimenting with parallel and series solar panel wiring
   c. Measuring voltage and amps in parallel and series solar panel wiring
2. Energy production (visits to local power production facilities)
   a. Statkraft - Nedre Leirfoss - hydropower facility
   b. Statkraft facility - district heating (urban energy)
   c. Power House (solar panels)

FRAMEWORK

- 170 students (9th grade)
- 4 STEM teachers
- X external actors
- 6 weeks, October-December

Materials Market

Materials Market exhibitions

Thursday & Friday, 11-12 May 2023

1.	3D Printing	Oliver Straser, University of Education Freiburg, Germany
2.	Ducky	Alice Lignereux, Ducky, Norway
3.	Escape Rooms	Alice Veldkamp, Universiteit Utrecht, Netherlands
4.	Gigawatt	Wouter Vink, Gigawatt, Netherlands
5.	ICSE	Elena Schäfer, University of Education Freiburg, Germany
6.	Science in School	Tamaryin Godinho, Science in School
7.	Science on Stage	Daniela Neumann, Science on Stage, Germany
8.	Social Robot kit	Natacha Gesquière, Universiteit van Gent, Belgium
9.	FlebocollectRosa	Gálvez Esteban, Flebocollect
10.	StemKey	Gultekin Cakmacki, Hacettepe University, Turkey
11.	Coach	Ad Mooldijk, CMA, Netherlands

StemKey: Design-based Approaches in STEM Education

Gultekin Cakmakci Hacettepe STEM & Maker Lab, Hacettepe University, Turkey
Mónica Baptista Institute of Education, University of Lisbon, Portugal
Materials Market

1. Introduction

Engineering concepts and practices are implicitly or explicitly integrated into K-12 curricula over the years (NGSS, 2013). Consequently, design-based learning has been commonly used in educational settings in addition to inquiry-based learning. As Thomas Hobbes puts it "Knowing is making: We know only what we make." Different engineering inquiries have been used in engineering education namely Engineering Design Process, Design Thinking, Reverse Engineering, Engineering Science, Engineering Analysis, and Engineering Optimization. A meta-analysis of 134 articles published between 2005 and 2019 in three journals in the USA (Science & Children, Science Scope, Science Teacher) indicated that a simplified version of Engineering Design Process (named Design-Build-Test model) was the most popular model used in K-12 education followed by Design Thinking (also named User-Centred Design Process) (Purzer et al., 2022). Among others, this proposal mainly focuses on the engineering design and design thinking processes. These tools could facilitate individuals to think like an engineer and accordingly guide them to innovate. At the conference, we will exhibit and share our professional development materials on design-based approaches in STEM education.

2. Examples of design-based approaches in different settings

2.1. Household appliance as a context for teaching engineering practices

Understanding engineering mindsets and ways of doing something are important for addressing global challenges. Nonetheless, research shows that teachers have difficulties in delivering engineering practices into their classrooms (Schnittka, 2012) and many pre-service teacher programs lack courses on engineering education (Aydeniz & Cakmakci, 2017). Quite often this topic is taught in a theoretical way, which does not take students experiences as a starting point. In a broad definition, technology is something created to solve a problem or meet a need. Examples include pencils, hair dryer, cell phones, processes to clean water, etc. Technologies like household appliances are a standard topic of engineering, offering a vast field of practical application examples. Children's first experiences with technology happen at home. Although such a rich context offers a lot to teach important features of engineering, they are not often used as a context in the curriculum, even less so in a hands-on manner. Thus, this proposal explores ways of incorporating engineering concepts and practices into STEM education in the context of household appliances by implementing some pedagogical tools proposed in the literature (Cakmakci, in press). It also provides pedagogical approaches that uses real-world context to teach STEM in an interconnected and meaningful way. With their broad portfolio of applications, household devices offer different ways to support learners' skills to apply their engineering knowledge and practices. Also, considering the whole value chain of household devices, offer immediate starting points to foster learners' attitudes, for example with environmental aspects (recycling of goods), or global availability of goods.

2.2. Reverse engineering as a context for teaching electricity

Reverse engineering can be described as the process of discovering the technological principles involved in the design of a device, object, or system, through the analysis of its structure, function, and operation. Reverse engineering aims to provide explanations to "how existing artefacts produce their overall (behaviour) functions in terms of underlying mechanisms" (van Eck, 2015, p. 356). In this proposal, we will present an example based on Reverse Engineering and focus in a STEM problem related to this concept. More specifically, we will explore the following scenario: imagine you are a team of engineers working for a technology company, and you are expected to evaluate a product (the mystery box) developed by a competing company. This box contains a device that allows learners to manipulate and predict their internal structure and functioning. Specifically, the learners have to find an answer to the following problem: How to develop a box with the same function as the mystery box? Learners have to make predictions on the circuits that are hidden inside. Afterward, they design their own box so that it would have with the same features as the mystery box. At this stage, learners explain the function of each of the circuit components (battery, wires, light bulb, resistors, switches), and use measurement instruments to collect the observable data. Then, they compare the two boxes, the mystery box and their own box, and share their constructions and explanations on how they work. Next, using their newly built boxes, the learners explore Ohm's law. This example follows an inquiry-based learning approach. So, learners could be engaged in several science and engineering practices: asking questions and defining problems, developing models and plans, constructing experiences and explanations, and designing solutions, using different sources of information and an electronics platform based on hardware and software, collecting and processing information/data, and obtaining and communicating information.

3. The materials market

This proposal discusses different design-based approaches in education and assessment of these approaches in STEM education. At the conference, we will exhibit and share our teaching materials on design-based approaches in STEM education.

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Conference website: *https://icse.eu/educating-the-educators/*
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