DESIGN RESEARCH IN MATHEMATICS EDUCATION: MAP READING SUPPORTS THE DEVELOPMENT OF SPATIAL ABILITY

A THESIS

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CHAPTER I

INTRODUCTION

Most people frequently face spatial problems in their daily life. Spatial forms can be represented in pictures or diagrams which are useful for communicating ideas. A picture is a kind of representation of spatial ideas such as a geometrical drawing, maps, plans, etc. Young children have many spatial experiences with their environment, especially through the sense of sight and touch (Dickson, 1984). The spatial experience starts before the development of language. Spatial matters are involved in learning and teaching mathematics as a representation of the real world. Lowrie (2010) suggested that students need spatial ability that allows them to consider all the elements of a task, including specific features of a graph and the surrounding text, when solving a mathematical task.

Clarke (2003) stated that maps are the main source of spatial information and spatial ability which is required to decode maps because of the spatial relation among visual elements. Many tools and instructional devices can help children to develop and organize their own thinking in map understanding. A map is such a kind of representation in graphic form. Therefore, a map can be a bridge between the real world and abstract world. In addition, it might help children to understand the other graphs in mathematics and science. Liben (2008) asserted that students in elementary school have a basic understanding of maps.

Developing map understanding is important to increase the spatial ability in reading maps because there is a positive relation between map understanding and

spatial ability. For instance, persons with better spatial visualization can interpret map content properly. Moreover, persons with better spatial orientation are able to compare map content to the surrounding environment (Rusch, 2008). However, according to the result of Diezman & Lowrie's study (2007) reported that 10-13 year old children have difficulty to understand the information in maps. Therefore, it is necessary to bring the students in the class into the map reading activities

Likewise, many educators do not give attention to map understanding and sometimes high jump to an abstract level in mapmaking and map reading. Drawing is a process that allows children to figure out the representation emotionally in their thinking (Sobel, 1998). Children can start the reading and writing process by telling stories, drawing a picture of the story, and writing the story in their own words. It is important for children to draw in the beginning of the process of mapmaking.

In recent years, many studies were conducted that consider the spatial ability and map literacy. Realistic Mathematics Education in geometry makes extensive use of interesting spatial and map tasks (Gravemeijer, 1990), but unfortunately, research on the effects of this specific strand is lacking. Moreover, there is a few of research for this domain in Indonesia (Mariana, 2010; Revina, et.al.2011). Realizing the importance of spatial ability and map literacy, we will design a learning sequence by using maps as a tool to support the development of spatial ability. Therefore, the purpose of this study is to contribute the local instruction theory of spatial ability particularly map reading. Consequently, the study is

guided by the research question: *How can map activities support the development of spatial ability particularly map reading?*

CHAPTER II

BACKGROUND AND RESEARCH QUESTION

2.1 Spatial Ability

A Spatial ability is an ability that consist of declarative and perceptual forms of knowledge to transform, manipulate, combine and operate information presented in a visual, diagrammatic or symbolic form (Lohman, et al, 1987; Hegarty & Kozhevnikov, 1999). Spatial ability can be used in particular representation and reasoning include diagrams, drawings, maps, and models. The three important elements of spatial ability are concept of space, tools of representation, and process of reasoning (National Research Council, 2006, p.12-13).

Table 2.1
A general description of spatial ability

Aspect of spatial ability	**Abstract concept**
Space	- The relationship among units of measurement (e.g., kilometers versus miles) - Different ways of calculating distance (e.g., miles and time) - The basis of coordinate systems (e.g., Cartesian versus polar coordinate) - The nature of spaces (e.g., 2-dimensional versus 3-dimensional)
Representation	- The relationships among views (e.g., orthogonal versus perspective maps) - The effect of projections (e.g., area map projections) - The principles of graphic design (e.g., organization in reading graph or map)
Reasoning	- The different ways of thinking about shortest distance (e.g., route distance in a rectangular street grid) - The ability to extrapolate and interpolate (e.g., estimating the slope of a hillside from a map) - Making decisions (e.g. selecting an alternative route)

Grattoni (2007) found that students' practice spatial abilities would improve their math ability. Although, that study was in small participant, the finding is similar to another study (Hegarty & Kozhevnikov, 1999) that showed spatial representation could promote problem solving success. It seems that spatial skills play an important role in solving certain kinds of mathematical problem solving. For example, the problem from calculus and geometry often explore the relation between time and area.

Lowrie (2010) suggest that students need to get spatial ability that allow them to consider all the elements of a task, including specific features of a graphic and the surrounding text, when solving mathematical task. Elementary students' spatial thinking improves more over the school year (Newcombe, 2010). A recent meta-analysis showed substantial improvements in spatial skill from wide variety of interventions, including academic coursework, task-specific practice, and playing computer games that need spatial thinking. Clarke (2003) stated that maps are the main source of spatial information and spatial ability is required to decode maps because of the spatial relation among visual elements. Therefore, the present study has intention to develop children's spatial ability through learning by using a map.

2.2 The Development of Spatial Ability

Piaget and Inhelder (1967) defined three stages in the development of spatial ability: (1) Preoperational stage is started from egocentric children to locate objects in their environment with respect to themselves. Children in this stage

understand limited topological spatial relationships. (2) Concrete operational stage occurs between seven to nine years old. They develop a cognitive map with a fixed frame that allows them to imagine and orient their body. Children also develop more complex understanding about external frame of topological relation such as left/right. (3) Formal operational stage is begun around 11 years old. Children develop an understanding of Euclidian spatial relation such as estimating distance.

Particularly, the present study is related to the map understanding which is closely to the spatial orientation. Therefore, we also focus on the developmental progression in spatial orientation (Clements & Sarama, 2009):

Table 2.2

The developmental progression in spatial orientation

Age (years)	**Developmental progression**
0 – 2	Understands initial vocabulary of spatial relations and location.
2 – 3	Orient a horizontal or vertical line in space
4	Extrapolate lines from positions on both axes and determine where they intersect if meaningful context
5 – 6	Can extrapolate two coordinates, understanding the integration of them to one position, as well as use coordinate labels in simple situations.
7	Reads and plots coordinate on maps
8+	Can follow and create maps, even if spatial relations are transformed.

