SPATIAL VISUALIZATION AND SPATIAL ORIENTATION TASKS TO SUPPORT THE DEVELOPMENT OF STUDENTS' SPATIAL ABILITY

A THESIS

Submitted in Partial Fulfillment of the Requirement for the Degree of Master of Science (M.Sc)

in

International Master Program on Mathematics Education (IMPoME)

Faculty of Teacher Training and Education Sriwijaya University

(In collaboration between Sriwijaya University and Utrecht University)

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FACULTY OF TEACHER TRAINING AND EDUCATION

SRIWIJAYA UNIVERSITY

JUNE 2013

APPROVAL PAGES

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Date of Approval: June 2013

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GRADUATE SCHOOL
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JUNE 2013

PREFACE

We realise that it is not easy to organize ideas and thinking on writing especially in an academic writing such as a thesis. Thanks to Allah Almighty, the master of the universe, without His blessing, we cannot finish this study and write this thesis.

With the limited abilities, it is hardly possible to finish this study and finish this thesis without all the support and good cooperation from all people. Therefore, it is not an exaggeration to author express gratitude to:

1. Prof. Dr. Zulkardi, M.I.Komp, M.Sc, as the Chairman of Mathematics Education course for facilitating the learning process.
2. Dr. Ratu Ilma Indra Putri, M.Si and Dr. Yusuf Hartono, the Sriwijaya University Supervising Committee, who have provided guidance to the author.
3. Mieke J. Abels, Dolly van Eerde and Maarten Dolk, the Utrecht University Supervising Committee he who have provided guidance to the author.
4. All lectures of Mathematics Education course of Sriwijaya and all the academic staff.
5. All lectures of Utrecht University and staff who provide the guidance and motivate the author in finishing this study.
6. Dikti and Neso Nuffic for providing our study finance.
7. My beloved parents H. Rusman. Is and Hj. Mardiah, M.Pd for all the prays, support in both moral and material.
8. My beloved brother and sister, Sesra Risma and Jumiatri Risma, for all the support and motivations.
9. Mr and Mrs. Muhammad for all the support and taking care of me.
10. My guardian angel, Muhamad Said who always be by my side, support, and motivate me.
11. Mrs. Toman Siregar, S.Pd,The headmastef of SD Negeri 117 Palembang; Mrs Fatmawati; S.Pd; Mrs. Yusnizar, S.Pd; and all teachers of SD Negeri 117 Palembang for all the support and cooperation.

Finally, we hope that this thesis can contribute to support the development of students' spatial ability and the research on this domain, and to improve the qualitiy of Indonesian education.

Palembang, June 2013

Dwi Afrini Risma

Spatial Visualisation and Spatial Orientation Task to Support the Development of Students' Spatial Ability

Abstract

Many studies have proven the importance of spatial ability for students; both for their educational or occupational success and for their everyday competence. Skills such as estimating, geometry, measurement, map-reading and simple drawing are some of the mathematics ideas behind this topic. Therefore, the development of students' spatial ability can no longer be ignored. Yet, in Indonesia the research on the domain of spatial ability and the development of students' spatial ability is still lack of attention. Some exercise such as spatial visualisation and spatial orientation task may support the development of students' spatial ability. In order to support the development of students' spatial ability, in present study we design 5 lessons that is combining the spatial visualisation and spatial orientation tasks. This study is also aimed to develop a local instructional theory in this domain. Consequently, design research is chosen as an appropriate approach for achieving the research aim. In addition, Pendidikan Matematika Realistik Indonesia (PMRI) which was adapted from Realistic Mathematics Education (RME) was deliberately chosen as the approach in the teaching-learning process in the classroom. To conjecture what will happen in the classroom, the Hypothetical Leaning Trajectory was designed which consists of mathematical goals, starting points, mathematical activities, and the hypothetical paths of students' thinking. Our hypothesis is that through the series of activities students can develop their spatial ability. Thus, we address the following research question: How can spatial orientation and spatial visualisation support the *development of students' spatial ability?*

Keywords: Spatial Ability, Spatial Orientation, Spatial Visualisation, Spatial Terms

Spatial Visualisation and Spatial Orientation Task to Support the Development of Students' Spatial Ability

Abstrak

Banyak penelitian telah membuktikan pentingnya kemampuan spasial bagi siswa, baik untuk kesuksesan pendidikan dan di dunia pekerjaan, maupun untuk kompetensi sehari-hari. Keterampilan seperti penaksiran, geometri, pengukuran, membaca peta, dan menggambar sederhana merupakan ide matematika di balik topik ini. Oleh karena itu, perkembangan kemampuan spasial siswa tidak boleh diabaikan. Namun. Penelitian di bidang ini, dan pengembangan kemampuan spasial siswa di Indonesia, masih kurang diperhatikan. Dengan memberikan beberapa latihan seperti latihan visualisasi spasial dan orientasi spasial, kita dapat membantu perkembangan kemampuan spasial siswa. Guna membantu perkembangan kemampuan spasial siswa, pada studi ini kami merancang 5 pembelajaran yang mengombinasikan latihan visualisasi spasial dan orientasi spasial. Studi ini juga bertujuan untuk mengembangkan teori pembelajaran lokal (local instructional theory) di bidang ini. Oleh karena itu, desain riset dipilih sebagai pendekatan yang tepat untuk mencapai tujuan penelitian. Selain itu, Pendidikan Matematika realistik Indonesia (PMRI) yang diadaptasi dari Realistic Mathematics Education (RME) sengaja dipilih sebagai pendekatan dalam proses belajar-mengajar di kelas. Untuk memspekuliasikan apa yang akan terjadi di kelas, dirancang hipotesis lintasan belajar yang terdiri dari tujuan pembelajaran, pengetahuan awal siswa, aktivitas matematika, dan hipotesis lintasan pemikiran siswa. Hipotesis kami adalah bahwa melalui serangkaian kegiatan siswa dapat mengembangkan kemampuan spasial mereka. Dengan demikian, kita merumuskan pertanyaan penelitian sebagai berikut: Bagaimana pemberian latihan orientasi spasial dan visualisasi spasial mendukung pengembangan kemampuan spasial siswa?

Kata Kunci: Kemampuan Spasial, Orientasi spasial, Visualisasi spasial, Istilah spasial

Spatial Visualisation and Spatial Orientation Task to Support the Development of Students' Spatial Ability

SUMMARY

Spatial ability is an important skill that student need to have. Educators need to recognize that acquiring a range of spatial skills is important for all pupils or students; both for their educational or occupational success and for their everyday competence. Skills such as estimating, geometry, measurement, map-reading and simple drawing are some of the mathematics ideas behind this topic. Considering the importance of this aspect, the development of students' spatial ability can no longer be ignored. In order to support the development of students' spatial ability, in present study we design a learning activities sequence that is combining the spatial visualisation and spatial orientation tasks.

This present study is aimed to develop a local instructional theory to support the development of students' spatial ability. Consequently, design research is chosen as an appropriate approach for achieving the research aim. In addition, Pendidikan Matematika Realistik Indonesia (PMRI) which was adapted from Realistic Mathematics Education (RME) was deliberately chosen as the approach in the teaching-learning process in the classroom. To conjecture what will happen in the classroom, the Hypothetical Leaning Trajectory HLT) was designed which consists of mathematical goals, starting points, mathematical activities, and the hypothetical paths of students' thinking. Our hypothesis is that trough the series of activities students can develop their spatial ability; to be more précised the strategy used by students in solving spatial problem will be developed. Thus, we address the following research question: How can spatial orientation and spatial *visualisation support the development of students' spatial ability?*

This research was conducted in two cycles, namely pilot experiment and teaching experiment. This research involved 3 students in pilot experiment, 39 students in teaching experiment, and a teacher of 3th grade of SD Negeri 117 Palembang, Indonesia. After the 6 activities in the first cycle, activities and materials were refined in order to improve the HLT. We eliminated the first activity in the preliminary experiment which did not really support the students in the following activity. Consequently, in the teaching experiment, we only had a series of 5 activities. The data were collected during the first cycle was video recording, students' works, classroom observation, field notes, and evaluation with the teacher.

The phases of students learning in the first cycle are: 1) Playing Tungkupan (Hide and Seek), 2) Finding the best place to build the control station, 3) Locating the picture, 4) Exploring the wall, 5) The adventure in the cube houses, and 6) Finding the treasure. Due to some refining in HLT, the phases of learning in the second cycle are: 1) Finding the best place to build the control station: students exploring and observing the miniature of the island from different perspective and

then make the representative drawing of the island from different side view, 2) Locating the picture: finding the viewpoint from which a picture was taken or matching the pictures of the miniature of the island that are portrayed from different perspective, 3) Exploring the wall: students construct and explore the structure of the objects made of bricks and identify its drawing from different views, 4) The Adventure In The Cube Houses: the students identify block structured from different view, and 5) Finding the treasure: the students construct the block building from some pictures of block building taken from different views.

In this research we found that: 1) for students in this age, Finding the Best Place to Build the Control Station (observing the island) can promote the development of students' ability in reading 2-dimensional representation of 3-dimensional object. After experiencing this activity, the students are able to reasoning the drawing of miniature of the island by considering the position of the objects; left and right. 2) When the students were constructing the miniature of the island for the first activity, the students were considering the position of the objects showed by the side views pictures. 3) Once the students know the top view of miniature of the island, the students did not need to see the side views pictures in locating the position of the objects while they were constructing the miniature for the second activity. 4) Some students drew one of the objects in the miniature from the top view; it indicates that students in that age already develop their sense of top view of an object. 5) Soon when students experience the Exploring the structure of the wall, they started to develop their navigation idea such as front, left, right, back, and top. 6) The strategy used by the students in indicating the top view of the objects was gradually progressed; in the first time, they really need to see the object from the top, once they get the idea of the top view, to draw the top view of the object they just see the object from the bird eye view. 7) The last two activities; namely the adventure in the cube house and finding the treasure help the students in reading, interpreting, and reasoning two dimensional drawing.

Concerning the findings of this research, we conclude that by experiencing working on some spatial visualisation and spatial orientation tasks such as: the activities of constructing the building, drawing, and analyzing two-dimensional shapes, students understand attributes and properties of two-dimensional space and the use of those attributes in solving some spatial problems.

Spatial Visualisation and Spatial Orientation Task to Support the Development of Students' Spatial Ability

RINGKASAN

Kemampuan spasial merupakan keterampilan yang harus dimiliki oleh siswa. Pendidik harus menyadari bahwa memiliki berbagai keterampilan spasial penting bagi semua siswa atau pelajar, baik untuk keberhasilan pendidikan atau pekerjaan mereka dan kompetensi mereka sehari-hari. Keterampilan seperti penaksiran, geometri, pengukuran, membaca peta, dan menggambar sederhana merupakan ide matematika di balik topik ini. Mengingat pentingnya aspek ini, perkembangan kemampuan spasial siwa tidak boleh diabaikan. Guna membantu perkembangan kemampuan spasial siswa, pada studi ini kami merancang serangkaian aktivitas pembelajaran yang mengombinasikan latihan visualisasi spasial dan orientasi spasial.

Studi ini bertujuan untuk mengembangkan Teori Pembelajaran Lokal (Local Instructional Theory) di bidang ini dan untuk mendukung perkembangan kemampuan spasial siswa. Oleh karena itu, Desain Riset dipilih sebagai pendekatan yang tepat untuk mencapai tujuan penelitian. Selanjutnya, Pendidikan Matematika realistik Indonesia (PMRI) yang diadaptasi dari Realistic Mathematics Education (RME) sengaja dipilih sebagai pendekatan dalam proses belajar-mengajar di kelas. Untuk memspekuliasikan apa yang akan terjadi di kelas, dirancang Hipotesis Lintasan Belajar atau Hypothetical Learning Trajectory (HLT)yang terdiri dari tujuan pembelajaran, pengetahuan awal siswa, aktivitas matematika, dan hipotesis lintasan pemikiran siswa. Hipotesis kami adalah bahwa melalui serangkaian kegiatan siswa dapat mengembangkan kemampuan spasial mereka. Dengan demikian, kami merumuskan pertanyaan penelitian sebagai berikut: Bagaimana pemberian latihan orientasi spasial dan visualisasi spasial mendukung pengembangan kemampuan spasial siswa?

Penelitian ini dilaksanakan pada dua siklus, yakni studi pendahuluan dan eksperimen mengajar. Penelitian ini melibatkan 3 siswa pada studi pendahuluan, 39 siswa pada studi percobaan dan seorang guru kelas 3 SD Negeri 117 Palembang, Indonesia pada eksperimen mengajar. Setelah 6 aktivitas pembelajaran diujicobakan pada siklus pertama, aktivitas dan materi pembelajaran disempurnakan guna meningkatkan HLT. Aktivitas pertama yang digunakan pada studi pendahuluan dieliminasi karena tidak terlalu mendukung siswa pada aktivitas pembelajar selanjutnya. Akibatnya, pada ekperimen mengajar, hanya terdapat 5 aktivitas pembelajaran saja. Data yang diperoleh dari siklus pertama adalah rekaman video, hasil kerja siswa, observasi kelas, catatan lapangan, dan evaluasi dengan guru.

Fase pembelajaran siswa pada siklus pertama adalah: 1) Bermain Tungkupan, 2) Menemukan yang paling tepat untuk mendirikan po penjagaan, 3) Menempatkan gambar, 4) Mengeksplorasi bentuk dinding 5) Pertualangan di

rumah kubus, and 6) Mencari harta karun. Karena adanya beberapa perbaikan pada HLT, fase pembelajaran pada siklus dua diubah menjadi sebagai berikut 1) Menemukan yang paling tepat untuk mendirikan pos penjagaan: siswa mengeksplorasi dan mengobservasi miniatur pulau dari arah yang berbeda kemudian mengambarkan tampak samping dari pulau tersebut dari arah tertentu, 2) Menempatkan gambar: menemukan titik pandang dari mana sebuah gambar diambil atau pencocokan gambar miniatur pulau yang diambil dari perspektif yang berbeda, 3) Mengeksplorasi bentuk dinding: siswa membuat dan mengeksplorasi struktur dinding yang terbuat dari batu bata dan mengidentifikasi gambarnya dari arah yang berbeda, 4) Pertualangan di rumah kubus: Siswa mengindentifikasi struktur kubus-kubus dari arah yang berbeda, dan 5) Mencari harta karun: Siswa menyusun rumah kubus dari gambar tampak samping dan tampak atas dari rumah kubus tersebut.

Pada riset ini ditemukan bahwa: 1) Untuk siswa di usia ini, aktivitas Menemukan tempat yang paling tepat untuk mendirikan pos penjagaan (mengobservasi pulau) dapat mendukung perkembangan kemampuan spasial siswa dalam membaca gambar representasi 2-dimensi dari benda 3-dimensi. Setelah mengalami aktivitas ini, siswa mampu menalar dan memberikan alasan terhadap gambar miniature pulau dengan mempertimbangkan posisi kanan dan kiri benda. 2) Pada saat siswa sedang membuat miniature pulau, siswa mempertimbangkan posisi kiri dan kanan yang ditunjukkan oleh objek. 3) Setelah siswa mengetahui tampak atas miniatur pulau, para siswa tidak perlu melihat gambar tampak samping dalam menemukan posisi benda saat mereka sedang membangun miniatur untuk kegiatan kedua. 4) Beberapa siswa menggambar salah satu objek dalam miniatur dari tampak atas, hal ini menunjukkan bahwa siswa di usia yang sudah mulai mengembangkan ide tampak atas suatu benda 5) ketika siswa melakukan aktivitas Menjelajahi struktur dinding, siswa mulai mengembangkan ide navigasi mereka seperti depan, kiri, kanan, belakang, dan atas. 6) Strategi yang digunakan oleh siswa dalam mengindikasikan tampak atas dari benda-benda secara bertahap berkembang, pertama kali, siswa benar-benar perlu melihat objek dari atas, setelah mereka mendapatkan ide tampak atas, untuk menggambar tampak atas objek siswa hanya melihat objek dari pandangan mata burung. 7) Dua kegiatan terakhir, yaitu petualangan di rumah kubus dan mencari harta Karun membantu siswa dalam membaca, menafsirkan, dan penalaran gambar dua dimensi.

Terkait dengan temuan penelitian ini, kami menyimpulkan bahwa dengan mengerjakan beberapa tugas visualisasi spasial dan tugas orientasi spasial seperti: kegiatan membangun bangunan, menggambar, dan menganalisis bentuk dua dimensi, siswa memahami atribut dan sifat-sifat ruang dua dimensi dan penggunaan atribut-atribut dalam memecahkan beberapa masalah spasial.

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CHAPTER I

INTRODUCTION

Spatial ability is an important skill that student need to have (Delice et al., 2009; Revina et al., 2010; Yue, 2006; Walker et al., 2011). As Smith (1992) suggested, educators need to recognize that acquiring a range of spatial skills is important for all pupils or students; both for their educational or occupational success and for their everyday competence. Skills such as estimating, map-reading and simple drawing are some of the mathematics ideas behind this topic (Smith, 1992). To be successful in subjects such as geometry, volume, and measurement students are required to have a good spatial ability. This topic is also one of the competences that are tested in PISA 2003 (PISA framework, 2003). Students possibly also know that this skill is needed in occupations such as architect, dentistry, engineer, and is also needed in subjects such as mathematics, physics, and geography.

A lot of research has been done in this domain (Delice, et al., 2009; Revina et al., 2010; Yue, 2006; Walker, et al., 2011; Holzinger & Swineford, 1946; Hegarty & Waller, 2005). Many researchers supported the statement that spatial ability is important to the development of mathematical thinking. Holzinger & Swineford (1946) claimed that spatial ability is closely related to academic achievement, particularly to success in math and geometry. Hegarty & Waller (2005) claimed that in general spatial ability together with intelligence and visual perception is required to develop mathematical thinking. Hegarty & Waller (2005) supported that spatial abilities are important for both constructing and comprehending abstract spatial representations in mathematical problem solving. Unfortunately, there is still limited research about this domain in Indonesia

(Revina et al., 2010). Because the system of our education is more centred on verbal and numerical ability, development of students' ability in this skill is still in lack of attention (Smith, 1992). In addition, there is limited research on how the design of learning activities affects the development of students' spatial abilities. A recent study focused on this topic is the research conducted by Revina et al. (2010).

Revina et al. (2010) in her study with participants from 5th grades of primary education in Palembang Indonesia used the building block activities to help students grasp the idea of volume measurement by unitary conceptual understanding. In this study, she developed a learning activity in which the small cubes are used as the unit for constructing bigger cubes and blocks. Since this study is limited to grasping the idea of volume measurement, in her study the students only went through the idea of spatial visualization of two regular three dimensional objects, namely cubes and blocks. Even though this research finding claimed that it does help students to develop students' conceptual understanding of volume measurement, it does not fully facilitate the development of students' spatial ability. In addition, it was more centred on spatial visualisation tasks. In fact, there are some other important components of spatial skills that also play a big role in developing students' spatial ability, namely spatial orientation and spatial rotation.

Therefore, more research in this important mathematical domain is needed. Based on these issues, it is necessary to design the instructional activities in which appropriate context and powerful models are elaborated, so we can support the development of students' spatial ability. It is also a challenge to improve the

mathematical education in Indonesian school. Pendidikan Matematika Realistik Indonesia (PMRI) or Indonesian Realistic Mathemathic Education is one of the approaches that can be used. This study is one of the efforts to the mathematical education in Indonesian school in general, and particularly to support the development of students' spatial ability.

Since the aim of this study is to help students in 3rd grades of elementary school to develop their spatial ability, we formulate the general research question as: How can spatial visualisation and spatial orientation tasks support the *development of students' spatial ability?*

To answer this question, we design a sequence of learning activities that is a combination of two components of spatial ability, namely spatial visualisation and spatial orientation. These two components are integrated into 6 different activities. In the first activity, students will play "Hide and Seek" or in Palembangnese language is also known as "Tungkupan". This activity is aimed to give students the sense for the next two activities. The second activities are set to let students experience the visualisation task by observing the miniature of the island and visualise the object on the miniature into two dimensional drawing. In the third activity, students are asked to locate the pictures of the miniature of the island based on where it was taken. The fourth activity is the zoom in on the second and third activity that is they will explore the wall and being introduced to the spatial term such as side views and top view. The last two activities is the more abstract activity in which students will work with small cubes and they are asked to draw the side views and the top view of the cubes arrangement and then construct the cube arrangement based on the views given.

CHAPTER II

BACKGROUND AND RESEARCH QUESTION

2.1. Spatial ability

Spatial ability is defined and evaluated in many ways in the literature. Carol (1993) stated that spatial ability has to do with how individuals deal with material presented in space or more specifically, with a collection of abilities involving imagining, perceiving, remembering, and transforming objects or forms or routes in the real world or through representations of the real world, as in a paper-and-pencil or computer test (Carol, 1993 in Kylllon & Gluck 2003). Hegarty & Waller (2005) and Kozhevnikov, Motes & Hegarty (2007) considered spatial ability as a form of mental activity that enables individuals to create spatial images and to manipulate them in solving various practical and theoretical problems (Pittalis & Christou, 2010).

Lohman (1988, 2000) indicated that spatial ability is composed of 3 separate abilities. These factors contribute the same importance to students' spatial abilities. He defined these three factors as follows:

1. Spatial visualisation is the ability to comprehend imaginary movement in a three-dimensional space or the ability to manipulate objects in the imagination
2. Spatial orientation is the ability of students to remain unconfused by the changing orientation, in which a spatial configuration may be represented.
3. Spatial relation is defined as the ability to mentally rotate a spatial object as a whole fast and correctly.

Researchers have found that spatial ability relates to achievement in math, even though in some cases the researchers' findings show inconsistency. Friedman (1995) found that spatial ability and math skills have little correlation. He found that verbal ability was a stronger predictor for math achievement than the spatial ability. He also found that spatial mathematics ability correlation is stronger among female than male learners. Hanaffin and Scout (1998) found a nonsignificant association between spatial ability and achievement and recommended a further research in this area.

Hanaffin, Truxaw, Vermilion, & Liu (2008) investigated the effect of students' spatial ability and type of instructional research. Their finding support the Rhode & Thompson (2007) finding, namely spatial ability in young adults predicted general cognitive abilities.

Pitta-Pantazi & Christou (2010) investigated the relation of students' spatial and object visualisation with their creative and practical abilities in three-dimensional geometry. The result suggested that preferences and experiences in spatial visualisation significantly related to students' practical abilities in three-dimensional arrays of cubes. Pittalis & Christou (2010) did a research that involved students in grade 5 to 9. The research finding claimed that spatial abilities constitute a strong predictor of students' performance in the four types of reasoning in 3D geometry. This research's findings suggested that an improvement of students' spatial abilities might result in an improvement of their 3D geometry thinking. Battista (1990) indicated spatial ability as one of the factors that affect success in geometry and geometric problem solving.

Many researchers supported the statement that spatial ability is important to the development of mathematical thinking. Holzinger & Swineford (1946) claimed that spatial ability is closely related to academic achievement, particularly to success in math and geometry. Hegarty & Waller (2005) claimed that in general spatial ability together with intelligence and visual perception is required to develop mathematical thinking. Hegarty & Waller (2005) supported that spatial abilities are important for both constructing and comprehending abstract spatial representations in mathematical problem solving.

Regarding to these facts, developing students 'spatial ability is a must. Smith (1992) pointed out that spatial ability can no longer be dismissed as a narrow aspect of intelligence, that is only important for certain manual or practical occupations. Indeed, spatial ability needs to be recognised as a fundamental part of intellectual functioning. Unfortunately, there is still limited research about this domain in Indonesia (Revina et al., 2010). Because the system of our education is more centred on verbal and numerical ability, development of students' ability in this skill is still in lack of attention (Smith, 1992). In addition, there is limited research on how the design of learning activities affects the development of students' spatial abilities. A recent study focused on this topic is the research conducted by Revina et al. (2010).

Revina et al. (2010) in her study with participants from 5th grades of primary education in Palembang Indonesia used the building block activities to help students grasp the idea of volume measurement by unitary conceptual understanding. Since this study is limited to grasping the idea of volume measurement, in her study the students only encountered the idea of spatial

visualization of two regular three-dimensional objects, namely cubes and blocks. Even though this research finding claimed that it does help students to develop their conceptual understanding of volume measurement, it does not fully facilitate the development of students' spatial ability in much broader understanding. In addition, the research was more centred on spatial visualisation tasks. In fact, there are some other important components of spatial skills that also play a big role in developing students' spatial ability, namely spatial orientation and spatial rotation.

Considering the importance of this domain and in order to fill the gap, a study based on RME principles is designed. In this study we use the combination of two components of spatial ability, namely spatial visualisation and spatial orientation. These two components are integrated into some tasks to support the development of students' spatial ability.

2.2. Realistic Mathematics Education (RME)

In this study we will use the Pendidikan Matematika Realistik Indonesia (PMRI) as an approach of the learning activity. PMRI is an approach in learning mathematics that is adapted from the Realistic Mathematic Education (RME). RME is developed based on the idea "mathematics as a human activity" (Freudenthal, 1991). In the process of doing mathematics, Freudenthal (1991) emphasizes that the students should be allowed and encouraged to invent their own idea and their own strategies (Revina et al, 2011).

According to Treffers (1987) and in Drijver (2003), there are five characteristics of RME. How those characteristics support the design of spatial visualization and spatial orientation activities will be described as follows.

1. The use of context in phenomenological exploration

In this design, students will work under one big context namely "we are the pirates", in which students will act as pirates. Therefore, they will do some activities that address them to be a "real" pirate. We set this learning activity in certain situation to engage them with the series of activities that they are going to work with. The context does not only help to engage the students but also make the learning activities become more interesting and meaningful for them. We expect that by using this context, the students will come up with the navigational term such as left, right, front, and back. At the same time, the context also supports the observation and exploration activities.

2. The Emergent modelling

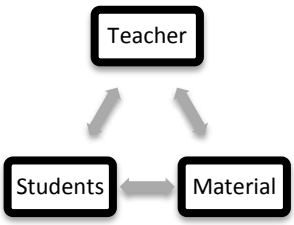
Models are representations of relationships that mathematicians have constructed over time as they have reflected on how one thing can be changed into another and as they have generalized ideas, strategies, and representations across contexts (Fosnot & Dolk, 2001). The idea of model of and model for is developed in chapter numbers and algebra. In geometry, the idea of modelling is still an issue which is still being discussed. Thus, instead of defining as model, we define the objects used in the learning activities as tools or media.

3. The use of students' contribution and creation

Instead of directly introduce some important concept such as the definition of top view, front view, back view, left view, and right view; in this study we let the student build their own understanding on defining this concept. However, those spatial terms are explicitly introduced to the students. We realise that probably the

idea of using navigational term may not explicitly mention by the students. Thus, we provide some bridging questions for teacher to solve this problem.

4. Students' interactivity



The patterns of the interaction set in our design can be described as follows: By working in group, students will not only interact with the material but in at the same time they also interact with their partner. Students also have a chance to individually investigate every problem given. In the discussion session, students work together with the teacher to construct the same understanding. So, the teacher has a role as a facilitator of the students' learning activities and discussion by giving questions in order to stimulate their thinking. By playing a role as the discussion facilitator, the teacher also has to deal with the material.

5. Intertwining

The activities designed have strands not only within the mathematics but also the other subjects such as geography and social science. Spatial visualization and spatial orientation tasks are some important foundations in learning geometry. This design also has something to do with students understanding in grasping the concept of angle and volume measurement (see Revina et al, 2011). One of the activities in this design is orientating the pictures on the map. To be able to do this, students should understand how to read a map. Reading maps is a skill that students learn in geography.

2.3. The Crucial Role of the teacher

Learning is a process that cannot be observed since it is happen in the brain. However, we can see the result of learning process by observing the progress of strategies used by the students. To make sure that the students do learn something during the learning activity, teacher plays important roles on it namely as the facilitator of learning activity. We will describe some important roles of teacher in the sequences of learning activities designed on this study as follows.

1. Guiding the process of learning activities

Not only as the one who start the learning activity by informing the students about what will they learn today, what is the goal of today's activity, and end the learning activity, a teacher also has another important roles i.e. to make sure that the learning process can be proceed. Teacher should make sure that the learning process flows as what it should be done.

2. Presenting the problem

A learning activity can be started by giving the problem that students should solve. In this study, the problems are being introduced right after the teacher introduces the contextual problem that students should solve. The context used on these series activities is carefully chosen. This is because the purpose of the context; to make the learning activity more meaningful and there are some aspects that should be considered by the students while working on the tasks. Considering this important issue, a teacher should inform the students what they should do and make sure that the students understand about what they should do.

3. Leading the discussion

In the whole series activities designed, we give space for students to have the discussion. We expect that the discussion will not only occur between teacher and the students but also among the students. Teacher is the one who leads the discussion by posing some question, raising a problem, or commenting on students works.

4. Encouraging every student to be actively participated

Each student has different characters. Some of them can easily speak their ideas while some others are little bit shy. Teacher can encourage those silent students to speak up their ideas by pointing them. Saying "Where is A, I do not hear your voice today. What is your opinion about it?", asking those students to repeat what their friend just says, or asking how their opinion about someone opinion, why they agree or disagree; would be some acts that can be done. To anticipate the bossy students or different level of students' understanding, a teacher can encourage them to work as a team work by stating "Everybody has different level understanding, ideas, and strategies. However, you can learn something from your friends' ideas or strategies. The more strategies you know, the more options you can choose".

5. Devil's advocate

Sometime in discussion, teachers can also play dumb or give incorrect answers or arguments. Some students tend to change their answer if the teacher asks them to repeat their answer. Some other will get confused when the teacher disagree with their argument. This is one of the ways to test that the students' understanding. However, teacher should be careful on it, because instead of testing student's

understanding it may lead the students to a misconception or misunderstanding. Thus, a teacher should emphasise the correct answer in the end of the discussion.

2.4. Spatial ability in Indonesian Curriculum

So far, there is no specific competence for developing students' spatial ability in Indonesian national curriculum. However, recently in the mathematics textbooks for children in the first and second grade that are published by Pendidikan Matematika Realistik Indonesia (PMRI) foundation, some tasks related to this topic are presented. It indicates that this is an important topic that we should concern about.

2.5. The Present Study

Based on (Clement & Sarama, 2009), 9 years old students have developed their ability in orientating and differentiating the left side and the right side. This ability is the important skill needed to work with the tasks that is designed in this study. Therefore, we decide to involve 9 years old students as the target group of this study. Furthermore, the material designed in this study is needed to support them in learning one of chapter in geometry namely space geometry and volume measurement. Those two concepts will be learnt in the higher grade. So, we expect that this design will scaffold them in grasping those two concepts.

In general, the previous study done by Lohman (1999) claimed that the three important components of spatial ability, namely spatial visualization, spatial orientation, and spatial relation, have the same importance in developing students' spatial ability. Revina et al. (2012) developed a design that integrated spatial visualization tasks. The results of this study claimed that the spatial visualization tasks developed students' spatial structuring. The design developed in this present

study will integrate two factors of spatial ability, namely spatial visualisation and spatial orientation. We hypothesise that the spatial orientation and spatial visualisation tasks can support students' spatial ability.

Therefore, the study in this report addresses a general question:

How can the spatial visualization and spatial orientation tasks support the *development of students' spatial ability?*

CHAPTER III

METHODOLOGY

3.1. Research Approach

This study is aimed to provide an empirically grounded theory about how mathematical instruction works in the domain of spatial ability. This study is aiming at designing and studying innovate lesson designs. This study is not aimed to test theories but is it is rather to discover ways to improve mathematics education and contribute to developing local instruction theories, more specific on developing students' spatial abilities. To be precise, the purpose of this study is to support the development of students' spatial abilities of 3rd grade of SD Negeri 117 Palembang. Considering the basic aims of this study, the design research is considered as the relevant approach to use.

As a concrete definition on what is design research regarding to this study, we will discuss three phases of conducting design research as described by Gravemeijer & Cobb (2006) as follows.

Phase One: The Preparing for the Experiment

The preparation classroom experiment is started by defining the mathematical learning goal. In this study, we aim to support the development of students' spatial ability by letting them experience working on spatial visualization and spatial orientation. In order to have relevant and systematic learning sequences, we design instructional activities including the conjecture of students' strategies and thinking. This instructional activity is known as Hypothetical Learning Trajectory (HLT). We also will conduct a pre-test in this phase as an effort to know students current knowledge and the level of student reasoning using the

spatial ability. A literature study will also be done to give supporting theory on both developing the HLT and also in analyzing the pre-test result.

Phase Two: Experimenting in the Classroom

This phase is about conducting the design experiment. In this study, we will do two cycles. The first cycle will be done in small group of students. This cycle is a kind of piloting project in which we will try out the HLT in a group of three students. This piloting group will experience all six lessons designed for which the researcher will act as the teacher. With this small group of students, we will test the instructional activities designed from the previous phase and make the validity on the conjecture and the hypothesis made. The HLT probably will be improved or revised in the end of this cycle. The content of HLT is also probably preserved; it depends on how the result found in the first cycle. The improved HLT will be implemented in the second cycle period. In second cycle, we will work with larger number of students. The students will experience six activities in which they will have some classroom discussion.

One of the philosophies of educational design research is as ecological research. Thus, in this second cycle, the learning activities will be brought by the teacher. Not only to support the students' learning in the whole class discussion, the role of the teacher is also to probe the students' understanding and reasoning, and to find out why they used particular approaches. Thus, there will be lots of discussion between teacher and researcher regarding the reflection on how the learning activities are being run.

Phase Three: Conducting Retrospective Analysis

One of the primary aims is typically to contribute to the development of a local instruction theory; other goals may concern more encompassing issues, or ontological innovations (Gravemeijer & Cobb, 2006). In this phase, we will analyze all data collected during the classroom experiment phase. We will compare all the conjecture made with the real students' reaction. How it remains difference and the same will also being analyzed. By doing the analysis, we aim to find the answer for the research question we have. The product of this phase is not only the description about how we can support the development of students' spatial activity, but also to develop a more effective instructional activity on developing the students' spatial ability.

3.2. Data Collection

In this study, we use four different methods of data collection; written test, classroom observation, interview and teaching experiment. Thus, the data that will be analyzed are students' works, interview, field notes and videotaped observation. The methods chosen are relevant with the research questions we addressed. Since the aim of this study is to get a clear description on how we can support students' development of spatial ability, then the data collected in this study will also be analyzed qualitatively. The data will be collected in Sekolah Dasar (SD) Negeri 117 Palembang during the preparation phase, pre-test, preliminary teaching experiment, teaching experiment, and post test.

Target Group

This study involved 42 pupils of 3rd grades of elementary school in Palembang Indonesia namely SD Negeri 117 Palembang, and a classroom teacher of SD

Negeri 117 Palembang. Three of the pupils are involved in the first cycle; meanwhile the other 39 pupils are involved in the second cycle. Those 39 pupils are grouped into small group consisting of three or four pupils. Each group consists of high achiever pupils, medium achiever pupils, and low achiever pupils.

3.2.1. Preparation Phase

During this period, we will conduct a classroom observation, pre-test and an interview with the teacher. First explanation about the classroom observation and interview will be described. The pre-test will be explained in the Pre-test and Post-test section.

Classroom Observation

Before conducting the teaching experiment, the observations will be done to know on the teaching and learning atmosphere in the classroom. We also want to know the teaching approach used by teacher. We believe that the social norms and sociomathematical norms that exist in the classroom influence how students learn mathematics. Considering the importance of those aspects, we use a list of important aspects on for observation to make sure that we get all information that we need, such as the interaction between teacher and the pupils, the interaction among students, how the reaction of students when they are dealing with the materials, etc. To make sure that there is no important thing that we skipped, we also make a video registration. Thus, the data we will collect from the observation will be field notes and a video registration.

Interview

Teacher has a big role in the teaching experiment, thus we need to know her/his understanding to the topic that we propose her/him to teach. We also are also

interested to know how her/his knowledge about PMRI. By knowing her/his experience in teaching the mathematical activity, we want to get insight about her/his understanding on spatial ability and the importance of spatial ability in mathematics. We also want to know how the teaching approach that she/he do when teaching the materials related to students' spatial ability. The interview is also an effort done to verify our findings during the observation. The interview will be audio-taped.

3.2.2. Preliminary Teaching Experiment (First Cycle)

A week after the interview, we conducted a preliminary teaching phase. In this phase, we will work with a small groups consisted of 3 pupils. Those six pupils are different students that are also in the same grade of the target group. In this phase, the learning activities will be brought by the researcher. The general aim of this first cycle is to get insight about how the design can be understood by the students, and to identify which activities promote students learning. Thus, this phase is an important phase to improve the design. All the data collected during this small experiment, such as videotaping, students works, and field note, will be analyzed to improve the design.

3.2.3. Teaching Experiment (Second Cycle)

Considering the importance of spatial ability, we design a series of learning activities to support students' spatial ability development. The series of activities, which is improved on the data analysis of the first cycled, will be taught to 20 pupils. During this phase, we conducted observations from which we will have observations and field note, and a series of learning activities from which we will have students' works. In this phase, a learning series of activities will be brought

by teacher, meanwhile the researcher will be the observer. While observing, the researcher will also conduct a small interview with the students in order to make an inventory of pupils' solution procedures, and to clarify pupils' way of thinking and strategies. All teaching experiments session will be videotaped, and all students' works will be gathered to be analyzed to answer the research questions posed.

3.2.4. Pre-Assessment and Post-Test

In order to get insight into students' current understanding and awareness of spatial ability we conduct a pre-assessment after the observation in preparation phase. The pre-assessment also help us to revise the design. In both pre and post-test, we will present some problems related to spatial visualization task and spatial orientation tasks. Basically, we use different task on the pre-assessment and post-test. Since the aim of the pre-assessment is to know students prior knowledge, the task is more focus on assessing students' ability in orientating the left side and the right side. For the post-test, the focus is on assessing what students have developed after experiencing the series of activities. However, there is also a task that is used in both pre-assessment and post-test.

All the students involved in second cycle activity will take both pre-assessment and post-test; meanwhile the students who involved in first cycle will only take pre-test. At the end of second cycle phase, we conduct a post-test. The general aim of the post-test is to measure to what extend the spatial visualization and spatial orientation activity support students' spatial ability development by comparing the result of pre-test and the post-test.

3.2.5. Validity and reliability

As mentioned in the HLT, each lesson brings different essential goal as we expected, however its main aim is to support pupils' development of spatial ability. Thus, we will analyze the result qualitatively. We contribute to the reliability of the data collection by making a video registration and presenting the tractability of our research in the HLT section. The video registrations contribute to the internal reliability of the present study, and the tractability of this study contributes to external reliability. The reliability of this design research is accomplished in qualitative way. Since we will use three different methods, it enables us to do data triangulation. The data triangulation involves different sources: the written test, field note, interview, the pupils work, and videotaping.

The problems presented in the written test have been validated by some expert and have been used in the similar study. The HLT and the instruments used in this study have been also being discussed with some experts in mathematics education. These facts contribute to the validity of the data.