The participant of the research is that second graders in primary school. It means that we focus on the concrete operational stage in spatial ability. In designing activity in the classroom, we consider the developmental progression at 7 to 8 years old.

The better approach for mapping experience is in visual, kinesthetic, and emotional. However, many educators do not attention with those and sometimes do high jump to abstract level in mapmaking and map reading. Children start the reading and writing process by telling stories, drawing a picture of story, and writing the story in their own words. It is important for children to draw in the beginning process in mapmaking. Drawing is a process that allows children to figure out the representation emotionally in their thinking. Children's map represents their experience of beauty, secrecy, adventure and comfort. The development of emotional bonds and cognitive skill needs to go hand in appropriate approach. The progression of children's mapmaking is microcosm of cognitive development in elementary school (Sobel, 1998). Considering the development cognitive of children in every level age and phase thinking, it addresses about the phase of children thinking for each two level age, from five until twelve ages. Each phase of thinking is related to some appropriate context of map for each level age children. For instance, five and six year old children are familiar with context related to their home and neighborhood. Asking first graders about a neighborhood map can make sense for them.

2.3 Map Understanding

In general, maps are visual representation/graphic data where information is encoded through the spatial location of fixed position marks (Mackinlay, 1999). It is necessary to deal with understanding the map. Wiegand (2006) stated five types of fundamental knowledge to well understand a map:

a) Understanding that map represent space
b) Understanding the alignment and perspective of the map
c) Understanding scale
d) Understanding symbols and texts
e) Using maps to find the way

The representation of mathematical ideas, concepts, and relationship in graphical form is common in mathematics. Graphic include graph, maps, diagrams, hierarchies and network. Liben (2008) stated that students in elementary have basic understanding about map. Developing this understanding is notable to increase the ability in reading maps properly because according to the result of Diezman&Lowrie's study (2007) is that 10-13 year old has difficulty with the information in maps to understand it. In the last five years, Diezman and Lowrie have explored how students interpret the mathematical graphic including maps with their own structure and spatial arrangement.

The model of map understanding is in line with how our brain arranges knowledge and spatial process. Many tools and instructional devices can help children to develop and organize their own thinking in map understanding. Map is

such a kind of representation in graphic form. Therefore, a map can be a bridge between the real world and abstract world and help children to prepare understanding the other graphs in mathematics and science. Based on cognitive perspective, an increased emphasis on map understanding will enhance the objective of greater mathematical and scientific literacy.

2.4 Spatial skills and maps for children

In the classroom, teaching and learning are limited and fail to connect map skills with other curriculum areas, including mathematics. Most students do not have ability and understanding to use map even. Moreover, many of young children get difficulty and misunderstanding about space that is conflict between sensory concrete and abstract frames of reference. Therefore, Clement (2009) suggested that it is important to guide children to:

a. Develop abilities to build relationship among objects in space.

b. Extend the size of that space

c. Link primary and secondary meaning and uses of spatial information

d. Develop mental rotation abilities

e. Go beyond map skills to engage in actual use of maps in local environment

f. Develop an understanding of the mathematics of maps.

Children need to learn about model and maps including incidental and planned experience such as frequent discussion about spatial relation, finding a missing object, and finding the way back home. Teacher should provide instruction on using maps that explicitly relates to world space and maps. It might be started by

generating four mathematical question (Clements & Sarama, 2009): (1) Which way (direction), (2) How far (distance), (3) Where (location), (4) What objects (identification). Children must learn about mapping process and more sophisticated ideas of direction and location. In addition, they should develop navigation ideas, such as left, right, front, back, etc. Then, they might represent these ideas in simple route maps within the classroom.

Therefore, a specific experience with map can help students to get more understanding about map. For instance, the present study will encourage children to work with model animals to build maps of the zoo with these models. Children might use cut out shapes of animals, trees, and sandbox in the playground and lay them out on a felt board as a simple map. These are good starting situation. Models and maps should eventually move beyond simple iconic picture and challenge children to connect the abstract and sensory-concrete meanings of maps symbols. Introducing such situation can evoke geometric correspondences. Realistic Mathematics Education in geometry makes extensive use of interesting spatial and map tasks (Gravemeijer, 1990), but unfortunately, research on the effects of this specific strand is lacking.

2.5 Realistic Mathematic Education (RME)

RME is the domain specific instruction theory that offers a framework for interpreting students' activity in learning mathematics (Gravemeijer, 1994). According Freudenthal's view, two important points in learning mathematics are that mathematics must be "real" and mathematics as a human activity. In teaching

mathematics realistic, the teachers should consider to the mathematizing which is a process to interpret, organize, and construct meaning of situation with mathematical modeling. The mathematizing involves the spatial relationship (Gravemeijer, 1994). The present study considers the spatial aspect in mathematics through a learning map. We design Hypothetical Learning Trajectory (HLT) for supporting students' development of map understanding particularly spatial ability aspect. The design influenced by five characteristic of RME (Treffers, 1987, cited in Zulkardi, 2002) as described follow:

a. Use of contextual problem

   The real and meaningful context is important thing for students as a starting point for learning process. In this design, the context of map provides students to develop their spatial ability. The problem about map allows students to realize what are they doing and generate some questions, wonder, and critical thinking, such as why and what if.

b. Use of Model

   This design used a map as a representation of model between the real worlds to the abstract world. Map is kind of geometric model in mathematics.

c. Use of students' contribution

   The series of instructional activity consider the opportunity to students in contributing their own informal problem solving strategies. The activity of map reading offers the students to use their previous experience about map.

d. Interactivity

Students' interaction enhances justification agreement and reflection on the work (Gravemeijer, 1994). During the learning process, students will be encouraged in classroom discussion, such as gallery poster session will prompt students to discuss the map that their produce in mapmaking activity as a part of the design.

e. Intertwining of learning strands

Map skills as the topic of the design is related to the spatial aspects in mathematics closely to build geometric building visualization. In addition, this topic also intertwine with geography lesson particularly map reading. It shows that the connection to other subjects is more meaningful in real world.

2.5 Map reading in Indonesian curriculum

The topic of map activity in Indonesian curriculum is firstly introduced as a part of social subject for elementary students. The table below describes topic of map for grade 1 in Indonesia curriculum (Depdiknas, 2006).

Table 2.3

Map topic in Indonesia curriculum

The second Semester of Grade 1	
Standard Competence	**Basic Competence**
2. Describe the neighborhood	2.1 Tell the important experience around the neighbourhood.

	2.2 Describe the position of the neighbourhood.

It is not common in Indonesia to learn about map activity as a part of teaching and learning mathematics in the school. It shows less emphasis to consider the map understanding as a part of spatial ability aspect in mathematics classroom. Therefore, the present study would like to focus on the process of how students understand the maps to support the development of spatial ability in mathematics classroom.

2.6 Present study

In the previous study of Shintia's thesis, it considers about spatial ability especially spatial visualization. That study provided some activities that are in line Pendidikan Matematika Realistik Indonesia (PMRI). The study found that spatial visualization task can support students spatial structuring in learning volume measurement. The present study is also related to the spatial ability, we provide the activity of map which is following the characteristic of PMRI. The activity of map is such learning process by using maps to support the development of spatial ability. The hypothesis of this study is that the activities of map can help children to develop their spatial ability. Related to the hypothesis, the researcher formulated research question for this study: *How can map activities support the development of spatial ability particularly map reading?*

The research question is focused on the role of the map activities in supporting children's learning. The study investigated the influence of the instructional sequence of map activity on the development of students' spatial ability. The components of the instructional setting can contribute to supportive map activity. The analysis is emphasized to a better understanding of the complexity of such an instructional setting and its influence on the development of students' spatial ability.

CHAPTER III

METHODOLOGY

3.1 Research approach

The purpose of the present study is to contribute the local instruction theory of spatial ability particularly map reading. The study focuses on the general research question: *How can map activities support the development of spatial ability?* The activity of map is such learning process by using maps to support the development of spatial ability. This implies that the researchers need to design an instructional sequence of map activity and research how the design supports students to reach particular end goals. Therefore, the approach of present study used design research because it considers design as a crucial part of the research. The main reason of use design research is to develop Hypothetical Learning Trajectory (HLT) together with instructional material and to contribute the local domain theory of Realistic Mathematic Education (RME) especially in spatial aspects. The main result of design research is not a design that works, but the reason why, how, and to what extent it works. Therefore, a design research is evaluated as an innovation and improvisation that are useful in educational practice because it is grounding in experience and developing in practice to generate empirically grounded theory.

3.2 Data collection

3.2.1 Preparation phase

In this phase, the researcher collected some various data to get some information as a starting point of the research. The data of preparation phase is described as following:

a. Classroom observation

   The researcher observed the class experiment before doing the teaching experiment. The purpose of classroom observation is to know :(a) the culture of classroom, (b) teacher's and students' activity, and (c) the interaction between teacher and students during teaching and learning process. The researcher took video recording and field notes during classroom observation. The classroom observation will be guided by the list topic in scheme of observation (appendix 1).

b. Interview with the teacher

   Interview with the teacher was conducted after the classroom observation. The aim of interview is to know the teaching and learning process from the teacher's perspective and to clarify the data of classroom observation. The interview will be guided by the list topic in scheme of interview (appendix 2). Furthermore, the interview was recorded in audio recording and be backed up by making field notes.

3.2.2 Preliminary teaching experiment (first cycle)

The first cycle of design was conducted in small group consist of 5 students grade 2 in Indonesia elementary school. The researcher was a teacher in this cycle. The

teaching and learning process was recorded in the video recording. In addition, the researcher collected the written work of student and conduct mini interview to know the response of students' thinking about the content of the design. Therefore, the purpose of the first cycle is as a pilot study to test the conjectures and improve the design and also as a discussion with the teacher who will implement the design in the second cycle.

3.2.3 Teaching experiment (second cycle)

The second cycle of the design was held in one class of grade 2 in Indonesia elementary school. The teacher implemented the revision of design according the result in the first cycle (appendix 3). In this phase, the researcher has two focus group consists of 2 students who are in the middle level of achievement. During the teaching and learning process, the researcher collected the data of video recording by using one static camera that focus on the work of focus group and one dynamic camera that record classroom activities. Some interesting fragments of video were chosen to be transcribed and analysed in retrospective analysis. The researcher also took field notes for teaching and learning process. In addition, the written works of students were collected to know students' thinking during the teaching and learning process. Field notes and copies of students' written work are additional data sources.

3.2.4 Pre-test and Post-test

- Pre-test

  To assess the pre-knowledge of the students' thinking and achievement about the topic, the pre-test was held before teaching experiment. The

participant of pre-test is all of student in the teaching experiment class and students worked individually. In the pre-test, there are some problems related to map understanding and spatial ability as a topic of the research.

- Post-test

  Similarly, the post-test was given to students of teaching experiment class to know the students' achievement after teaching experiment phase. Students solved some problems about map understanding and spatial ability.

3.2.5 Validity and reliability

The validity and the reliability from the result of the research can be considered as the quality of the research. In this research, the validity and reliability were regarded from the two ways which are internal and external:

a. Internal validity is mostly related to the quality of data collection. In this issue, the present study considers about the various data such as interview, observation, and video recording which lead to the data triangulation. The validity of finding can be checked by using different source of information. For instance, considering the type of data, the researcher makes efforts to corroborate the interview data with the other sources of information, such as observation and field notes that can provide some back-up for the content.

b. External validity refers to generalizability of the result from the specific contexts to other contexts. An important way to do so is by framing issues in more general.

c. Internal reliability refers to the reliability within a research. We consider the data from video recording to improve the internal reliability. The selective fragment of video recording will account to the reasonableness and argumentative power of inferences and assertions.

d. External reliability refers to the track ability. The research must be clear in such a way the reader can track the learning process and reconstruct the study.