3.3. Data Analysis

3.3.1. Pre-Assessment

We will conduct pre-test in first cycle and second cycle. The result of pre-test both in first cycle and second cycle will be analyzed in both qualitative and quantitative way. The quantitative analysis will be done by indentifying the number of wrong answers and correct answers. The questions presented in the pre-test are about indentifying students' sense of direction such as left and right, and students sense of spatial orientation. Thus, we will do the qualitative analysis on each students answer in order to know their current knowledge and sense of

spatial orientation and sense of direction. In conclusion, the results of the pre-test help us to determine students' current knowledge and the starting point in the HLT.

3.3.2. Preliminary Teaching Experiment (First Cycle)

During the preliminary teaching experiment, we conduct pre-test, post-test, classroom observation, and interview. The video registration of classroom observation will be analyzed by watching the whole part of the video. The interesting and important fragment of the video such as when the students come up with interesting strategy, idea, or when the design fails to help the students will be selected. The selected fragment will be transcribed and used to test the conjectures of HLT.

While conducting the classroom observation, we will make some notes. This note is considered as one of the important data collection, since our awareness of the possibilities of losing certain important moment due to the limitation of video recorder. We consider the field note as the complementary data of classroom observation. Thus, we will analyze it together with the videotaped of the classroom activities.

Since the learning activity conducted in small group thus we will have more intense communication with the students. The result of discussion or interview will be analyzed in order to improve the HLT. The data obtained during the first cycle will be analyzed to improve and revise the HLT. The revised HLT will be used in second cycle.

3.3.3. Teaching Experiment (Second Cycle)

During the teaching experiment, we also conduct pre-test, post-test, classroom observation, and interview. In the second cycle we will do teaching experiment in a bigger scale, namely whole students in the classroom.

The classroom observation will be more focus on the focused group. The video registration of classroom observation will be analyzed by watching the whole part of the video. The video registration of each lesson will be examined to get an overview of the lesson. Then the analyses are focused on the focused group. The interesting and important fragment of the video such as when the students come up with interesting strategy, idea, when an unexpected solution or strategy occurs, or when the design fails to help the students, will be selected. The selected fragment will be transcribed and used to test the conjectures of HLT.

The teacher interview is also aimed to clarify our interpretation and to avoid personal subjectivity. In the end of teaching experiment, we will also conduct a small interview with the focused group to do further observation and to get more detailed information on the development of students' spatial ability.

Written work of the students will be analysed as additional data when testing the conjectures. During the analyses discussions with colleagues and supervisors can support the validity and reliability of the data analysis. The result of analysis will be used to draw the conclusion, to answer the research question, and to revise the original HLT.

3.3.4. Post-Test

The result of post-test conducted in the preliminary teaching experiment and teaching experiment will be analysed in qualitative and quantitative way. As well

as the pre-test, the result of post-test both in first cycle and second cycle will be analyzed in both qualitative and quantitative way. The quantitative analysis will be done by indentifying the number of wrong answers and correct answers. The qualitative analysis will be done by analyzing each answer given. The result of post-test and pre-test will be compared to measure the development of students' spatial ability after experiencing learning in this series of activities.

3.3.5. Validity and Reliability

The fact that we use different method allows us to have different kind of data. The result of all the data analysis will be triangulated to get a clear description on our research question. By doing the data triangulation, we also want to get more valid description on our hypothesis. The data triangulation together with the testing of the conjectures of the HLT with the data enables us to determine the internal validity. We also consider about the external validity of the analysis by present the analysis in such a way that others can find out if and how they can adjust the HLT to their own local setting.

The reliability of the data analysis is contributed by two aspects namely the track ability and the inter subjectivity. The clear description of how the researcher works on this study so that people can easily follow the process constitutes the track ability aspect. The transparency of the data analysis contributes to the external reliability. Moreover, a cross interpretation with colleagues and supervisors is needed to fulfil the inter subjectivity aspect. It is done to avoid the researcher's own point view or subjectivity toward the interpretation of the data collected. The cross interpretation contributes to internal reliability.

CHAPTER IV

HYPOTHETICAL LEARNING TRAJECTORY

The aim of this study is to contribute to the development of a local instruction theory for spatial ability. In achieving this aim, the instructional activities are designed to facilitate the development od students' spatial ability. To fully facilitate and scaffold the development, we design a series of learning activities. The key aspects of the mathematical activities designed are described in Hypothetical Learning Trajectory (HLT). The key aspects that are intended are the mathematical goals of students, the mathematical learning activities, and the hypotheses about the process of students' thinking and learning.

The main goal of the activities designed is to supports the development of students' spatial visualization and spatial orientation. In this chapter, we elaborate the HLT that will be used in the present study. It contains sequence of six activities in three weeks period of teaching that is designed to reach the aim of this study. This HLT will be implemented in the third grade of primary school in Indonesia. In each lesson, we will describe the starting point of the students, the learning goals, the mathematical activity, and the conjectures of students' thinking.

4.1. Lesson 1: Playing Tungkupan

Starting point

- Students have sense of direction
- Students can differentiate left and right
- Students are familiar with the term left, right, front, and back

Learning goal

- To let students experience and feel what is the sight seeing
- As a scaffolding for the second activity

Description the mathematical activity

The aim of this activity is to give insight to the students for the next activity in which students will find the best place to observe the island. In this activity, students will play hide and seek. However, to make sure that we reach the goal of the activity, the game is modified. Students will play this game in group of 12 – 13 students. So, it will be about two or three big groups. The role of the game will be described as follow:

There will be two groups who play the game; the observer and the player. The player team will hide in the playground meanwhile the observer will observe the playground form outside of the playground. Each observer should observe the playground and make a note about who they can see or they cannot see from their standing position. The playground will look like the following picture

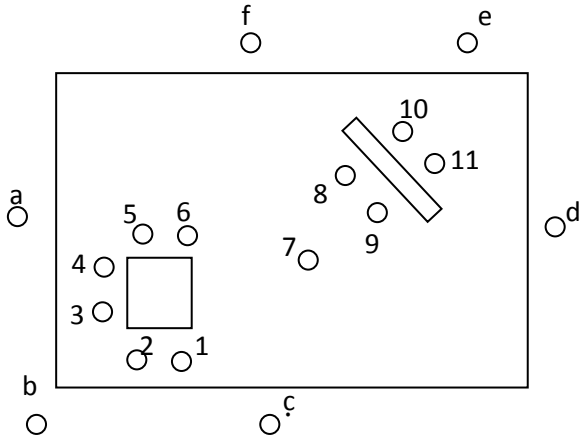


Figure 4.1. The set of the playground

In general, the classroom activities will be done during this meeting are:

- Introduction to the context that students will work with during the whole series of activities
- Introduction to today's activity
- Students playing in the playground
- Classroom discussion
- Summary of today activity and closing

Teacher's role

Teacher has important role in this activity. She/he should make sure that students understand the problem and know what they should do. Nevertheless, teacher also has important role as the facilitator of classroom discussion. Teacher is the one who control the plot of the discussion by posing some important questions such as:

- Who can you see from your position?
- Why you cannot see your friends from this position? How so? Hidden by what? Do you think that the other position can see it?
- Which position those allow you to see more students in the playground?
- Who is the student that is in the unbeneficial position?
- Do you agree with your friends' answer?
- Why do you agree or disagree with your friends' answer?

Conjecture of students' reaction

The reaction given by the students will be vary, it depends on his/her position while observing his/her friends. As an example, students who observing in a will say that he/she will see 3, 4, 5, 6, 7, 8, and 9, meanwhile students who observing in e will only see 4, 5, 6, 10, and 11. The answer will also may vary within a

position, such as students who observing in a will claim that he/she can see 2, meanwhile the other observer who observe in the same position will claim that he he/she can see 2.

4.2. Lesson 2: Finding the best place to build a control station

Starting Point

- Students have sense of direction such as left, right
- Students are familiar with the term such as left, right, top, front, back.
- Students know the different between 3D object and 2D figure

Learning Goal

Main goal: develop students spatial visualization awareness

Sub goal:

- represent three dimensional shapes in two dimensional drawings
- interpret, recognize, and communicate about two dimensional drawings or pictures of three-dimensional objects
- identify objects from different view

Mathematical Activity

Students investigate the side views of the island.

Description of activity and teacher's role

In this activity students are given a set of miniature of an island in which there are 3 different building on it, namely two navigator towers and big wall. Students will work in the context in which they will have to observe the island from side views from the spyglass. It would be nice to see how young children make a "note" about what they see on the spyglass. Teacher should emphasize that because they see the island from the ship, so they only see the island from the side view not

from the bird eye view. Teacher also should let student notice that they will make a note that will be read by the other pirates. Thus, they have to make a clear and concise documentary, in order to let any pirates can also understand it. The following picture is the picture of miniature of the island that students will work with.

After finishing their work, students will have a walking gallery. Students are allowed to walk around and see another group work. After that they have to go back to their own group and reflect on what they have done. The learning activities continued by the discussion. Teacher may start the discussion by asking about students responses to their own work and the other groups' works. Teacher may discuss about the remarkable student's works and because the goal of this activity is to let students draw the different point, thus there should be interesting to discuss the drawing. If none of the students make a draw, then teacher can discuss about what the students did. Teacher may start the discussion about students' strategy, ask the question about what they did, and how they did it, why they did in that way, and then ask the other students to think about the work, and discuss whether it is acceptable correct or not.

It seems that it is impossible to go further in one discussion. The teacher may continue the discussion on the next meeting. In the next day, teacher may bring pictures of the island from different views, and discuss about how the position of the three building from different point of view. Teacher may discuss about how the whole part of the towers cannot be seen because of be covered by wall from some certain views, how the wall look like from different point of view, etc.

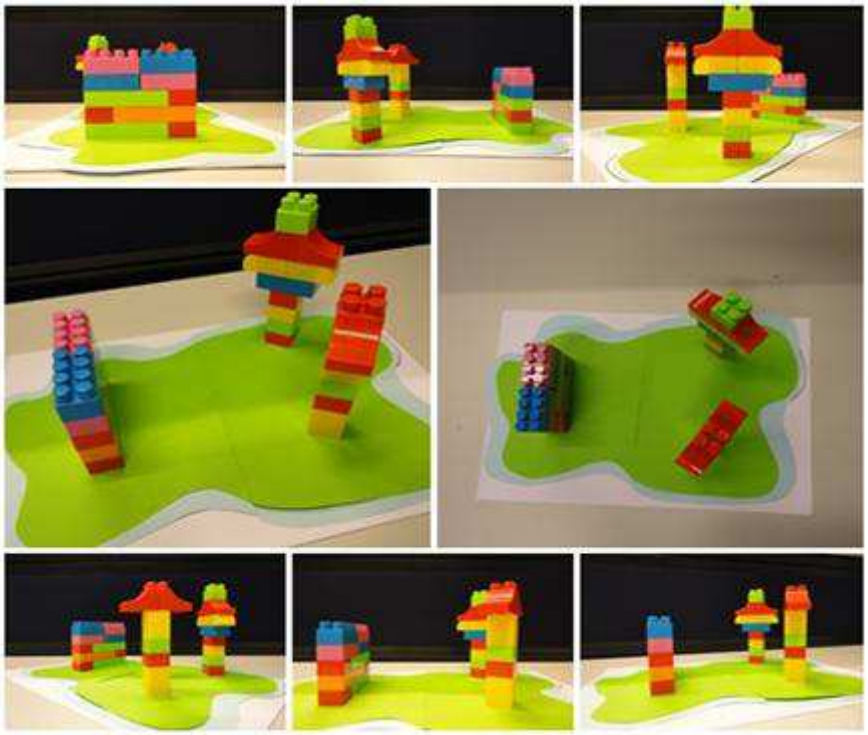


Figure 4.2. The picture of miniature of the island

Conjecture of Students' reaction

There will be variation on students work, such as some of them will make note, some of them will make a draw. Some students will make a note such as:

- There are 3 things in the island, 2 towers and one part of broken wall. The tower next to the other tower and then the broken wall is next to the second tower.
- Those three building are arranged as follow
  - Tower-tower-wall (because they see it from the front)
  - Wall-tower-tower (because they see it from the back)
- They make clear description about how the tower cannot be seen fully because of it covered by the broken wall, etc.

Some students will make draw such as:

- They make the draw from bird eye view

- They claim that they make the draw just from one side of view by ignoring the fact how exactly the side view (how those three object seen from side view), but they represent it as three dimensional object by drawing the part of the object that cannot be seen from the some view
- They draw only from some point of view such as front, left and right. They claim that the draw of front and back view will be the same.
- They draw only two side view namely back and left, or the other combination such as front and left, front and right, and back and right because they assume that the drawing will be the same.
- Students draw two dimensional representation of the island from the side view

4.3. Lesson 3: Locating the Pictures

Starting Point

- Students have sense of direction
- Students aware that a 3D object may have different side views
- Students know the different between 3D object and 2D figure
- Students are familiar with map

Learning Goal

Main goal: To develop students' spatial orientation awareness

Sub goal:

- interpret, recognize, and communicate about two dimensional drawings or pictures of three-dimensional objects
- develop students spatial visualisation and spatial orientation awareness
- Locating pictures of an objects taken from side views on the top view given
- Introduce students to the term "top view"*****

- make connections between different views of the same objects
- solve problems using the spatial awareness they have developed

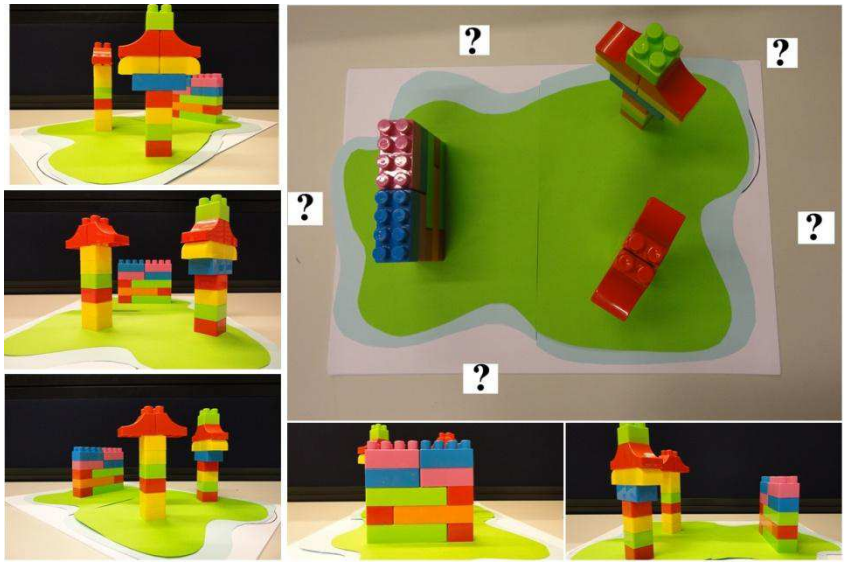


Figure 4.3. The picture of students' task

Description of activity and teacher's role

In this activity, students will work in spatial orientation activity, in which they will locate the pictures on the map. We design this task in order to develop students' spatial orientation. The pictures are about how the island viewed from different point of its side view. The goal of this activity is to introduce student to the term "top view" by letting them to work with a map on an island. On the map, there will be location of those three building and some question marks. Those question mark indicate the possible location where the pictures taken. Students are asked to put those pictures on the correct position. Encourage the students to solve the problem without any extra help. Some students may have difficulty to locate the pictures. To help the students, teacher may show the bird view of the island. If it does not work, teacher can also let them work with the miniature of the island, just like the island that they worked with in the first activity. During the group

working period, teacher has to keep on eye with all of group, make sure that they did not share their answer to the other group.

After they solve the problem, one of the groups will present their work. Teacher can ask whether there are some groups that have different answer. The group with different answer may also present their work in front of class. And then teacher can start the discussion on how their answers are the same, and then discuss about the differences. Teacher may ask about how they find their answer or to be more specific: how they locate the picture, why they did it, what strategy they use, etc. If all of the groups have the same answer, the teacher may start the discussion by asking those each group to tell about their strategy to solve one different problem. Teacher may ask to another group whether they have different strategy, and ask about the possibility that the other pictures are being located on that position. In the end of discussion, teacher then shows the miniatur of the island and confirms whether their answer is correct or not. By showing them the miniature of the island, then teacher can introduce the map as the top view of the island.

Conjecture of Students' reaction

Students may do some trial-error to locate the picture. Some students may also use the fact that the position (left and right) of the building will be different if they see it from different position. These students will solve the problem by observing the miniature of the island and comparing what is seen in the picture. Some students may not need to use the miniature of the island; they can directly locate the picture just by seeing the pictures.

4.4. Lesson 4: Exploring the Wall

Starting point

- Students are familiar with term side views
- Students are familiar with term top view
- Students aware that an 3D object may have different side views
- Students aware about the top view of a 3D object

Learning goal

Main goal: Introduce the term front view, left view, back view, and right view.

Sub goal:

- interpret, recognize, and communicate about two dimensional drawings or pictures of three-dimensional objects
- develop students spatial visualisation and spatial orientation awareness
- solve problems using the spatial awareness they have developed
- make connections between different views of the same objects

Description of mathematical activity and teacher's role

After letting the students experience exploring the island from different views, in this activity, students will be focused on a specific object. Students will observe the wall that is used in the second and third activity. We propose to use this object is because the wall have exactly four side views. By doing so, it will be easier for students to get the idea of front view, left view, back view, right view, and top view.

In the beginning of learning activity, students are presented with pictures of the bird eye view of the object, the top view and the side view of the object. Teacher will lead the discussion about how these two pictures are difference. Then

the teacher introduces the term side views and present all of the side view of the wall.

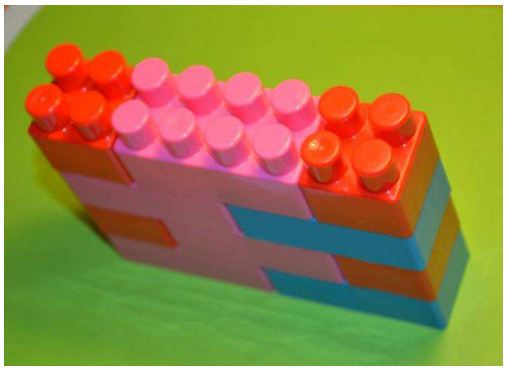


Figure 4.4. The bird eye view picture of the wall

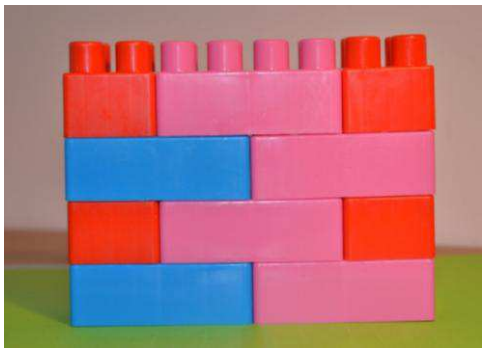


Figure 4.5. The front view picture of the wall

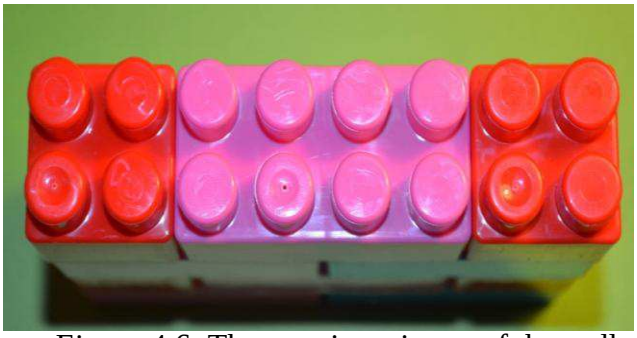


Figure 4.6. The top view picture of the wall

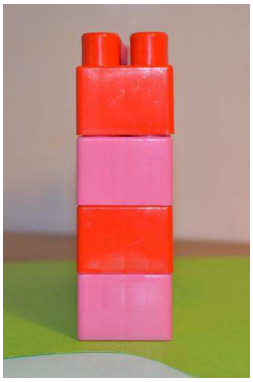


Figure 4.7. The right view picture of the wall

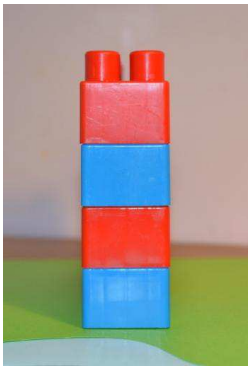


Figure 4.8. The left view picture of the wall

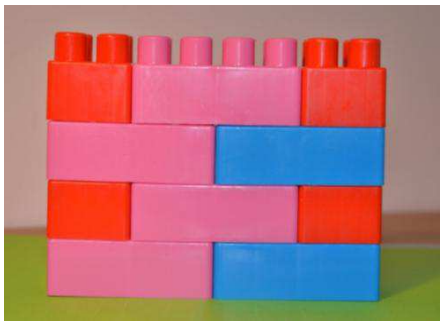


Figure 4.9. The back view picture of the wall

After students are familiar with the term, teacher may show the picture of the wall in part A of the students worksheet. Teacher can ask the students to construct the first wall showed in their worksheet. The teacher then asks students to draw the front view of the wall. For the drawing of the wall from left view and the right view will be left as an exercise for students. The tasks (part B) will be done together with their group. During the working period, teacher may walk around and observing students strategy. The following picture is the first task that students should solve.