3.3 Data analysis

3.3.1 Preparation phase

a. Classroom observation and interview with teacher

The selected fragment of the data classroom observation and teacher interview was transcribed and analyzed. Observation and interview criteria are analyzed to find out the description about classroom culture between students' and teacher's interaction each other's. These observation criteria are defined in terms of both verbal and nonverbal behaviors. Therefore, the result of those analyses will be used to get the insight into the context which lesson will be conducted.

b. Pre-test

In analyzing the result of pre-test, the focus is on the strategy that students use to solve the problem about map in the written test. The analysis will be done in quantitative and qualitative analysis. The students' solution to each of the problem were investigated and identified as a particular level of students' spatial ability. The results of pre-test takes account into a starting point of students' thinking in HLT and contribute to insight of a developmental trajectory for students' spatial ability.

3.3.2 Preliminary teaching experiment (first cycle)

During preliminary teaching experiment in small group, the selected fragment from video recording and interview with students was transcribed and analyzed to consider the content of HLT. The reflection after the preliminary teaching experiment led to adapting the conjectures and the teaching sequence, which became the starting point for a teaching experiment in the second cycle. This cyclic process aimed both at empirically grounded answers to hypothesis concerning the research question and at a conjectures local instruction theory. Changes in HLT are purposed to create optimal condition in the second cycle. In addition, the pre-test and post-test that is given in the first cycle were analyzed to know students' thinking and achievement in quantitative and qualitative analysis. Therefore, the results of first cycle were used to revise the HLT since it shapes the idea about activities, the level of students and the possibilities of the education setting in HLT.

3.3.3 Teaching experiment (second cycle)

The data collection during the teaching experiments varied. The researcher collected students' work, field notes, and video recording of every lesson. The researcher analyzed the data of pre-test and post-test in the second cycle. Moreover, some interesting students' work was selected to figure out how students solve the problem and to be used for testing the conjectures in HLT. The field notes are written up into lesson reports which identify the important episodes from classroom discussion to the particular students in the learning process of all lessons. In addition, the researcher watched the video registrations of each lesson and transcribed the transcript of the interesting fragment video. It is used to describe the group discussion or the classroom discussion and to analyze the students' contribution. The results of the analysis were regarded to draw the conclusions, to answer the research question and to revise the HLT.

3.3.4 Post-test

The researcher need to analyze the result of pre-test to investigate what extent students had reached the learning goal after the teaching experiment. The result of post-test was analyzed in quantitative and qualitative analysis. The researcher will compare the result between the post-test and pre-test.

3.3.5 Validity and reliability

During retrospective analysis phase, the researcher discussed with supervisors. The discussion can support the validity and reliability of the data analysis.

a. Internal validity: the different source of data which is data triangulation was used in data analysis. During the analysis, the researcher tested conjectures that are generated at specific episode from different data material such as fields' notes, tests, and students' works.
b. External validity concerns to the results of HLT on generalizability of the conclusion presented in such a way that other researcher can adjust them to their own local settings.
c. Internal reliability refers to the discussion with others to interpret the data and draw the conclusions.
d. External reliability emphasis on the track ability. The teaching experiments and data analysis were guided by the conjectures of HLT. The researcher describe this process systematically in such a way it offered other researchers the possibility to replicate the learning process and draw the same conclusion through the cycles of teaching experiments and data analysis.

Chapter IV

Hypothetical Learning Trajectory

A HLT is a framework of learning activity that consists of learning goal, starting point, mathematical learning, and conjecture of students' thinking. In this chapter, we elaborated HLT that involve 5 activities in a learning sequence of map understanding related to the spatial thinking particularly spatial orientation. Spatial orientation is one of the main component of spatial ability that allows children to learn about orientating themselves, to take different perspective, to describe routes, to understand the shape/figure and realize the spatial relationship between objects (van Nes & de Lange, 2007).These activity emphasize the three mathematical question that is related to the map problem (Clements & Samara, 2009) are (1) Which way? (direction), (2) Where? (location), and (3)What objects? (Identification). The development of the children's thinking is started from map reading to map making followed by communication in using a map. Therefore, the first activity is about map reading of school map and the last activity is map making from a miniature zoo.

4.1 Lesson 1 : Read a school map

Learning goal

- Students understand their own school map
- Students can read their school map

- Students can realize the position of others room according to the school map.

Starting point

- Students recognize the shape square as a room on the map.
- Students realize position of their class on the map.

Classroom culture

1. Teacher asks students to raise their hand if students want to ask question.
2. Teacher encourages students to tell their opinion.
3. Teacher will raise her hand as a sign to silent.
4. Students should work in team work.

Description activity

This activity offers the experience of map reading for students to do activity by using a school map to find the certain room on it. Students should realize the position of the room on the map and follow the path. Also, this activity provide opportunity for students to understand the symbol or pictorial figure on the map

1. Introduce the school map and tell the problem

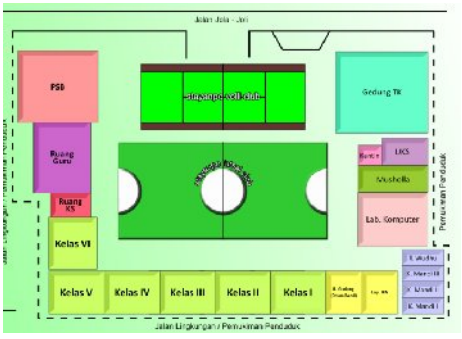

Figure 4.1 The school map

The problem: A pupil fell and she injured. Therefore, a teacher asks students to go from Kelas II to UKS (School health program) room for taking the first aid box. They will find that room based on the given map.