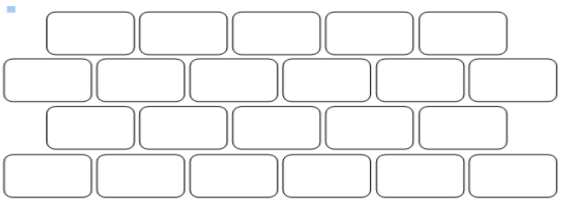


Figure 4.10. The front view of the wall (the first task)

Some students may have difficulty in interpreting the pictures showed in part B. Teacher may suggest them to ask with their own groups or to the other group.

The learning activity will be continued by the discussion. Teacher has an important role not only as the facilitator of the discussion but also someone who pose the important question. Teacher may ask some important questions such as:

- Why do you draw the left and the right view of the wall in such way?
- Will the wall have the same view if we see it from the left side and the right side?
- How about the front and the back?

The discussion then continued to part C, in which students have to construct the wall from the top view given. Finally, the students will draw the side views of the wall they have constructed.

Conjecture of students' reaction

The following pictures are some possible drawing given by students when they are asked to draw the left view of the first wall.

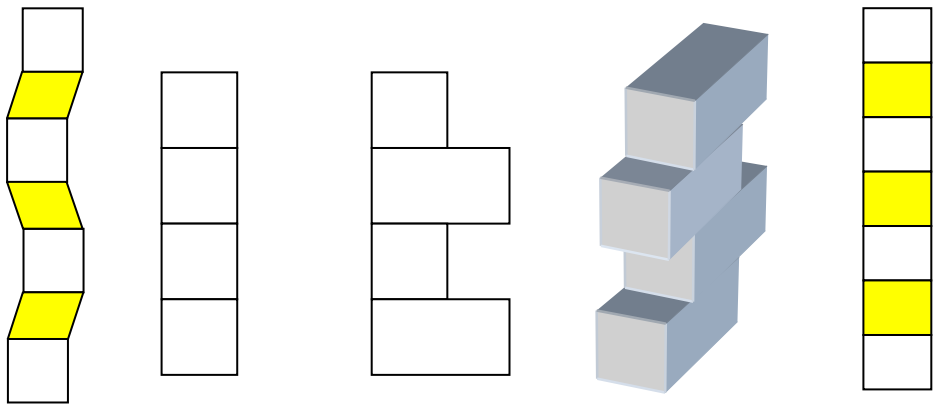


Figure 4.11. Conjecture of Student's drawing

Explanation:

Figure (i) : The yellow parallelogram is representing the uncovered surfaces.

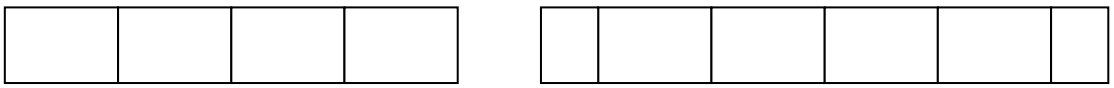
Figure (ii) : Students draw the correct drawing

Figure (iii) : Students draw in such way to show that there are two blocks that is uncovered

Figure (iv) : Students draw the 3D of the wall from side view.

Figure (v) : Similar with the figure (i), students may also draw the surface of the block that they can see. The difference is that students draw it as square because they know that the surfaces of the blocks that they see have the same area.

Similar with the left and the right view, we may find a variation in students' top view drawing. The following pictures are some of the draw that students may make.



(vi) (vii)

Figure 4.12. Conjecture of Student's drawing

4.5. Lesson 5: Exploring the Cube House

Starting point

- Students have sense of direction
- Students know about the term side views and top views
- Students are familiar with the cubes
- Students can differentiate the bird eye view drawing and the side views drawing

Learning Goal

- Students can identify cubes arrangement from different views
- Students can make connection between different views of the same object
- Students can interpret, recognize, and communicate about two dimensional drawing or pictures of three dimensional shapes
- Students can represent three-dimensional shape in two dimensional drawing

Description of mathematical activity and teacher's role

Students will arrange some cubes and make the draw of the side views and the top view of the cubes building. During the learning activity, students will work with the worksheet. Students will make drawing of different views from three cubes building. The first cube building is set in the students' worksheet (see figure 1); they have to make it together within in a group. They have to reconstruct the bird eye view of the cube building, and then draw the side view and the top view of the cube building. For the second cubes building, students will also work together as a group. Student will construct their own group cubes building and draw the side views and its top view. For the third cubes, students will work individually. They will construct their own cubes building and draw the side view and its top view. In this last cubes building, each students will make a cubes building composed by four small cubes.

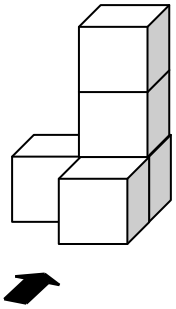
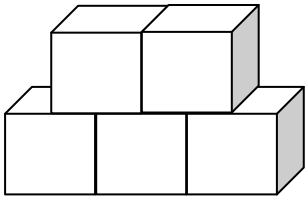


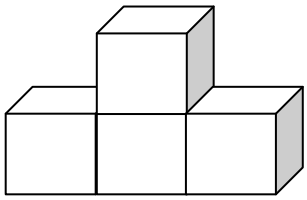
Figure 4.13. The first cube building

There are some important things that teacher should emphasize

- Teacher may and may not use the cubes when they are dealing with the task
- Student will construct the cubes on the playground given.
- The black arrow indicate the front view
- In this activity, students are not allowed to constructs the cube house as shown by the following picture



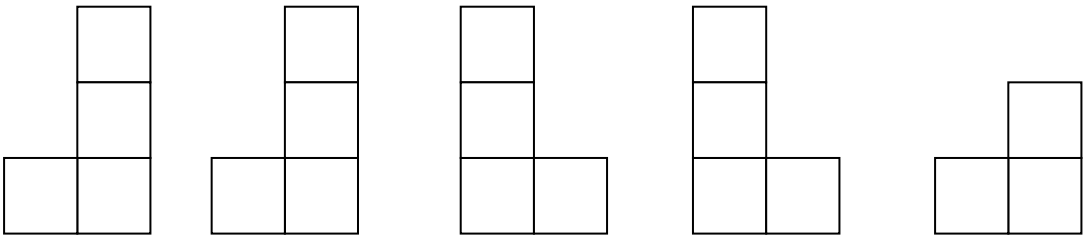
But, the cube house only can be constructed as the following picture



Conjecture of students' reaction

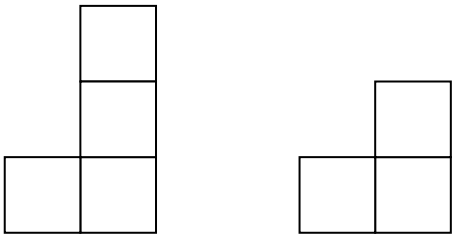
The answer of students may vary:

Some groups may draw exactly as what we expected



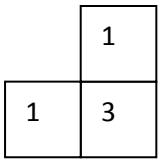
Front view right view back view left view top view

Some groups may draw all the side views as the same drawing because they state that all of the side view has the same drawing.

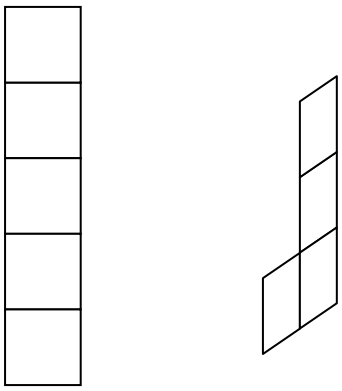


Side view top view

Some students may draw the top view of the cubes building and indicate the height numbers



Some group my draw something like this



Front view right view

4.6. Lesson 6: Finding the Treasure

Starting point

- Students have sense of direction
- Students know about the term side views and top views
- Students are familiar with the cubes
- Student have experienced learning in activity 4

- Students can differentiate the bird eye view drawing and the side views drawing

Learning Goal

- Students can identify cubes arrangement from different views
- Students can make connection between different views of the same object
- Students can interpret, recognize, and communicate about two dimensional drawing or pictures of three dimensional shapes
- Students can construct the cube building from the its given three different views.

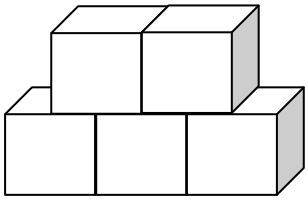
Description of mathematical activity and teacher's role

Students are given three problems that they have to discuss in their group. They will work in the worksheet, in which there are 3 problems or puzzles related to the context that they are working with. The problems are about how to unlock the three important things that are needed to get the treasure. The puzzles itself are students have to construct the intended cubes building from three pictures of different views given. We expect students can solve the problem mentally. In general, we expect students can solve these problems by reflecting on what they have done in the previous meeting. Some students may have difficulty to solve the problems, give them the cubes as the tool. If it is possible, teacher may encourage students who can solve the problems quickly to draw their construction from bird eye view.

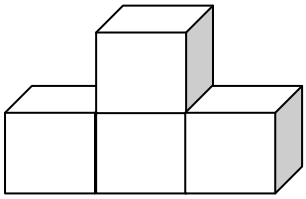
There are some important things that teacher should emphasize

- Teacher may and may not use the cubes when they are dealing with the task
- Student will construct the cubes on the playground given.

- The black arrow indicate the front view
- In this activity, students are not allowed to constructs the cube house as shown by the following picture



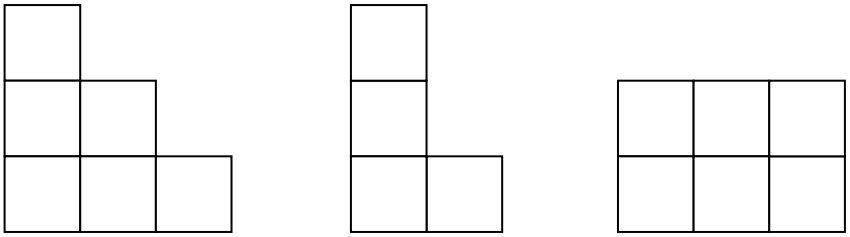
But, the cube house only can be constructed as the following picture



Conjecture of students' reaction

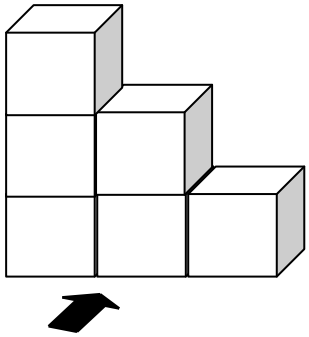
We try to elaborate the possible students' reaction in solving this following problem.

Given three picture of the cubes which taken from the front view, right view and top view. Construct the cube arrangement from the given views!

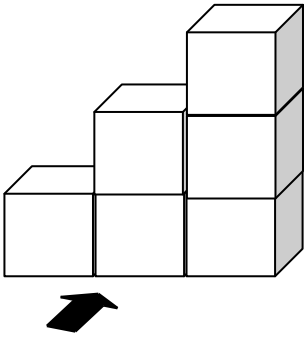


Front view right view top view

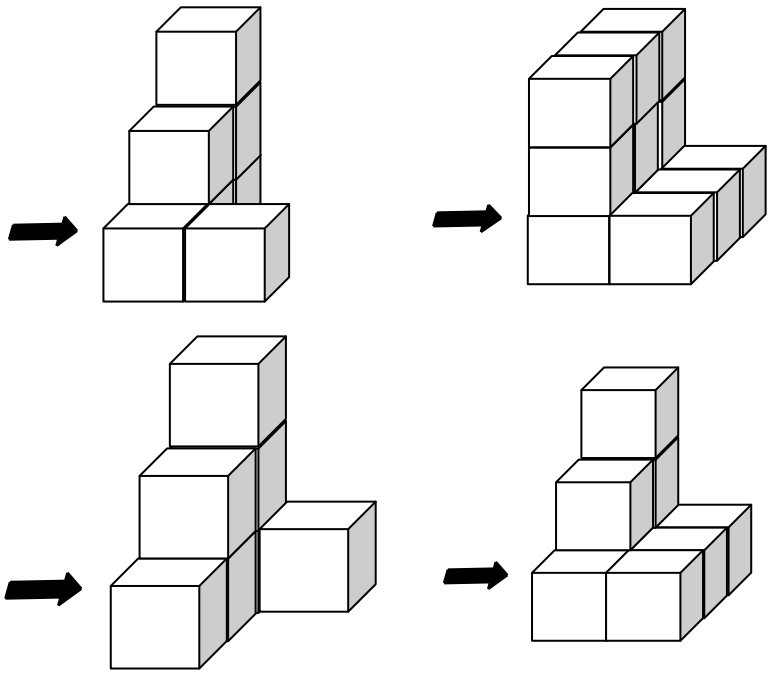
Based on the literature and the experience, most of student will construct the cube as the following picture:



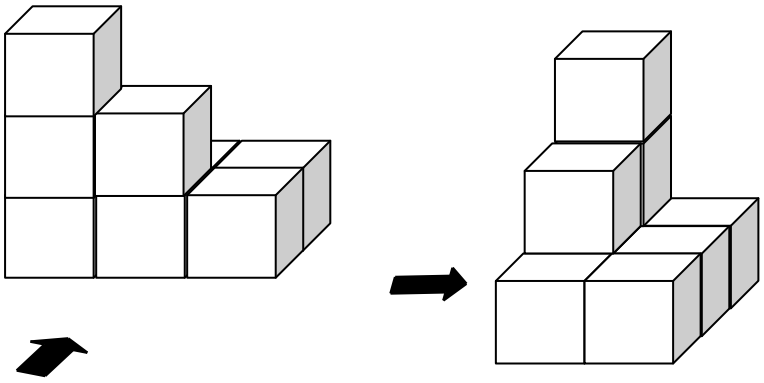
However, it is also possible to find the students who disoriented. Therefore, they will construct is as the following picture



The level of difficulty will be increase as soon as they get the second drawing; we conjecture that students may construct the cubes as shown in the following picture:



The following pictures are the cubes arrangement that may be constructed by the students when the students get the top view of the cubes arrangement.



CHAPTER V

TESTING HYPOTHETICAL LEARNING TRAJECTORY

As we described, in this study we plan to have at least two cycles of HLT implementation namely the pilot experiment and the teaching experiment. All data are collected during both the pilot experiment and the teaching experiment will be analysed. The analysis will be related with the initial HLT in chapter 2. We will describe whether the design supports the development of students' spatial ability. This discussion will lead into the explanation how and why this design supports the development of students' spatial ability. Both the analysis on the first and the second cycle of HLT implementation will be described as follow.

5.1. The Timeline of the Research

Table 5.1.
Timeline of Research

	Date	Description
Preparing for the experiment		
Preparation	October 2012 – January 2013	Studying literatures and designing HLT
Preliminary research to school (communicating with school and teacher)		Communicating the plan of the research including HLT and research method
Teaching Experiment for the first cycle		
1st meeting	14th of February 2013	• Pre-test • Lesson 1: Playing Tungkupan (Hide and Seek) • Lesson 2: Finding the best place to build a control station
2nd meeting	15th of February 2013	Lesson 3: Locating the picture
3rd meeting	16th of February 2013	• Lesson 4: Exploring the wall

4th meeting	19th of February 2013	• Lesson 5: Exploring the cube house • Lesson 5: Discussion • Lesson 6: Finding the treasures
5th meeting	20th of February 2013	Post-test
Analyzing the Preliminary Experiment and Improving the HLT		
Discussion with teacher	5th – 12th of March 2013	Discussing the coherence of the lesson and conjecture of students thinking
Preparation for Teaching experiment	15th – 20th of March 2013	Refining the HLT, the design, and the instruments
Teaching experiment for second cycle		
1st meeting	2nd of April 2013	Pre-test
2nd meeting	3nd of April 2013	Lesson 1: Finding the best place to build a control station
3rd meeting	4nd of April 2013	Lesson 2 : Locating the pictures
4th meeting	5nd of April 2013	• Lesson 3 : Exploring the wall • Lesson 4 : Exploring the cube house
5th meeting	15th of April 2013	• Lesson 4 : Exploring the cube house (discussion part) • Lesson 5: Finding the treasures • Post-test

5.2. Analysis on the First Cycle of Hypothetical Learning Trajectory Implementation

This study is conducted in 3rd grade (9 years old) of Sekolah Dasar Negeri (elementary school) 117 Palembang. The first cycle of HLT implementation involve 3 random students from grade 3 of classroom B. Those students are Pinka, Siti, and Syahrul. Those students are representation of different students' level achievement. Pinka is one of the students who have a high level achievement in

their class; she has a very good in logical reasoning. Siti is the representation of students with middle level achievement; she can solve the problems faster but sometimes also very careless. Syahrul is the representation of the lower level achievement students; he is the slower one but has a deep analysis.

The preliminary experiment is conducted in teachers' office. The HLT is divided into 6 lessons that the first lesson is aimed to support the second lesson; the second lesson is aimed to support the third lesson, and so on. During this series of activities, the researcher act as the teacher and the observer. The analysis on the preliminary experiment will be focus on discussing what works and what does not work, and the development of students' spatial ability after experiencing this series of activities.

5.2.1. Pre-Assessment

The pre-test was conducted to determine the students' preliminary knowledge and to know students' understanding towards the material will be given. The pre-test consist of two different tasks in which the questions presented are multiple choices and short answers. Students have to solve those tasks individually. We find that those problems seem easy for students since they solve it less than 15 minutes. When we interview the students, they state that those problems are quite easy and they just answer as they wanted to. They state that it is because most of the questions are multiple choices. We will describe tasks and the analysis of the results as follows.

Task 1

The first tasks are testing students' ability to differentiate left side and the right side. On the first task, students are presented with a picture of a girl sitting on her

desk. There are some objects on the pictures such as computer, calendar, window, trash can, etc. In this task, students are asked to determine which objects are on the left and on the right side. On this task, students are also asked to orientate their position as such they are sitting on the girl position and determine a particular object whether it is on the left or on the right side. Based on Clement and Sarama (2010), students on this age have developed their ability in differentiating the left side and the right side (spatial orientation ability). In this series of activities, students will employs this ability. By presenting this problem, we want to know whether they have difficulties in dealing with the orientation of left and right since this skill is one of the skills that students should have in order to be able to follow this sequence of activities.

The following picture is a picture of Anita who is studying in her bedroom. On the picture you may see calendar, window, trash can, pencil glasses, the monitor of the computer, keyboard, and PC computer.

Problem 1

1. Imagine that you are sitting on Anita's position. Where is the window? Is it on the left or your right side?
   Answer: _____

We consider that students' answer in this question is invalid. It is because when they are working with this question, Pinka interfere the other students' answer by stating that the correct answer is left side. Without considering the answer, Syahrul writes down left on his paper. Siti does consider about Pinka's answer, however she gives up on Pinka's answer because of seeing both of her friends already have finished the first task. After those students finished the tasks, we ask the students about the orientation matter such as which object is on their left and which object is on their right. We find that the students have no difficulties to differentiate which object is on their left side and which object on their right side. However, when we ask them to determine which object will be on the left side of somebody who is facing in front them, we find that Pinka sometimes disorients with left side and right side. This fact gives us explanation why Pinka answer the first question as left side.

Problem 2

Imagine that you are standing in front of Anita

2. Which objects are on your right side?
   a. calendar
   b. window
   c. trash can
   d. pencil glass
   e. monitor computer
   f. mouse
   g. keyboard
   h. PC komputer

In this problem, students are allowed to circle more than one option. Although the instruction said so, the students just circle one option. We miss important things; we did not check whether the students are familiar with some term such as PC Computer, mouse, monitor, and keyboard. During they were working on this task, we frequently caught that Syahrul see Pinka's work.

Problem 3

Imagine that you are standing in front of Anita	
Which objects are on your left side?	
a. calendar	e. monitor computer
b. window	f. mouse
c. trash can	g. keyboard
d. pencil glass	h. PC komputer

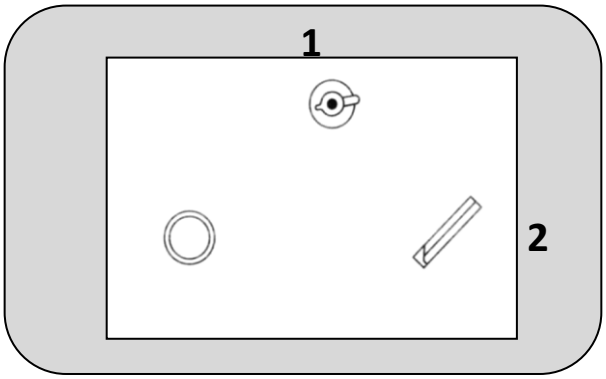
In this problem, students are also allowed to circle more than one option. As well as their answer on the previous problem, in this problem those students also circle one option. We also did not get a clear description why they choose the option.

Task 2

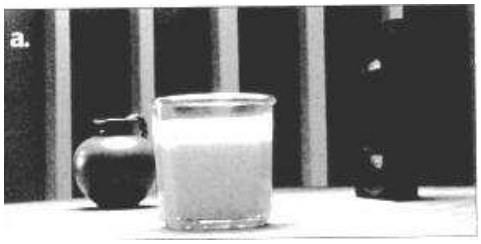
In this task, students are presented with some pictures of three objects that are put on the table. The pictures were taken from different view, namely the 5 side views and the bird eye view. They are also presented with the drawing of the top view from those objects. The students are asked to determine which picture is taken from the particular point. This task is one of the competences that students are going to explore on this design. This task will also be used on the post-test. We choose it as the task that are being tested because we want to have a description on how the strategies used by the students probably changing after they experience the series of activities. At the same time, we also want to know their prior knowledge about this topic. While working on this task, they have to employ their sense of spatial visualisation and spatial orientation. The task that we were discussed is presented as follow.

The following picture is a picture of three objects on the table.

If we see those objects from the top, we will see the following picture.



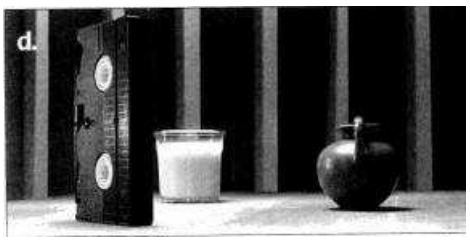
Adi walked around the table and took these following pictures



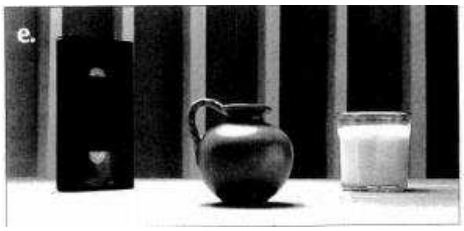
Picture a

picture b

picture c



picture d



Picture e

Problem 1 and 2:

For these following question, circle on one option that is correct!

Imagine that you are walking around the table. From those pictures:

1. Which picture is taken when Adi is in point 1?
   a. picture a
   b. picture b
   c. picture c
   d. picture d
   e. picture e

2. Which picture is taken when Adi is in point 2?
   a. picture a
   b. picture b
   c. picture c
   d. picture d
   e. picture e

When the students are dealing with this problem, they do not really see the pictures. They do not consider about which one is the correct answer. They just randomly choose the answers. All of the students give different answers. Almost none of them give correct answers on those two questions except Siti who answers the second problem correctly. Siti answers' are a and d for problem 1 and problem 2 respectively. In fact the correct answer for problem 1 and problem 2 of this task are e and d, respectively.

Based in the interview conducted after the students' finished answering the questions, we find that the students do not do the tasks seriously. They just randomly choose an option. The students even state that those pictures are just similar and make no difference. So there will be no difference if they pick any option. Table 5.2 shows students' answer on all questions in the pre-test.

Table 5.2.

Table of student's answers on pre-test

Problem Name	Task 1							Task 2	
	Problem 1	Problem 2			Problem 3			Problem 1	Problem 2
		1	2	3	1	2	3		
Pinka Yunika	Left			√	√			a	a
Siti Sarah Apriani	Left	√				√		a	√
Syahrul Ramadhan	Left			√		√		b	b
Correct Answer	right	a	e	h	b	c	d	e	d

5.2.2. Preliminary Experiment

5.2.2.1. Lesson 1: Playing Tungkupan

The first lesson in the preliminary experiment is playing Tungkupan or Hide and Seek. The learning activity is started by asking the students whether they are familiar with this traditional game. As expected, they are familiar with this game. The learning activity is not done as we designed in the HLT. The fact that the school yard is being used by the other group of students makes us decide to do some changing in the actual learning trajectory. So, instead of having physical activities, we decide to do some observation and discussion.

In this lesson, students are given a situation in which they are playing Tungkupan. The students are asked to observe a paper that is folded into triangular prismatic and 3 Lego® blocks. Each block represents each student. The teacher tells the students that one of the students is lose, so he/she should be the seeker. The observation is started by arranging the blocks and the prismatic in the position that is shown in figure 5.1. The learning activity is continued by letting the students arranging the blocks and exploring the arrangement by themselves.

Figure 5.1. The students are observing the blocks

The following conversation shows how the observation and the discussion are done.

1. Teacher : Now Pinka is the seeker. Syahrul hides inside the folded paper and Siti hides in here. If Pinka stands in here, can she possibly see Syahrul and Siti?
2. Pinka : No (shakes her head)
3. Teacher : Why?
4. Pinka : Because Syahrul is in here and Siti is in here!
5. Teacher : If Pinka moves to here (moving the block). Can she see Syahrul?
6. Siti : (smiling) Yes!
7. Teacher : Can she see Siti?
8. Pinka : Yes.
9. Teacher : Why don't you try to see from here, can you see Siti?
10. Pinka : (standing and observing) No!
11. Teacher : Why don't you try to see from here, Siti?
12. Siti : (standing and observing) No!
13. Teacher : Why cannot you see it?
14. Siti : It is covered!
15. Teacher : What make it unseen?
16. Pinka : By…
17. Siti : The folded paper!
18. Teacher : Yes.

From the dialogue we can see how the students are easily changing their answer. The dialogue also shows how the observing activity help the students in clarifying their answer. During the discussion session we often find the students answer yes and no without observing the blocks and the folded paper. Sometimes we find that

the students debating and criticizing their friends answer. Observing the blocks becomes the solution in the debates. The learning activities is stopped by the teacher after each students experiences to be the seeker.

Discussion

During learning in this lesson, the students do not find any difficulties. Although this task is considered as easy for them, we find that students sometime give the wrong answer. This happens because the students do not observe the blocks before stating their answer. The students are able to determine the correct answer after they do the observation. At the discussion, the students sometimes also argue their friend answers. In order to clarify their friends' answer, the students observe the blocks together. Based on these facts, we conclude that observing becomes the tool for the students to determine and to clarify their answers.

After experience learning, the students start to develop their sense on hidden and seen area. The students need this sense when they are dealing with the activities in lesson 2. Apparently, the sense of hidden and seen area is one of the mathematical concepts on geometry, namely sightseeing. Sightseeing is one of geometry concepts that should be mastered by the students. This concept is a basic concept in learning the concept of angle and projective geometry.

5.2.2.2. Lesson 2: Finding the Best Place to Build the Control Station

The second lesson is done in the same day with the first activity. This lesson is started soon after the teacher ended the first activity. In the beginning of the lesson, the teacher introduces the context that the students will work with for the rest of the series of activities. Teacher asks the students about the characteristic of pirates, Pinka does not have any idea; she said that she is not familiar with it.

Figure 5.2. The students is observing the island with the spyglass

Next, the teacher tells the students their "first mission" or their first task. At the same time, the teacher shows the miniature of the island and asks students to observe it. Their first task in this lesson is observing the island and finding the best place to build the control station. Teacher tells the students that they can use the strategy used from playing Tungkupan to find the best place. Those students have different interpretation about the term 'best place'. This fact does not only lead the students to different choices of location but also different arguments. The students are then asked to draw or describing in words how they see the miniature from their 'best place'. Figure 5.3 show Pinka, Siti, and Syahrul's drawing.

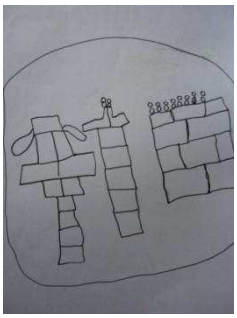
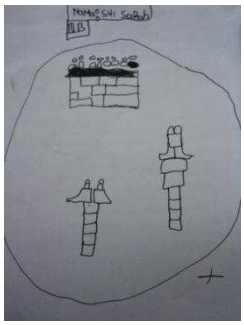
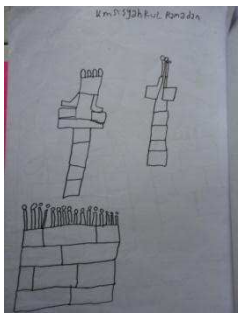
(a)  (b)  (c) 

Figure 5.3. The students' drawings: (a) Pinka's drawing (b) Siti's drawing (c) Syahrul's drawing

The following dialogue shows how Siti interpret the term 'best place'.

1. Teacher : From which point did you observe?
2. Siti : On this mark

Then teacher asks the students to observe from Siti's mark

3. Teacher : So, in your opinion this is the best place isn't it? Why?
4. Siti : Because it is safe in here.
5. Teacher : Why?
6. Siti : It is safe in here. There are this tower and this tower, so I chose this point.
7. Teacher : So...
8. Siti : How to explain it?! It is safe in here (pointing the area hidden behind the tower a) and so in here (pointing the hidden area behind the tower b).
9. Teacher : Hmm...?
10. Siti : Because you can hide here, people cannot see you!

From this conversation, we can see how Siti interpret the 'best place' as the place that enables more people to hide. Later in the discussion session, we ask her opinion about the 'best place'. From this discussion we know that in her opinion, the idea of 'best place' is related to the sense that they have developed in the previous lesson. For the one who is hiding, the 'best place' should be the best place that cannot be seen by the seeker. Meanwhile, from the seeker perspective the 'best place' should be the place which has the least unseen area. Although the teacher asks her to put her position as the seeker, Siti still stick on her

argumentation. It is hard to convince the students about the interpretation of ‘best place’. During the discussion, they frequently said “bingung” or ‘confusing”.

The learning activity is continued by discussing students’ work. The students are able to interpret, communicating, and explain their drawing. The following conversation shows how Pinka and Siti criticize Syahrul’s drawing.

1. Teacher : What do you think about the location that is chosen by Syahrul?
2. Siti : But Syahrul drew it incorrectly. Syahrul should draw it in here (pointing the wall and then pointing the area between the towers)
3. Teacher : Hmm... Why?
4. Siti : Because it should be in the middle (pointing the miniature of wall)
5. Teacher : Hmm..
6. Siti : This one is correct (pointing the tower 1)
7. Siti and Pinka : (at the same time) But this one is incorrect!
8. Teacher : So, whet should it be? (pointing the wall)
9. Siti : It is in the middle!
10. Teacher : So, how is the correct drawing supposed to be?
11. Siti and Pinka: It is in here (pointing the wall and the pointing the area between the towers, and this one is in here (poiting the tower 2 and showing that those objects are in one same line)

From this conversation we can see how students are able to reasoning their friend’s work. Siti and Pinka consider the position (left and right) of the object showed by the drawing. However, none of the students explicitly use this term in communicating their works.

Discussion

In this lesson, we find some interesting findings. The first is none of the students come up with written work. From the discussion we know that it is because they like drawing and it is also easy make and explain a drawing rather than writing sentences. From students’ drawing we find that none of the students draws the miniature of the island in 3-dimensional representation.

We find that the students are struggling to get the idea of ‘best place’. The students are confused by the concept that they get from previous lesson. There are some assumptions why this confusing occurs; we realize that the first activity do not done as we planned, thus there are some important discussion missed. In the previous lesson we focus the discussion on the role of the hider not the seeker. This fact may affect on how students react on this problem. At the same time, students’ prior knowledge and experience in playing this game may also cause the confusing. We also consider teacher’s roles in creating this confusing. We aware that teacher’s suggestion about the strategy used to solve this problem may contribute in the way students interpret the ‘best place’. In conclusion, instead of helping the students when they are dealing with this task, we found that the previous lesson create a confusing and misinterpretation.

Furthermore, we also find that the students do not use navigational term such as left and right, so we should add some instructional guidance for the teacher to promote the students in using the navigational term in discussing their works. After experiencing this activity, the students start to use their spatial orientation ability in discussing and communicating their drawings.

5.2.2.3. Lesson 3: Locating the Pictures

We start the third lesson by having the students read the context (see appendix II) and the instruction. After the reading session, we ask the students to retell the story by their own words. The idea of asking them to read the story is to know which approach is better for the students: the teacher tells the story or the students read it by themselves. None of the students are able to tell what they understand from the text. The text becomes less meaningful for them. To anticipate

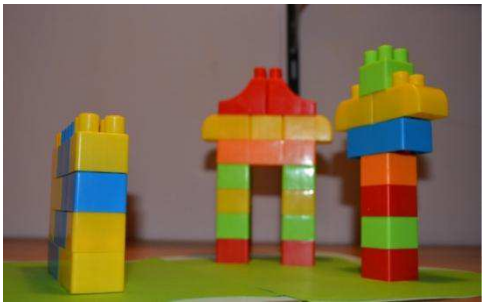
misunderstanding or misinterpretation, the teacher then tells the story and the task that the students should do; the students should match 6 side view pictures of miniature on the map of the island (top view of miniature).

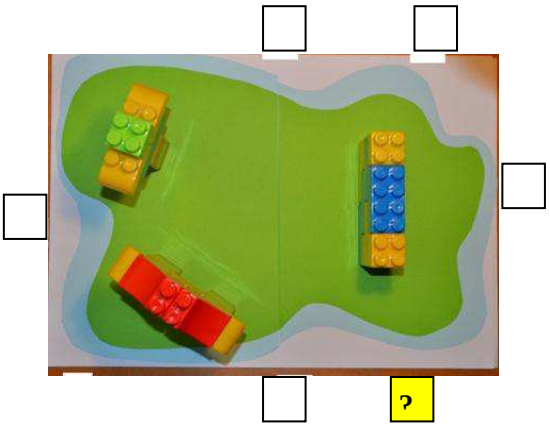
In order to solve the problem, the students are given the Lego® blocks which are already constructed as gate, tower, and wall. The first task that students should do is arranging the gate, tower, and wall as shown in the pictures. In general, the students do not find any difficulties in arranging the blocks. The students use different strategy in arranging the miniature. Pinka and Siti arrange the miniature by seeing one of the side view pictures, meanwhile Syahrul see the map. The students have little argumentation when they are working with this task, since their strategy lead them to different arrangement. In the end, the students agree with Syahrul opinion that seeing the map is the most effective way for them.

After arranging the miniature, the students then work with the students' worksheet, individually. The learning activity is continued by having discussion session. In this session, teacher and students discuss about students answer, how they solve the problem, and what strategy used to solve the problem. During this session, we find that the students consider the position of the objects and the location of the objects showed in the miniature in matching the pictures. The students relate what is shown in the pictures and what they see in the miniature. The following conversation shows how the students discuss their works. At the time the students is identifying where the figure a should be located on the map (figure b).

1. Teacher : So which picture has not been discussed?
2. Pinka : this one! (pointing the yellow square on picture b)
3. Teacher : Where it suppose to be? (pointing the miniature)
4. Pinka : in here! (pointing the yellow square on the miniature)

5. Teacher : Yes, in here! Let's we observe from here! (pointing the yellow square on the miniature)





(a) (b)

The students than move around the table and observe the miniature of the island from the yellow square mark. The students then squat and see the miniature.

6. Pinka : this one (pointing the wall) is being seen first!
7. Syahrul : It should be 'd'!
8. Pinka : 'a'!
9. Syahrul : 'd'!
10. Siti : 'f'! 'f'!
11. Teacher : which one?
12. Syahrul : 'd... d... d...'!
13. Pinka : 'aaaaaaaaaa...'!
14. Siti : 'f'!
15. Teacher : Why it is 'f'?
16. Siti : Because, 'f' is same. This one is far (pointing the tower), this one is near (pointing the gate), this one is near (pointing the wall)
17. Teacher : How did you see when you observe it?
18. Siti : this one is being seen first! (pointing the wall). So, it is 'a'!

However, this fact does not guarantee that the students will come up with the correct answers. From their works, we find that the Siti and Pinka only give 3 correct answers. Surprisingly, Syahrul can match 5 pictures correctly. Syahrul makes one mistake because he matches a picture in two locations. We cannot elaborate more on how and what strategy used by Syahrul since he hardly speaks out his strategy. He isn't able to tell his strategy in solving the problem; he only

smiles when his friends ask his strategy. The teacher stops this lesson after the teacher introduce the maps as the top view and ask the students to describe the differences between the side view pictures of the miniature and the top view picture.

Discussion

When we ask the students to read the problem, we find that the students are not able to retell what they understand from the reading. We find that the context become less meaningful for the students. We conclude that it is better to have the teacher tells the story rather than asking the students to read and understand the problem by themselves. This is because it will be more effective and more meaningful the students. We also find that locating 6 pictures will really difficult for students in this age, since the pictures only have slightly differences.

The idea of giving a students worksheet is not really practice for the students. We find that it is not handy for the students and make students give a bigger effort on solving this problem. We find that not only Syahrul who matches a picture in two locations but also Pinka. The fact that Syahrul and Pinka match a picture in two locations show that the idea of giving a number on the picture and then ask the students to write down the number on the map is not really practice. Thus, we suggest making some changing for the teaching experiment.