Students' conjecture

- Students will use a school map to find UKS room.
- They will work in group of 4 to discuss about what they understand and interpret the map. For example, where is their position on the map? Or the meaning of pictorial figures on the map.
- Later, they will discuss about the way to go UKS room.
- A few groups might have different way to find the way of UKS room.

2. Teacher generates the discussion about:

    a. Is it easy to find UKS room?

    b. How do students understand about the map?

    c. How do students find the UKS room?

    d. What are the rooms that they pass during the way to UKS?

3. Teacher compares which group is the fastest and the slowest group that find UKS room.

4. The fastest and the slowest group talk their experience by using a map.

Students' conjecture

- Students can read a map easily because they recognize the position of the object in the map to the real condition.
- Students who can read a map easily will follow the path in the map to find the room.

- Students understand the pictorial figures on the map.
- Students have difficulty to realize the position in the starting point.
- Students get lost when they follow the school map to find the room.

5. Closing the lesson

Teacher reflects the lesson by asking some questions:

- What do we learn?
- What is the important to learn about read a map?
- What is your strategy to read a map easily?

4.2 Lesson 2 : Left Versus Right

Learning goal

- Students understand about the term of orientation, such as forward, go back, left and right.
- Students are able to distinguish between left and right.
- Students can find the position of certain object by using orientation term.

Starting point

- Students have already heard about the term of orientation.
- Students have already known the position of objects.

Description activity

In the previous activity, students have already experience outside about finding the room. They realize the position of the rooms in the school map. In this activity, students know the position of their friend according the classroom map.

Also, they find the position of students sitting based on the instruction that using term of orientation. Therefore, this activity encourage student to realize about the orientation.

Before discuss about classroom map, students have a little experience to move their body by simple instruction of orientation.

1. Classroom experience

   In the beginning activity, teacher asks students about the term of orientation:

   - Have you ever heard about go forward/go back/turn the left/turn the right?
   - Can you give me the example of direction sentence of certain object?
   - Where does student A sit?

In this activity, students do it outside the class. Students have experience by moving their body according the instruction from the teacher, such as:

a. Turn the left
b. Turn the right
c. Go forward 3 steps
d. Go back 2 steps

This activity be held for all students in the class during 5 minutes.

Students' conjecture:

1. Some students move correctly based on the instruction, especially go forward and go back.

2. Some students have difficulty to turn the left and the right.

Teacher's Action

Teacher tells the students who have difficulty to follow their friend's movement in turning the left or right.

2. Classroom discussion

   There is a classroom discussion after they have experience on moving their body. Topic discussion:

   1. Why can some students not distinguish between left and right?
   2. How do students distinguish between left and right?
   3. Can you tell your way to do it?

      Student's conjecture:

      a. Some students consider their hand as the sign, such as right hand to write, so another hand is left hand.
      b. Use the position of object, such as a watch is on the left hand side.

3. Work about classroom map in group

   Teacher said that she needs students' help to make a classroom map to know the position of the students.

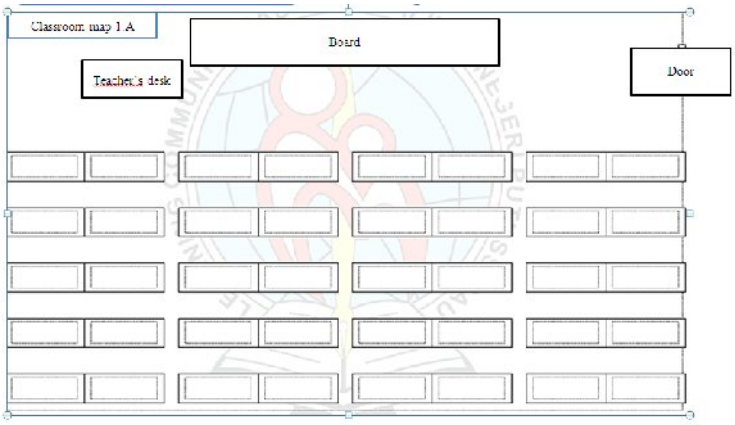

Figure 4.2 Classroom map

4. After they finish work on classroom map, teacher asks students to look the classroom map that they have done and realize the position of some students, here are some question about students' position on the classroom map such as
    a. Who does sit on the right of student A?
    b. Who does sit on the left of student B?
    c. Who does sit behind of student C?
    d. Who does sit in front of student D?
    e. Who does sit on the two steps to the right of student E?
    f. Who does sit on the three steps to the left of student F?
    g. Who does sit on the two steps to the forward of the student G?
    h. Who does sit on the two steps behind of student H?
    i. Who does sit on the three steps to the right and two steps forward of students I?

Students' conjecture:

Students answer in the paper A4 for each question and show the answer. It can generate the classroom discussion whether students answer correctly or not about how they answer the question according to the instruction on the question.

5. Closing the lesson

   Teacher reflects the lesson by asking some questions:

   - What do we learn?
   - What is the important to learn about directional term such as left, right, forward, and go back?
   - What is your strategy to distinguish left side and right side?

4.3 Lesson 3 : The map of palace

Learning goal

- Students get better understanding about direction.
- Students learn about simple navigation.

Starting point

Student are able to use and distinguish the left and the right side.

Description activity:

In the previous activity, students have already learned and about the term of orientation, such as left, right, etc. Those terms are used in this navigational game

that uses the map of palace. When, they play this game, students use such of puppet to help them follow the direction.

Story: The king will tell you the room of palace. However, there is a blank map and you have to fill the name of the room. By using the puppet, you will enter the palace and give the name of the room on the map.