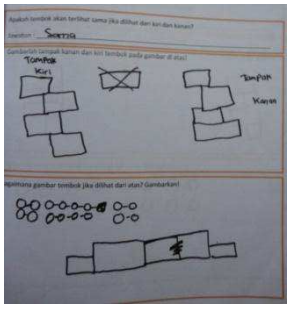
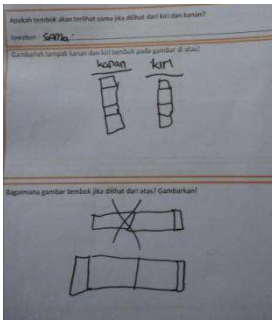
After experiencing this lesson, the students are able to relate the drawing with the real situation and develop their ability in orienting the objects as shown in the picture.

5.2.2.4. Lesson 4: Exploring the Wall

The main goal of this activity is to introduce the spatial terms such as top view, front view, back view, left view, and right view. The learning activity is started by showing the students the picture of the wall which was used in the miniature. At the same time, teacher introduces the spatial terms and emphasizes that from now on they will use this terms.

In this lesson, students are given three problems. In each problem, the students are asked to draw the top view, the right view, and the left view of a wall. The students are also asked to identify whether the front and back view of the wall have the same drawing. In order to solve this problem, the students are provided with wooden blocks and cubes. Figure 5.4 show how the students' work on problem one.

From figure 5.4 we can see how varies students' drawing. It is surprising for us to see student's top view drawing. From those pictures we can see how the students consider the part of the wall which is put on the third layer. These students consider the top view of the wall from both third layer and top layer. When the teacher ask the students why they consider the visible part of the third as the top view, the students state that it is because they can see those part from the top. These students interpret the top view as all the part that is visible if we see the wall from the top. From this statement we conclude that the students have a higher level of understanding on interpreting the idea of top view. From figure 5.4 we also see how Siti even comes up with a correct drawing.

(a)  (b)  (c) 

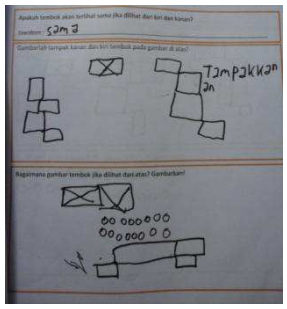
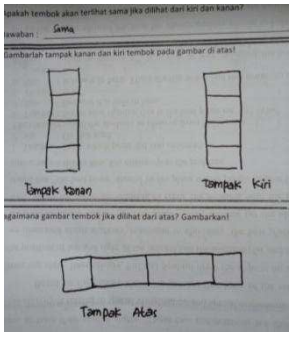
(d)  (e) 

Figure 5.4. The students' answers on the first problem: (a) The picture of the wall (b) Pinka's answers (c) Siti's answers (d) Syahrul's answers (e) The correct drawing

Furthermore, the students also give the same reason for the left and the right view. The students define the side view as the part of the objects that is visible from the side view; this part is also include the goes in and goes out part. Although the students give a correct definition, none of the students comes up with a correct drawing. Pinka and Syahrul draw the front view of the blocks which is visible from left view instead of drawing the left view. Meanwhile Siti draw rectangles and squares as the left view. She says the squares represent the goes in part and the rectangles represent the goes out part. None of the students come up with the idea that the visible part of the wooden block from the left view has a square shape. This idea is discussed in the discussion session. In the discussion the teacher show the pictures of the wall which are taken from the side

view and top view. The teacher also focuses the discussion on how the correct drawing should be. After showing and discussing the pictures of the wall in problem 1, the students can draw the correct drawing for problem 2 and problem 3. They find that problem 2 and problem 3 is simpler and easier compared with problem 1.

Discussion

From students' drawing on the top view, we find that these students interpret the top view as the part of the wall which is visible if we see it from the top. This interpretation shows how these students have a high level of definition. The students also give a high level interpretation on side view. However, this fact is not reflected on how students draw the left view and the right view of the wall. We find that none of the students come up with the idea that the visible parts of the wall from the left and the right side have square shapes.

We find that during working on this task, the students are struggling on constructing the wall with four layers. We also find that the first problem is the most difficult problems compared with the second and the third problem. From these findings we conclude that we should redesign the task. We propose to change the order of the task and reduce the number of layers on the wall. After experiencing this lesson, the students start to use the spatial term such as left view, back view, front view, right view, and top view.

5.2.2.5. Lesson 5: The Adventure in the Cube Houses

In this lesson, the students work in the context namely the Adventure in the Cube Houses. The students are situated that they will hunt a treasure. In order to find the treasure they have to find the clues in the complex of houses which is made of cubes. One of the cube houses' owner has important clues and tools. The cube house' owner will give the clues if they do three tasks. The first task is they should draw the side views and the top view of his house. The owner also wants to construct two other cube houses. So, the task is the students have to construct and draw the side views and the top view of 3 cube houses.

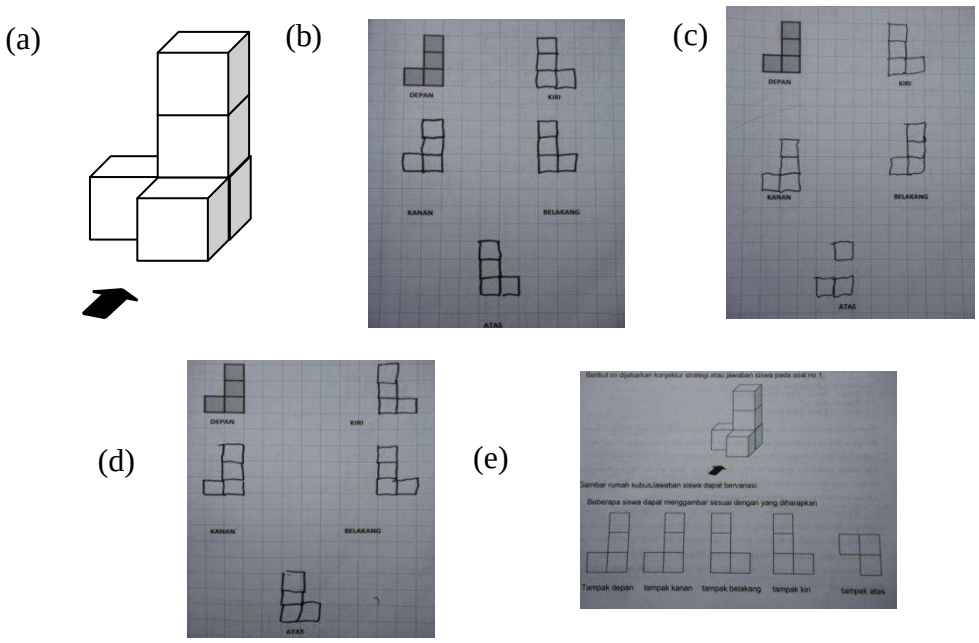


Figure 5.5. The students' answers on the first problem: (a) The picture of the cube house (b) Pinka's answers (c) Siti's answers (d) Syahrul's answers (e) The correct drawing

The learning activity is started by telling the context and the task that the students should do. Then for the next 20 minutes students work with this task individually. There are three cube houses that should be constructed by the students. The first cube house is given. Meanwhile the second and third cube

houses should be constructed by the students from five and four wooden cubes, respectively.

The learning activity is then continued by having discussion session. In this session, the teacher and the students discuss about their drawing and elaborate students' thinking. The pictures on figure 5.5 show students' work on task 1. From figure 5.5 we can see how the students draw the students draw the side views of the cubes house correctly (exception for Siti's drawing on back view). Those students state that they draw the goes out part in such way because of what they understand from the previous activity. They are even able to reason why they draw the goes out part in that way. However, we are aware that the example given may contribute on affecting students' drawing.

Even though the students can draw the side view of the cube house correctly and reason it, the students are not able to draw the top view of the cube house correctly. If we see Pinka and Syahrul drawings, they draw the side view of the cube house as the top view. When the teacher asks them about their drawing, they just say "I don't know, I don't have any idea" and "it's difficult". Siti draw the top view of the cube house with two squares and a separated square (see figure 5.5 c). It is something that we did not conjecture before.

After discussing students' answer on problem 1, the teacher shows the pictures of side views and top view of the first cube house. The teacher uses the pictures to discuss which drawing is correct or incorrect. The students find that drawing the top view of the cube house is similar to drawing the top view of the wall, "Oh… It's just like the top view of the wall that we learn yesterday, isn't ma'am? It's easy then", Siti said. After students see the pictures, they are able to

draw the correct drawing the top view of the cube house and reason why they draw it in that way. The teacher then asked the students to draw the side view and the top view of the other cube houses. The learning activity is stopped after the students finish their drawing.

Discussion

When the students work on the tasks, we find that they are struggling in drawing the top view of the cube houses. We assume that it is because they relate their experience in the previous lesson. However, this assumption is not supported with the fact that the students are not able to draw the top view of the cube house. We conjecture that if the students are able to draw the side view of the cube house, then they should be able to draw its top view. This conjecture is made because we reflect on what students experience from the previous activity. In the previous activity, we find that they were able to draw the top view and have difficulties in drawing the side view. This finding is contradicted with what we find on this lesson. Furthermore, we think that the way example presented may contribute to how students solve the problems. Changing the example may open more chances in getting different drawings. Thus, we will change the example for the first problem.

Another remarkable finding is none of the students come up with three-dimensional drawing. All of the students draw exactly what is shown in the side views of the cube house. It indicates that the students can interpret the meaning of side view.

After experiencing this lesson, the students are able to draw the side views and the top view of the cube house. The students become more familiar with the

spatial terms such as side view and top view. In conclusion, after experiencing this activity the students start to develop their ability in drawing, interpreting, and reasoning two-dimensional drawing of a three-dimensional object.

5.2.2.6. Lesson 6: Finding the Treasure

The lesson is started by telling the students about the context and the problem that they will work with. If in the lesson 5 the students are asked to draw the side views and the top view of cube houses, in this lesson the students are asked to construct the cube house from the side views and the top view given. The students are struggling to solve these tasks. The students use different strategy in constructing the cube house. Siti and Pinka start the constructing from the front view given, meanwhile Syahrul construct from the top view. At the time, Syahrul construct the cube house from the top view. After constructing the top view, he stops working and observe what Pinka and Siti are doing. Pinka constructs the cube house on a layer. In the beginning, she constructs the front view as if it is a top view, she then continue constructing from another view by adding some cubes next to the cubes which are arranged. Siti only sees what Pinka is doing and then try the same strategy. They keep doing the construction until Syahrul interrupts them.

1. Syahrul : You should not do that.
2. Pinka : So, how should I do? Tell me if you can do it.
3. Syahrul : You may not add in this side (pointing the area out of the top view-cubes). You will break the top view.
4. Pinka : So, where can I add the cubes then? How can I construct the front and left view?
5. Syahrul : I don't know. But, I am sure that you may not add on this side. (pointing the area out of the top view-cubes).
6. Pinka : Hmm…
7. Teacher : Do you agree with him Pinka?
8. Pinka : Somehow. But, where can I add the cubes then, miss?
9. Syahrul : Anywhere! Except this side, isn't it? (Pointing the area out of the top view-cubes).
10. Teacher : I don't know!
11. Pinka : Hmm… Can I add on the top?! (whispering)
12. Teacher : May be!
13. Siti : I think it will work!

From the conversation we can see how Syahrul understands what the top view means. He can interpret the top view well. However, he cannot relate what he knows to continue the construction from the side view. He did not come up with the idea of adding some cubes on the cubes which is arranged based on top view (top-view cubes). The students then start working together. Because the students are really struggling to finish this task, then teacher guides them in arranging the cubes. Due to they are only given three views, the students are then asked to draw the other views. The students do not find any difficulties in drawing the side views of the cube house.

After finishing working on problem 1, the students start working together in solving the rest of the problems. When solving problem 2 and problem 3, they start constructing the cube houses from the top view and then followed by the front view and left view. During working on the second and third problem, the teacher guides the students in solving the task by giving some scaffold questions. The students do not find any difficulties after experiencing working on the first task. They are able to interpret, reason, and communicating their construction and their drawings. The learning activity is continued by having reflection. In this session, the students summarise what they have learnt in this lesson. The students state that this task is quite difficult for them. Siti even says that this is the most difficult task in this learning sequence, “the most difficult task in our learning, ma’am!” Siti said. The learning activity is stop after the teacher summarise all activity that students have done during this preliminary experiment.

Discussion

We find that the students are really struggling in solving the task. The students use different strategy in constructing the cube house. Syahrul start from the top view, meanwhile Siti and Pinka start from the front view. In line 5 and line 9 of the dialogue, we can see how Syahrul notice that adding cubes out of the top view-cubes will lead to the wrong construction. However, his idea stuck on this stage, he cannot come up with the idea of adding cubes on top view-cubes. He does understand what the top view show, but he seems does not know that three down-up squares indicate that the cube house has three layers.

Meanwhile, Pinka who starts the construction from the front view keeps adding the cubes on the first layer. The differences of interpretation and strategies among the students show the different level of understanding. Syahrul notices what the top view means, he can interpret and use the drawing as the tool on communicating his idea. Siti and Pinka ignore what the drawings tell them. They cannot interpret well the side views drawing and the top view drawing means.

Based on analysis of students' work, we find that the number of cubes used in the first and third problem is too much and too difficult for them. So, we decide to make the problem simpler for the teaching experiment.

After experiencing this activity, the students are able to construct the cube house from three given views. The students also start to develop their ability in 'read' the 2-dimensional representation of 3-dimensional objects. In conclusion, the students develop their ability in communicating, interpreting, the 2-dimensional representation of 3-dimensional objects and reasoning their drawing.

5.2.3. Post-Test

In the end of learning sequence, we conduct a post-test. The goal of conducting the post-test is to see the development of students' spatial ability after experiencing the learning sequence. We use different questions for pre-assessment and post-test. In the post-test we present 2 tasks.

Task 1

The first task is the second task that is used in pre-assessment. From two problems, the students are able to answer one question correctly (see table 5.3). After experiencing this series of activities, Pinka and Syahrul are able to answer problem 1 and problem 2, respectively. Meanwhile, Siti's result shows no development. However, when the students solve this task, we can see the development of students' strategy in solving this problem. In the pre-assessment, the students stated that the pictures are the same and have no differences. When they solve this task in post test, the students start to 'read' the pictures. They rotate the answer sheet several times, and try to match the pictures on the position showed by the number. All of the sudden, the pictures mean something for them. The following fragment is taken when Pinka is working with the first problem of task 1.

Pinka : (rotating the answer sheet) The teacup is in the middle… Teacup is in the middle… it must be c or e. c or e ya?! But… the glass is in the right… and… the… what is this? Hmm… Whatever lah… it is in the left. So… Which one is correct ya?! Hmm… (rotate the answer sheet and observe the pictures). It must be e… Yes! Yes!

The fragment is taken when Pinka talks to herself while doing the task. From her dialogue we can see how she considers the position left and right of the objects. It indicates that Pinka uses her spatial awareness in solving the problem.

Be able to orientate and to relate both the top view and side view pictures indicate that the students not only develop the spatial orientation ability, but also spatial visualization.

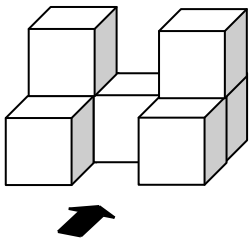
Siti answers the first problem incorrectly; instead of e she answers b. Syahrul also answers the first problem incorrectly, he answers c. We do not observe why Siti and Syahrul answer b and c, respectively. We assume that Syahrul answer's is related to Pinka's thinking. He probably thinks that the correct answer is c because the only pictures show that teacup in the middle are c and e. He presumably does not further consider the position of the object. The students also do the same strategy for solving problem 2.

Task 2

In this task, the students are asked to solve two problems. In the first question, the students are presented with the picture of cube house and they are asked to count the cubes on the picture. After that, they have to draw the top view, front view, back view, and the left view of the cube house.

Problem 1

Look at the following cube house!



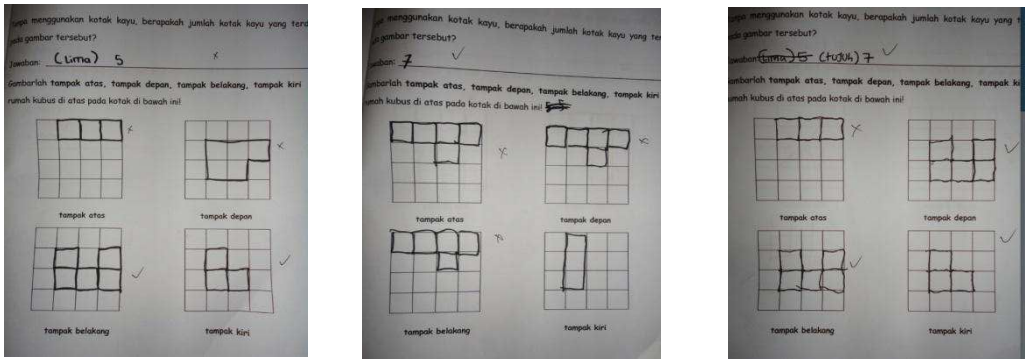
1. How many cubes are used to make the cube house?

Answer: _____

In solving this task, the students are challenged to count and draw the side views and the top view of the cube house without using wooden cubes. For the first question, we find that both Siti and Pinka come up with the answer 5. They count only the cubes which are visible from front view. Syahrul comes up with the answer 7. He says that in order to construct the left part of the cube house, he needs 3 cubes, so does the right part. He knows that there is a cube between of the left and the right part, so it makes 7. He tries to convince his friends that it is 7 instead of 5. However, Pinka and Siti are convinced with their own answers.

For the next questions, the students are challenged to draw the side views and the top view of the cube house without using the wooden cubes. They work for few minutes and then give up. They are not able to draw without see the real cube house. So, the teacher provides them with wooden cubes. The students then construct the cube house from the wooden cubes and draw its top view and side views. While constructing, Siti figures out that the number of cubes used in this cube house is 7 not 5. So, she revises her answer in question 1 from 5 become 7.

The following pictures show students' answer on problem1 for question 1 and question 2.



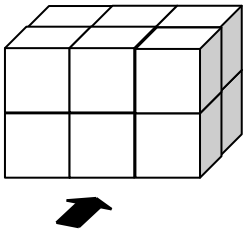
(a) (b) (c)

Figure 5.6. The students' answers on the first problem of second tasks: (a) Pinka's answers (b) Siti's answers (c) Syahrul's answers

From the pictures above, we can see that none of the students draw the side view and top view of the cube house as three dimensional drawing. In general, Pinka and Siti are able to draw the side view of the cube house correctly. However, we find that Syahrul is still struggling in drawing the side view. From those pictures we can see none of the students are able to draw the top view of the cube house correctly. Both Pinka and Siti draw three squares as the top view (see figure 5.6). Presumably it is because in their opinion, the top view of the cube house is only the taller part of the cube house and the connecting cube. The way students draw the top view of this cube house does not reflect on their understanding on the lesson 5. In lesson 5, the students are able to draw the top view of similar cube house. It indicates that the students' conceptual understanding on top view is still inconsistence.

Problem 2

Look at the following cube house!



1. How many cubes are used to make the cube house?

Answer: _____

While the students work on this task, we find that Siti is able to count the number of cubes used in the cube house without using wooden cubes. The following conversation shows how Siti count the number of cubes used in the cube house.

1. Teacher : How many blocks there?
2. Siti : it is 12, bu!

3. Teacher : How do you know?
4. Siti : Because there are 6 blocks on the front. Because there is two layers, so 6 plus 6 is 12, bu! (pointing the drawing)

Siti then continues drawing the front view and the left view of the cube house without constructing the cube house from wooden cubes. When the teacher ask her how the top view will be, she states that the top view will be the same as the front view. The fact that Siti is able to do the task without using the wooden cubes indicates that Siti develops her ability in spatial visualization and spatial orientation. However, we also aware: the fact that students have experience in working with the same cube house may affect Siti's thinking.