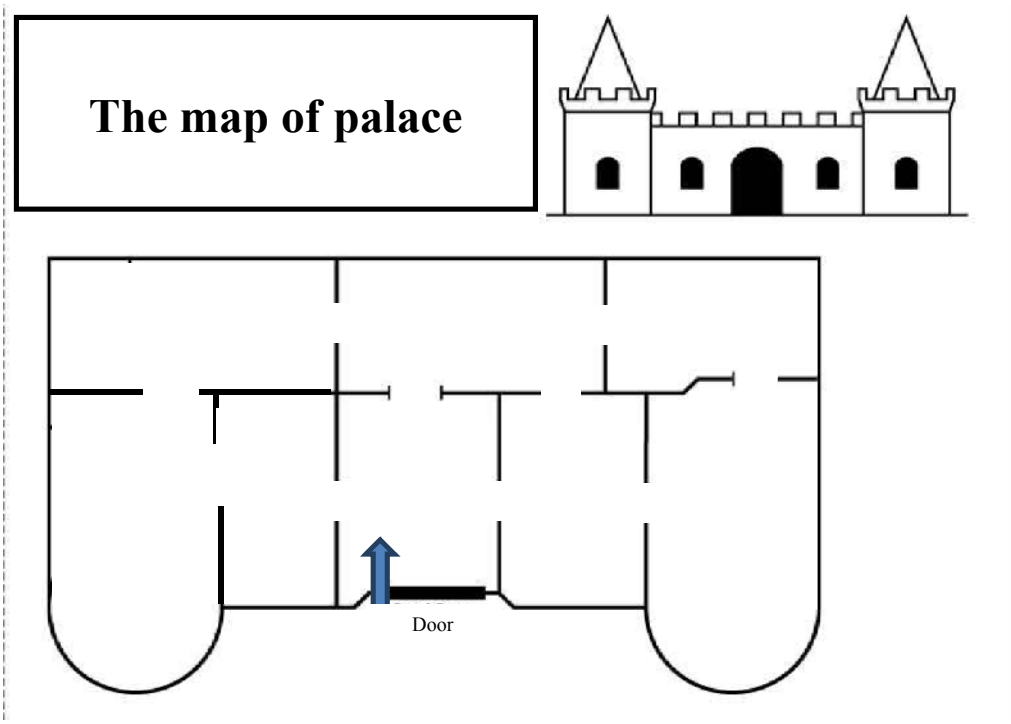

Figure 4.3 The map of palace

1. Students play a navigational game. In this game, teacher gives direction for the students to fill the name of the room on the map of palace

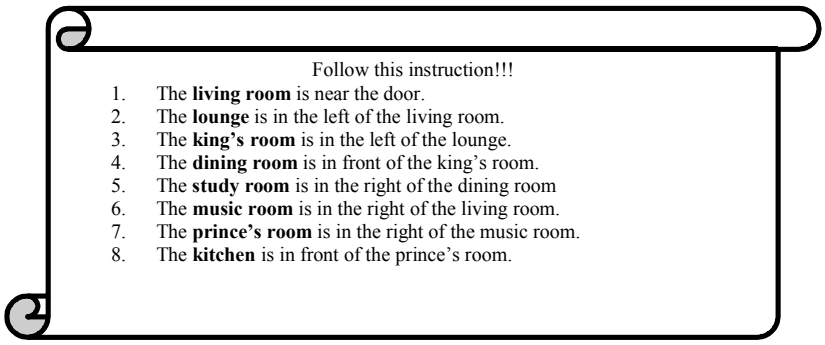

Figure 4.4. The instruction

2. Students put their map of the palace on the white board.

   The Answer:

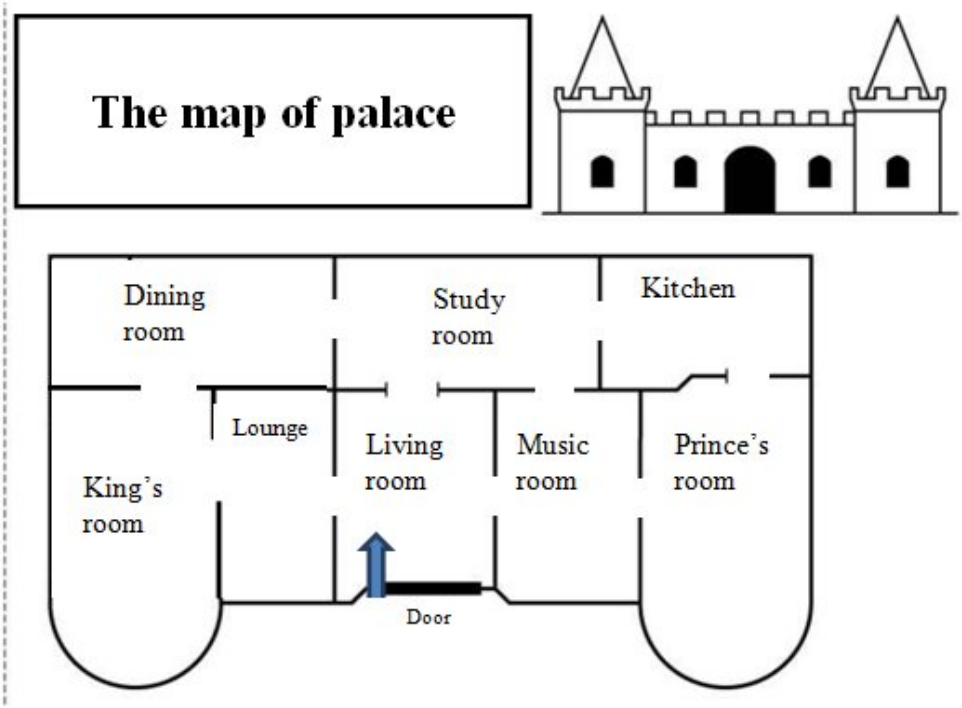

Figure 4.5 The answer

3. Students look the others' map and find the differences. Then, teacher can generate classroom discussion:

   - Is there a different map?

- What is the difference?
- Why is it different?

4. Classroom discussion

Students' conjecture:

a. There is a different map because students write the name of the room in the wrong place. It is caused of wrong orientation (i.e. left and right).
b. It must be consistent with the direction.
c. It must be in the same direction view.

Teacher's action:

Teacher asks about the possibility to have a such condition: (Lounge is in the left of living room).

Lounge	Living room	Lounge

4.4 Lesson 4 : The Puzzle of Map

Learning goal

- Students get better understanding about identification.
- Students make a simple route in finding the way.

Starting point

Students understand about direction.

Description activity:

In the previous activity, students are able to understand the direction by using the orientation term. For this activity, students identify the object by realizing the position of animal whether it is on the left or right side. Students use such a puppet for help them to imagine the real situation in the previous activity, but in this activity, students do not use puppet, so they have to keep hold the left side and the right side of the turtle.

In the beginning of activity, students work on the puzzle. They have a little discussion about how to arrange the puzzle. Indeed, students need to identify the pieces of puzzle in arranging the puzzle.

1. Teacher tells the story about the sea world.
2. Teacher introduce the problem

   The first problem: What are the sea animal on the puzzle?
3. Students must arrange the puzzle to answer the first problem.

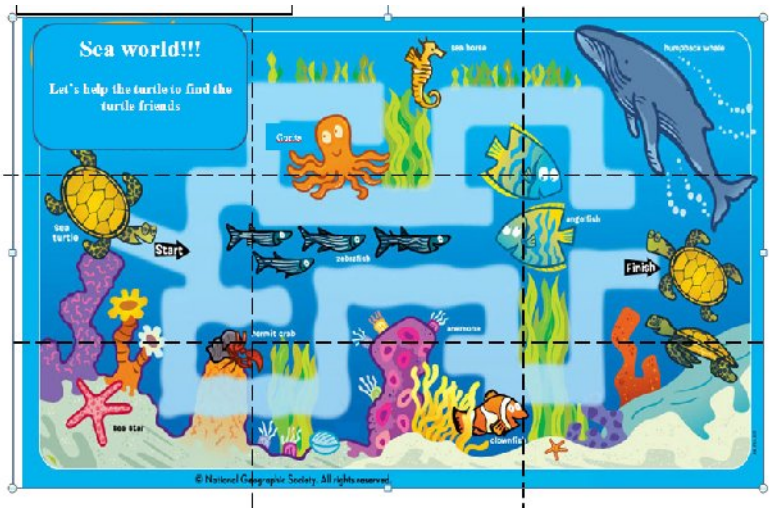

Figure 4.6 The puzzle

4. After students answer question about the animals on the puzzle. Teacher asks students How they arrange and finish the puzzle.

   Students' conjecture:

   a. Students do it by trial and error.

   b. Students consider imperfect picture on the edge for the each part of the puzzle.

   c. Students find the corner part of the whole puzzle to start the arranging of puzzle.

5. Next, Teacher tells the story of the turtle on the puzzle.

   The second problem: Help the turtle to find his friends?

6. Students work in the group to draw the route of the turtle.

   Students' response:

   a. Students make the way that is only passed by the turtle

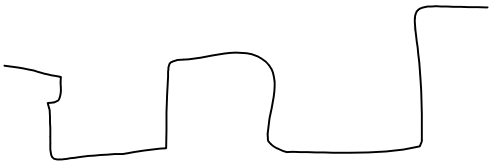

Figure 4.7 Students' response 1

   b. Students make all the bend of the way although it is not passed by the turtle

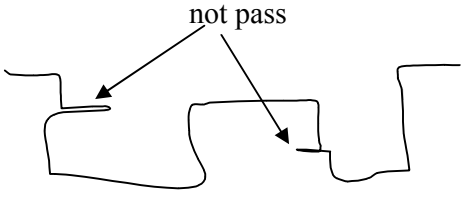

Figure 4.8 Students' response 2

7. Students write the name of the animals that is met by turtle during his way to find his friend. It will encourage students to consider about the other objects on the path and put them in the proper location.

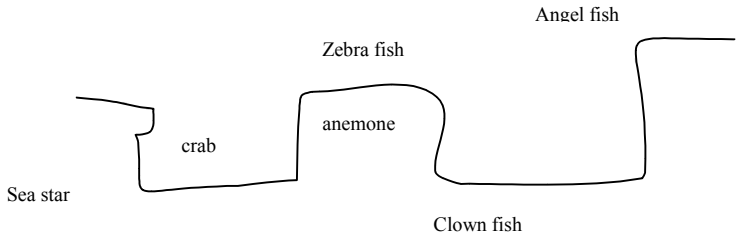

Figure 4.9 Students' response 3

8. Students will determine the position of the other animal according to the left and right side of the turtle. Based on the second and third activity, students are able to recognize the position of the certain object through considering the left and right side.

   Students' conjecture:

   a. Students will answer correctly

On the left side	On the right side
Crab	Sea star
Zebra fish	Anemone
Angel fish	Clown fish

   b. Students will answer in reverse way which is incorrect answer.

On the right side	On the left side
Crab	Sea star
Zebra fish	Anemone
Angel fish	Clown fish

4.5 Lesson 5 : The zoo map

Learning goal

- Students realize the position of the objects.
- Students can communicate and give the direction to find certain object
- Students make a simple map

Starting point

Students understand about orientation and direction.

Description activity:

In the beginning of activity, students will create the miniature zoo. This zoo be used as a representation of the place that will be explored .In the previous activity, students have ability about orientation and direction. In this activity, students are encouraged to communicate the idea of orientation and direction through guiding their friend in finding the way of animal in the zoo.

1. Teacher asks students to have a role play as an owner of the new zoo. Students will make a good arrangement of some animals, pond, and parks in the zoo.
2. Students work in group. Students arrange the miniature of the zoo on the board which is an area of the zoo.