At the same time, Syahrul also state that the correct answer is 12. However, he is confused with Pinka's answer. Pinka counts the cubes loudly, and she gets 16. She does not write her answer on the answer sheet until she constructs the cube house and find that the correct answer is 12. Syahrul that is listening Pinka's then write 16 in his answer sheet. In order to draw the left and front view of the cube house, Pinka and Syahrul need to construct the cube house from the wooden cubes. Pinka draw it correctly. Meanwhile, none of both left and front view of cubes house is drawn correctly by Syahrul. Table 5.3 show students' answer in all of the tasks given.

Table 5.3.

Table of student's answers on post-test

Task / **Name**	**Task 1**			**Task 2**						
	Problem			Problem 1 Views					Problem 2 Views	
	1	2	1	Top	Front	Back	Left	1	Left	Front
Pinka Yunika	√	c	5	X	x	√	√	√	√	√
Siti Sarah Apriani	b	√	√	X	√	√	√	√	√	√
Syahrul Ramadhan	c	√	√	X	x	x	x	16	x	X
Correct Answer	e	d	7	√	√	√	√	12	√	√

From the analysis of students' answers on the post-test, we find that the strategy used by the students in solving task 1 is gradually increased compared with what students did in pre-assessment. We observe that after experiencing the series of activity, the students start to use their spatial awareness in solving the problems. The students also start to understand the attribute and properties of 2-dimensional space and use it in communicating and solving the spatial problems.

5.3. The Concluding Remarks of the Preliminary Experiment

Even though the first lesson, namely Playing Tungkupan, elicit students' spatial sense in sightseeing, we find that this lesson does not really support the next following activities. From the second lesson, we find that students are struggling to get the concept of best place. The students are confused with the concept that they have learnt in the lesson 1. Thus, instead of helping the students, the first lesson creates a confusing for the students.

In the second lesson, we find that the students avoid using the spatial term such as left and right in discussing their work. So, there should be additional instructional guidance for teacher in order to stimulate the students in using spatial term. Students in this age like drawing more than writing; therefore we think it is better to change the instruction. All of students' drawings are the side view of the objects (2-dimensional drawing), none of them draw the 3-dimensional drawing. In addition, they draw it from side view. It leaves us a question; do the students only see the side view, to what extent students know about top view.

In the third lesson, we find that the students are not familiar with the term 'gapura' or gate. In this lesson, we find that the students fill a same option on two blank squares. It is obviously something that we do not want. Apparently, filling

an alphabet on the worksheet is less challenging for the students since it enables students to use trial and error strategy. Moreover, working in the worksheet is not only less challenging but also is not handy for the students.

From the fourth lesson: Exploring the Wall, we find that the first problem is more difficult than the second and the third problem. Therefore, we think that it is better to arrange the problem from the easiest to the most difficult. We observe how the students are struggling in constructing the wall with 4 layers. So, we suggest reducing the number of layer.

During working on the fifth lesson, we find that the students sometimes confuse with the task. It is probably because the instruction given is not clear enough. In order to avoid the confusing, the teacher should give more clear instruction for the students in the beginning of learning activity.

Based on our observation and conversation with the teacher, the complicated of cube house construction make the constructing activity become more difficult. In the last lesson, we find that the students are really struggling in constructing the cube house. So, we think it is better to change the cube arrangements.

5.4. The Improvement of Hypothetical Learning Trajectory

Regarding to some remarks that we get during the preliminary experiment, we will make some changing on the HLT. We expect some improvement on the teaching experiment after we change the HLT.

Based on the discussion that we had with the teacher about the conjecture of students' thinking and the design of learning activities, we decide to eliminate the first activity. This decision is made because we consider that based on some

interview with the students on the preliminary experiment and the discussion with the teacher. From the unstructured interview that we conducted after each session of the learning activity with the students, we find that the first activity seems not really helpful for them to get the sense for the second activity. They stated that playing Tungkupan is quite different with observing the island; they saw it as different activity. They failed to find the relation between those activities, even though in fact we already stated how those activities are related to each other. The first activity, playing Tungkupan, also do not help them in reasoning. During the discussion session, we also get the similar statements from the teacher. The teacher suggested eliminating the first activity to avoid students to get confused. In her opinion, the second activity namely Finding the best place to build the control station (observing the island) can be done without the first activity as long as the teacher gives clear instruction about what students should do and the aim of the activity.

Based on these reasons, we decide to eliminate the first activity. Thus, in the second cycle we only have 5 activities. The second activity in the preliminary experiment becomes the first activity in the teaching experiment; the third activity in the preliminary experiment becomes the second activity in the teaching experiment, and so on.

We also change the objects used in the first activity. Instead of using two towers and a big wall, we decide to use a gate, a wagon, and a wall. However, as well as in the preliminary experiment, those objects are still made from bricks or blocks. Instead of using the term “gapura”, we introduce the gate as “gerbang”. The instruction in this lesson is also added. If in the preliminary experiment the

miniature is already built, then in the teaching experiment, the students are asked to construct the miniature from the blocks given.

We change students' worksheet on lesson 2. As we described, in the preliminary experiment the students work with students' worksheet. In the teaching experiment, we decide to change the instruction and reduce the number of pictures used. In the teaching experiment, the students will be given 5 side view pictures and a map (top view of miniature). They are asked to match the pictures and glue it on the map. In this lesson, the students are also asked to construct their own miniature.

Since in the first and second problem the students do not come up with the navigational term such as left and right, so we add some instructional guidance for the teacher to stimulate the students to use the term during working on the task.

For the third lesson: Exploring the Wall, we change the order of problem presented in the students' worksheet from the easiest to the most difficult. Thus, the first problem becomes the last one, the third problem becomes the second, and the second problem becomes the first one.

We discuss with the teacher about how the students are confused when they are dealing with task on lesson 4. We conclude that it happens because the instructions given are not clear enough. Thus, we emphasise to the teacher what should be done and what should be told to the students. In order to do it, we add some instructional guidance in the teacher guide.

We change some problems used in lesson 5. We make it easier for student (see appendix ... pages...). We also consider that this task is really difficult for the

students, so we add some instructional guidance for teacher on how to support the students while working on the tasks.

5.5. The Refined Hypothetical Learning Trajectory

5.5.1. Lesson 1: Finding the Best Place to Build the Control Station

Starting Point

- Students have sense of direction such as left, right
- Students are familiar with the term such as left, right, top, front, back.
- Students know the different between 3D object and 2D figure

Learning Goal

Main goal: develop students spatial visualization awareness

Sub goal:

- represent three dimensional shapes in two dimensional drawings
- interpret, recognize, and communicate about two dimensional drawings or pictures of three-dimensional objects
- identify objects from different view

Mathematical Activity

Students investigate the side views of the island.

Description of activity and teacher's role

In this activity students are given a set of miniature of an island in which there are 3 different building on it, namely a navigator tower, a wagon and a big wall. The learning activity is started by asking the students to construct the miniature of the island from a bird eye view picture of the miniature. The learning activity is then continued by introducing the context and the problem that the students will work

with. Students will work in the context in which they will have to observe the island from side views from the spyglass. It would be nice to see how young children make a "note" about what they see on the spyglass. Teacher should emphasize that because they see the island from the ship, so they only see the island from the side view not from the bird eye view. Teacher also should let student notice that they will make a drawing that will be 'read' by the other pirates. Thus, they have to make a clear and concise documentary, in order to let any pirates can also understand it. The following picture is the picture of miniature of the island that students will work with.

After finishing their work, students will have a walking gallery. Students are allowed to walk around and see another group work. After that they have to go back to their own group and reflect on what they have done. The learning activities continued by the discussion. Teacher may start the discussion by asking about students responses to their own work and the other groups' works. Teacher may discuss about the remarkable student's works and because the goal of this activity is to let students draw the different point, thus there should be interesting to discuss the drawing. Teacher may start the discussion about students' strategy, ask the question about what they did, and how they did it, why they did in that way, and then ask the other students to think about the work, and discuss whether it is acceptable correct or not. The teacher may pose some following questions:

- How do you choose a position?
- Why is it the best position?
- How do you decide it?
- Why (this object) is in the left and (this object) is in the right?

- From which position do you draw it?
- Why do you draw (the object) in such way?

It seems that it is impossible to go further in one discussion. The teacher may continue the discussion on the next meeting. In the next day, teacher may bring pictures of the island from different views, and discuss about how the position of the three building from different point of view. Teacher may discuss about how the whole part of the towers cannot be seen because of be covered by wall from some certain views, how the wall look like from different point of view, etc.

It is important for the teacher to make sure that the students do not see the object from the top view. The teacher should emphasise that the students can only observe the miniature only from the side view.

Figure 5.7. The picture of miniature of the island

Conjecture of Students' reaction

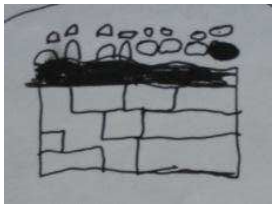
Students' works may vary. Based on the pilot experiment that we have been conducted, we conjecture that some students may draw the object on the miniature

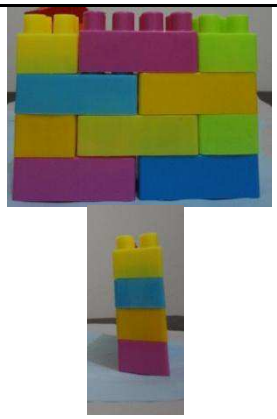
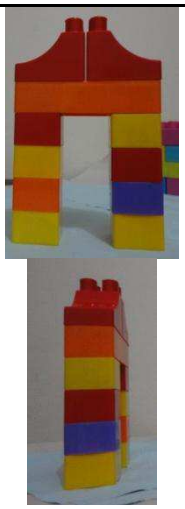
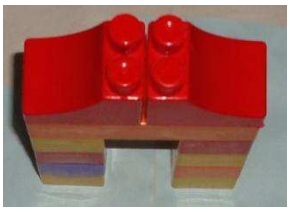
as shown on table 5.4. Regarding to the way students may draw the miniature, we make some conjectures such as:

- Some students may choose a position by considering whether it is the best place or not. A position is chosen after they have a discussion.
- Some students may just choose a position without considering whether it is the best or not. They just pick an arbitrary position and draw the miniature from the position.
- Some students may draw the objects in the miniature as it is shown, namely by considering the position of the objects (left and right) and the location (near and far).
- Some students may draw the objects in the miniature by only considering the position of the object.
- Some students may just draw the object in the miniature by ignoring the position (left and right) of the object.

Table 5.4.

Table of Conjecture Students' Drawing

Description	**Object**		
	The wall	The wagon	The gate
Some students may draw the object from its side view with its top view			

Some students may draw the object from its side view without its top view			
Some students may draw the top view of the object			
Some students may draw the 3D representation of the object			

5.5.2. Lesson 2: Locating the Pictures

Starting Point

- Students have sense of direction
- Students aware that a 3D object may have different side views
- Students know the different between 3D object and 2D figure
- Students are familiar with map

Learning Goal

Main goal: To develop students' spatial orientation awareness

Sub goal:

- interpret, recognize, and communicate about two dimensional drawings or pictures of three-dimensional objects
- develop students spatial visualisation and spatial orientation awareness
- Locating pictures of an objects taken from side views on the top view given
- Introduce students to the term "top view"*****
- make connections between different views of the same objects
- solve problems using the spatial awareness they have developed

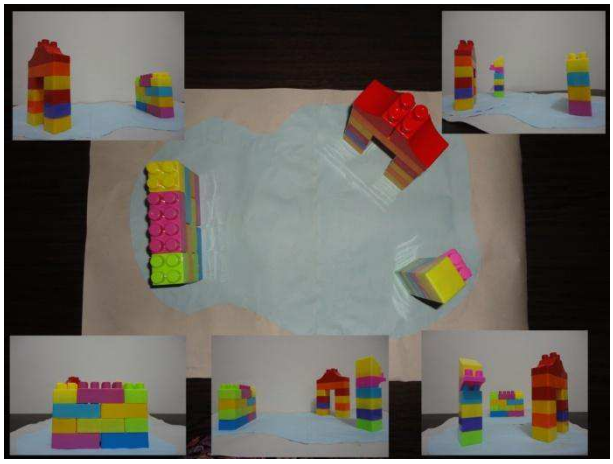


Figure 5.8. The picture of students' task

Description of activity and teacher's role

In this activity, students will work in spatial orientation activity, in which they will locate the pictures on the map. We design this task in order to develop students' spatial orientation. The pictures are about how the island viewed from different point of its side view. The goal of this activity is to introduce student to the term "top view" by letting them to work with a map on an island. On the map, there will be location of those three building and some question marks. Those question mark indicate the possible location where the pictures taken. Students are asked to put those pictures on the correct position.

Before working on the task, the students are asked to construct the miniature of the island. While the students are working on the task, the teacher may encourage the students to solve the problem without any extra help. Some students may have difficulty to locate the pictures. To help the students, teacher may let them work with the miniature of the island that is already built. During the group working period, teacher has to keep on eye with all of group, make sure that they did not share their answer to the other group.

After they solve the problem, one of the groups will present their work. Teacher can ask whether there are some groups that have different answer. The group with different answer may also present their work in front of class. And then teacher can start the discussion on how their answers are the same, and then discuss about the differences. Teacher may ask about how they find their answer or to be more specific: how they locate the picture, why they did it, what strategy they use, etc. If all of the groups have the same answer, the teacher may start the discussion by asking those each group to tell about their strategy to solve one

different problem. Teacher may ask to another group whether they have different strategy, and ask about the possibility that the other pictures are being located on that position. In the end of discussion, teacher then shows the miniature of the island and confirms whether their answer is correct or not. By showing them the miniature of the island, then teacher can introduce the map as the top view of the island.

Conjecture of Students' reaction

- Students may do some trial-error to locate the picture.
- Some students may also use the fact that the position (left and right) of the building will be different if they see it from different position. These students will solve the problem by observing the miniature of the island and comparing what is seen in the picture.
- Some students may also consider the location (near and far) of the objects on the miniature of the island.
- Some students may not need to use the miniature of the island; they can directly locate the picture just by seeing the pictures.

5.5.3. Lesson 3: Exploring the Wall

Starting point

- Students are familiar with term side views
- Students are familiar with term top view
- Students aware that an 3D object may have different side views
- Students aware about the top view of a 3D object

Learning goal

Main goal: Introduce the term front view, left view, back view, and right view.

Sub goal:

- interpret, recognize, and communicate about two dimensional drawings or pictures of three-dimensional objects
- develop students spatial visualisation and spatial orientation awareness
- solve problems using the spatial awareness they have developed
- make connections between different views of the same objects

Description of mathematical activity and teacher's role

After letting the students experience exploring the island from different views, in this activity, students will be focused on a specific object. Students will observe the wall that is used in the second and third activity. We propose to use this object is because the wall have exactly four side views. By doing so, it will be easier for students to get the idea of front view, left view, back view, right view, and top view.

In the beginning of learning activity, students are presented with pictures of the bird eye view of the object, the top view and the side view of the object. Teacher will lead the discussion about how these two pictures are difference. Then

the teacher introduces the term side views and present all of the side view of the wall.

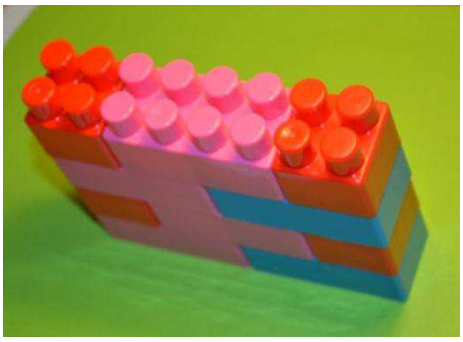


Figure 5.9. The bird eye view picture of the wall

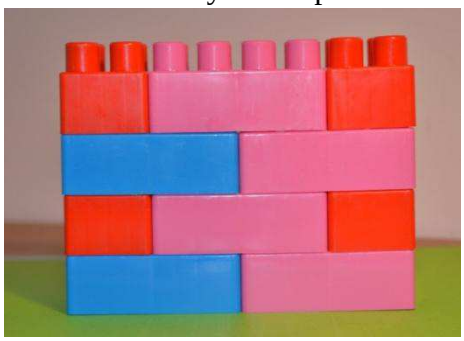


Figure 5.10 The front view picture of the wall

Figure 5.11. The top view picture of the wall

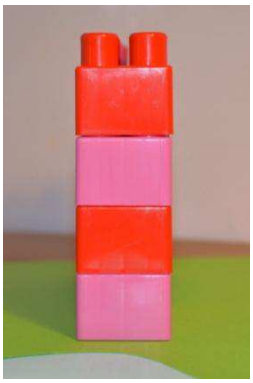


Figure 5.12 The right view picture of the wall

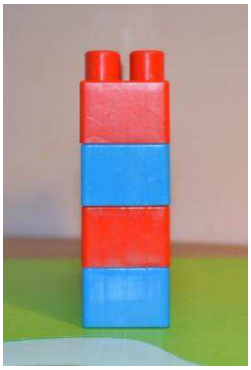


Figure 5.13 The left view picture of the wall

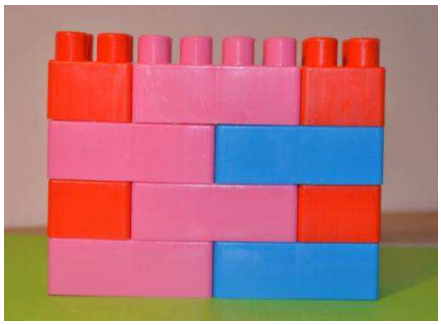


Figure 5.14. The back view picture of the wall

After students are familiar with the term, teacher may show the picture of the wall in part A of the students worksheet. Teacher can ask the students to construct the first wall showed in their worksheet. The teacher then asks students to draw the front view of the wall. For the drawing of the wall from left view and the right view will be left as an exercise for students. The tasks (part B) will be done together with their group. During the working period, teacher may walk around and observing students strategy. The problem that students will work with will be discussed as follow.

Part A

In part A, the students is presented by the following pictures, and then they are asked to predict whether the back view of the walls have the same drawing.

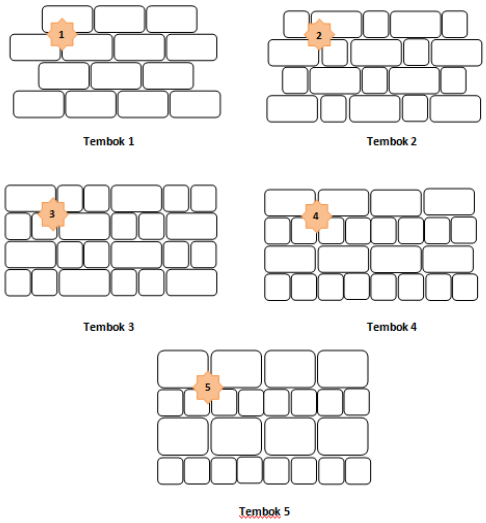


Figure 5.15. The front view pictures of the walls

Conjecture of students' reaction

Some students may answer yes and some students may answer no

Part B

In this part, the students are asked to predict whether the walls have the same shape and then they are asked to draw the top view, the right view, and the left view of the walls.