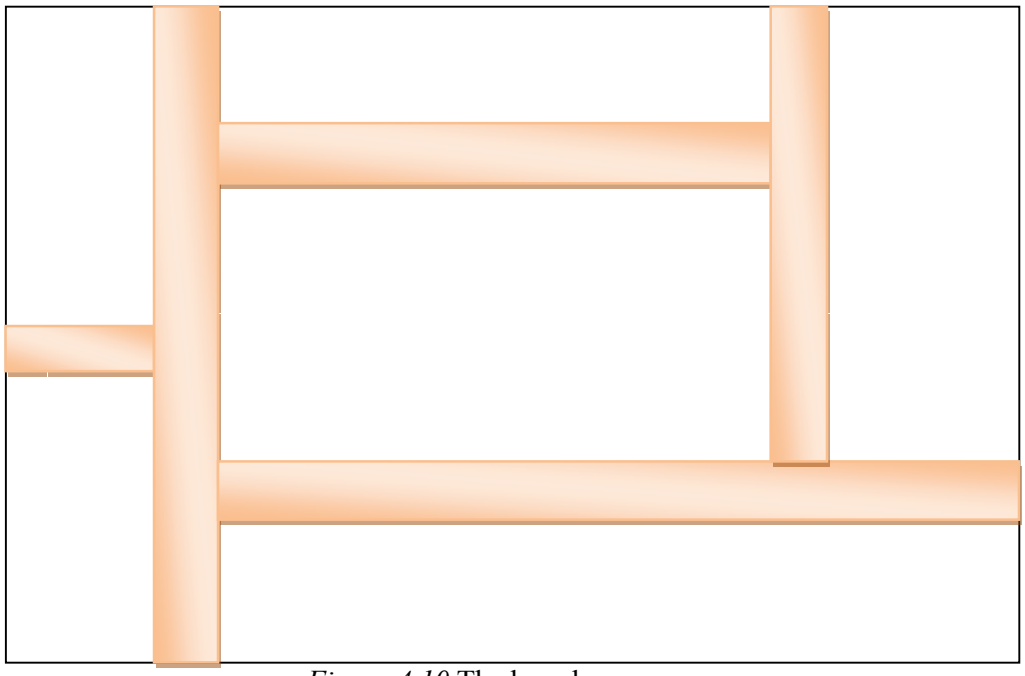

Figure 4.10 The board

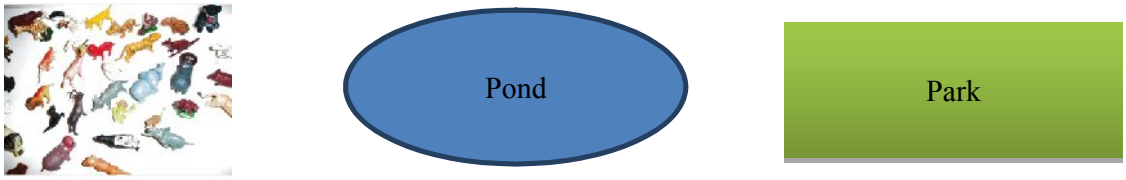

Figure 4.11 The stuff for miniature

3. Students come up with different arrangement of miniature zoo.
4. Students can explore their miniature zoo.

   Students' conjecture:

   - Students explain the arrangement of their own zoo.
   - Students can start to illustrate the position of the animals from the gate of zoo. For example, the position of tiger is on the right side of lion

- Students use the direction and orientation knowledge from the previous lesson to figure out the position of the objects. It means that students have to communicate by giving the correct direction.

5. The miniature of zoo is a kind of representation 3-dimensional place. Next, students deal with 2-dimensional place.
6. Students take the animals and other stuffs from the board and just write down those things on the board. For instance,

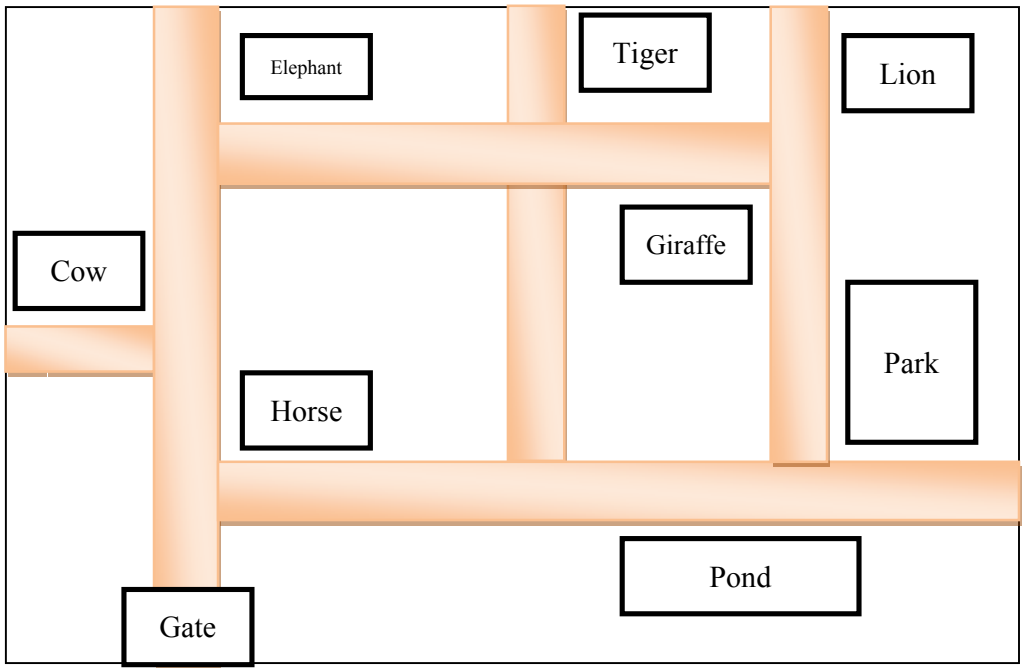

Figure 4.12 Students' answer

7. Next, teacher tells to the students that as an owner of the zoo, they have to make a map for the visitors in the zoo. Students will make a simple map of their zoo on the worksheet.
8. Students explain their map to other friend (as the visitor) who has different arrangement. Students should communicate their map clearly.