Problem 1

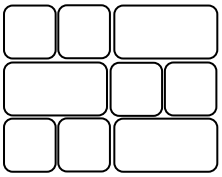
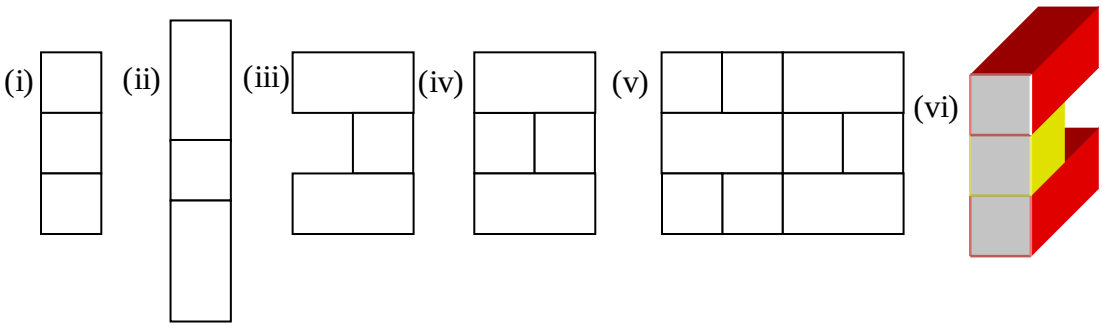


Figure 5.16. The front view pictures of the walls

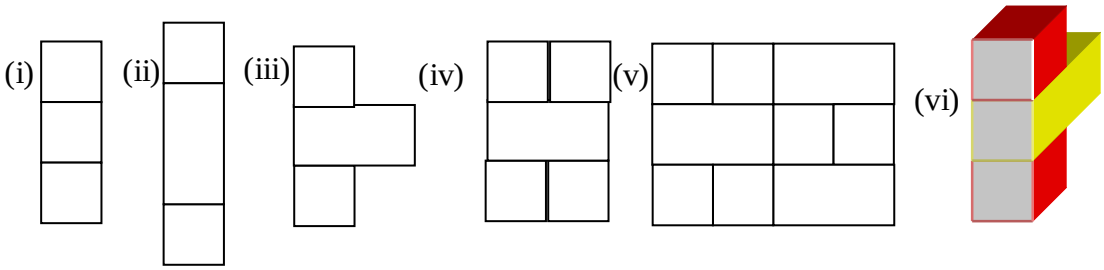
Conjecture of students' reaction

- Some students may answer yes and some students may answer no

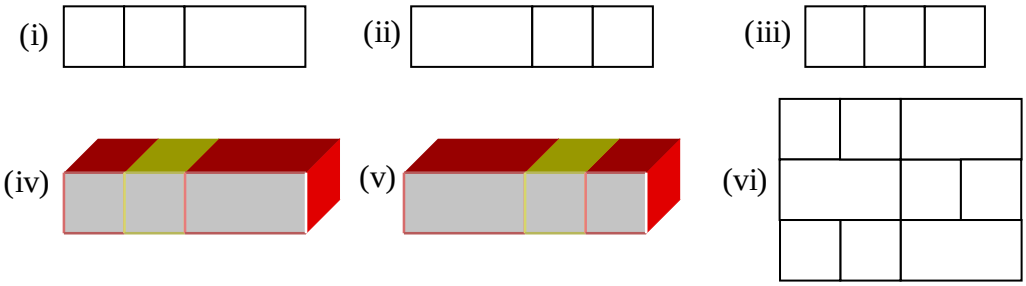
- Some students may draw the right view as shown by the following pictures



- Some students may draw the left view as shown by the following pictures



- Some students may draw the top view of the wall as shown by the following pictures



Problem 2

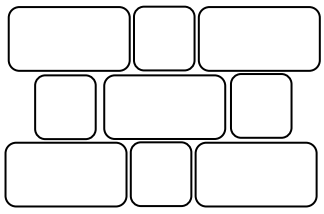
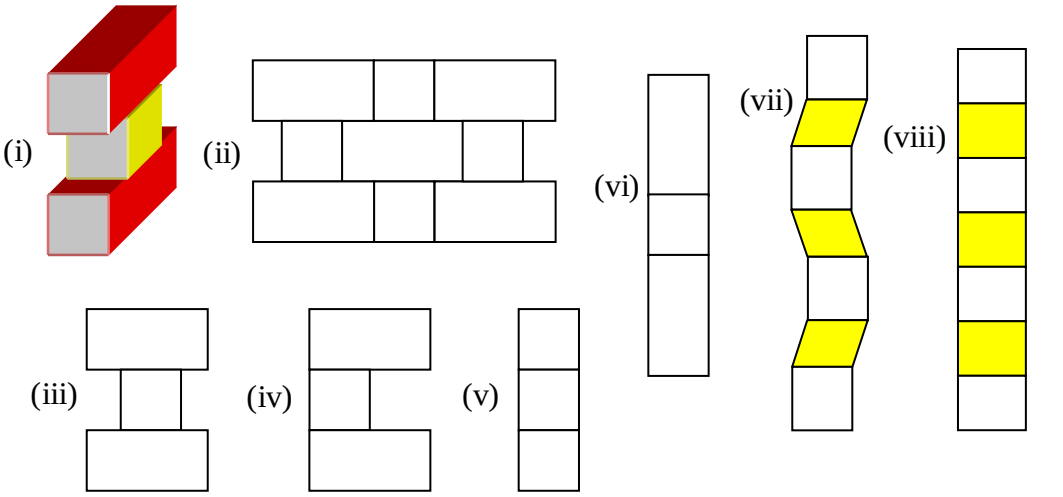


Figure 5.17. The front view pictures of the walls

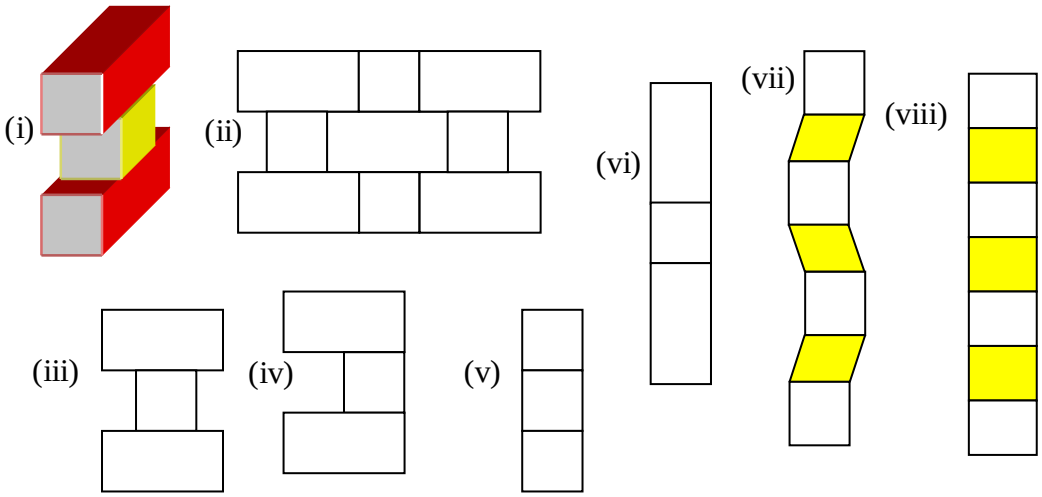
Conjecture of students' reaction

- Some students may answer yes and some students may answer no

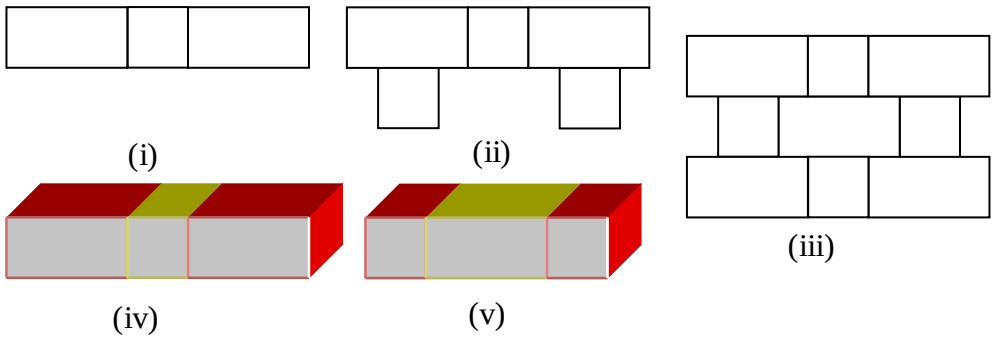
- Some students may draw the right view as shown by the following pictures



- Some students may draw the left view as shown by the following pictures



- Some students may draw the top view of the wall as shown by the following pictures



Problem 3

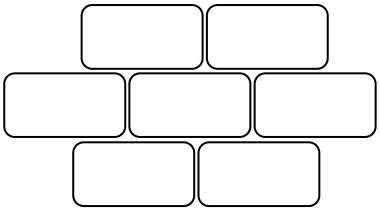
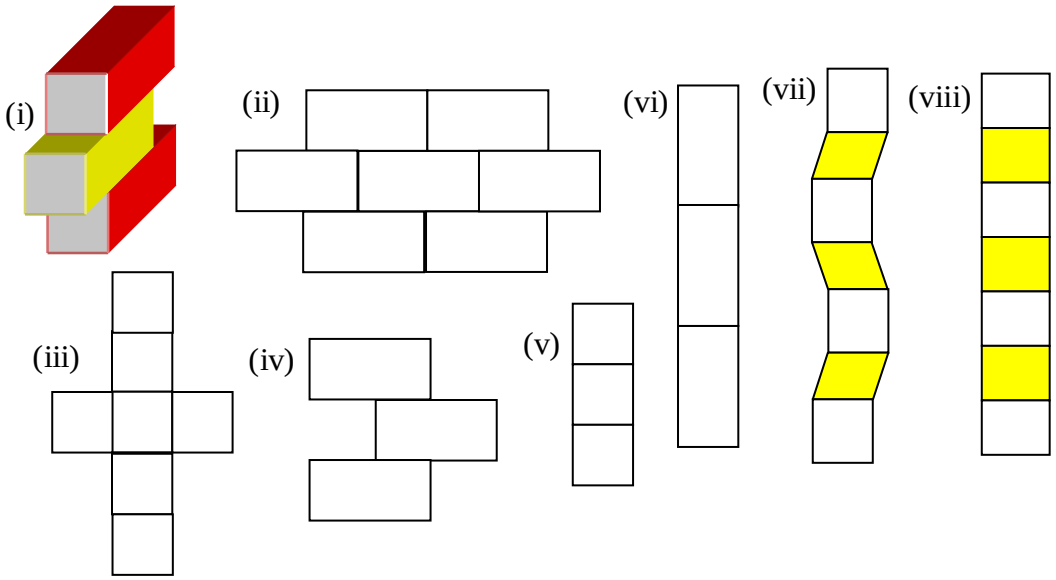


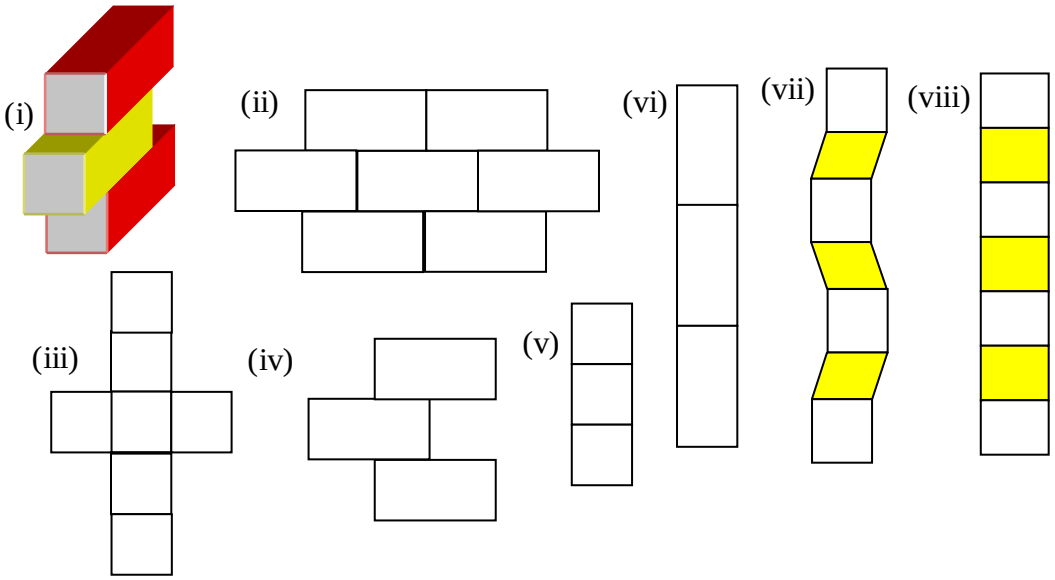
Figure 5.18. The front view pictures of the wall

Conjecture of students' reaction

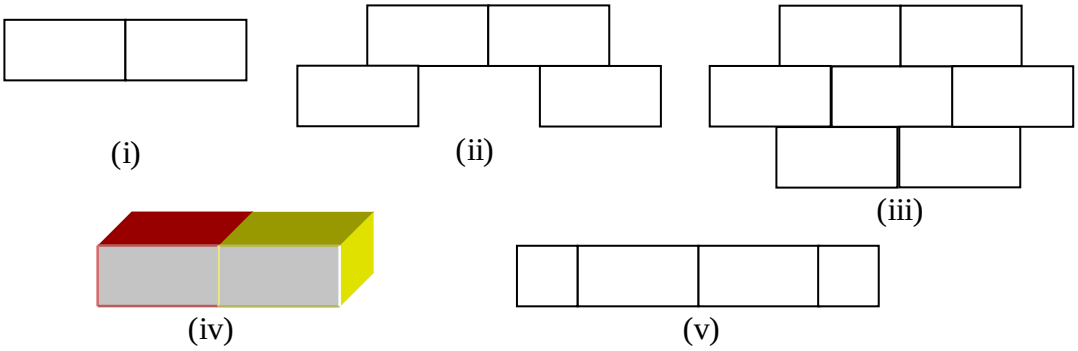
- Some students may answer yes and some students may answer no
- Some students may draw the right view as shown by the following pictures



- Some students may draw the left view as shown by the following pictures



- Some students may draw the top view of the wall as shown by the following pictures



Some students may have difficulty in interpreting the pictures showed in part B. Teacher may suggest them to ask with their own groups or to the other group.

The learning activity will be continued by the discussion. Teacher has an important role not only as the facilitator of the discussion but also someone who pose the important question. Teacher may ask some important questions such as:

- Why do you draw the left and the right view of the wall in such way?
- Will the wall have the same view if we see it from the left side and the right side?
- How about the front and the back?

The discussion then continued to part C (see Appendix), in which students have to construct the wall from the top view given. Finally, the students will draw the side views of the wall they have constructed.

5.5.4. Lesson 4: The Adventure in the Cube Houses

Starting point

- Students have sense of direction
- Students know about the term side views and top views
- Students are familiar with the cubes
- Students can differentiate the bird eye view drawing and the side views drawing

Learning Goal

- Students can identify cubes arrangement from different views
- Students can make connection between different views of the same object
- Students can interpret, recognize, and communicate about two dimensional drawing or pictures of three dimensional shapes
- Students can represent three-dimensional shape in two dimensional drawing

Description of mathematical activity and teacher's role

Students will arrange some cubes and make the draw of the side views and the top view of the cubes building. During the learning activity, students will work with the worksheet. Students will make drawing of different views from three cubes building. The first cube building is set in the students' worksheet (see figure 1); they have to make it together within in a group. They have to reconstruct the bird eye view of the cube building, and then draw the side view and the top view of the cube building. For the second cubes building, students will also work together as a group. Student will construct their own group cubes building from 5 cubes and draw the side views and its top view. For the third cubes, students will work individually. They will construct their own cubes building and draw the side view

and its top view. In this last cubes building, each students will make a cubes building consisted of four small cubes.

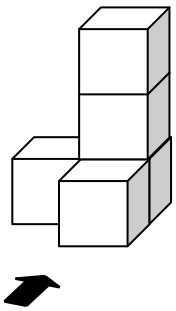
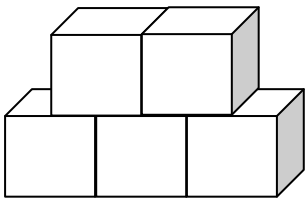


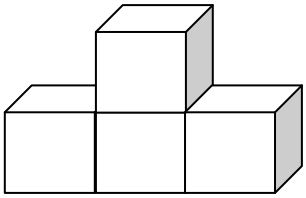
Figure 5.19. The first cube building

There are some important things that teacher should emphasize

- Teacher may and may not use the cubes when they are dealing with the task
- Student will construct the cubes on the playground given.
- The black arrow indicate the front view
- In this activity, students are not allowed to constructs the cube house as shown by the following picture



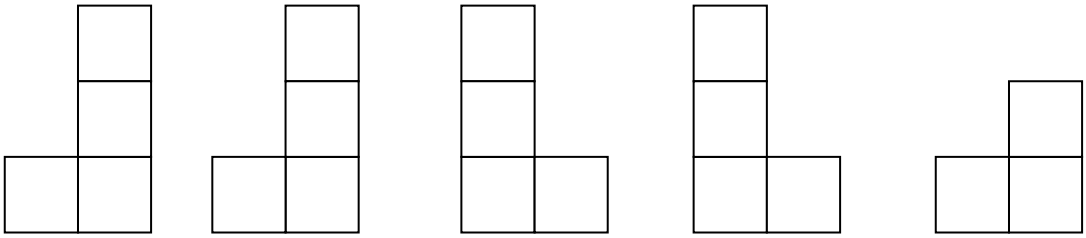
But, the cube house only can be constructed as the following picture



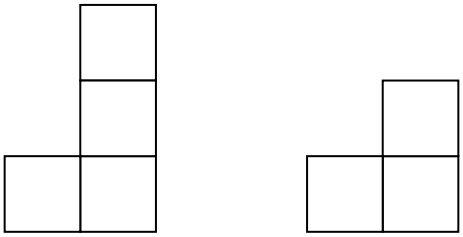
Conjecture of students' reaction

The answer of students may vary:

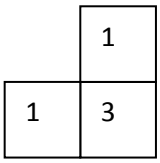
- Some groups may draw exactly as what we expected



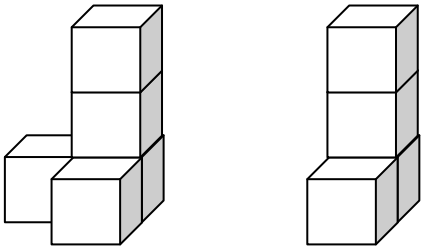
- Some groups may draw all the side views as the same drawing because they state that all of the side view has the same drawing.



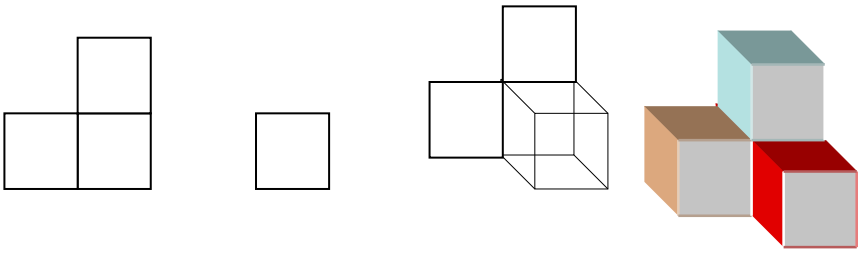
- Some students may draw the top view of the cubes building and indicate the height numbers



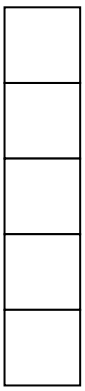
- Some students may draw the three dimensional representation of the cubes



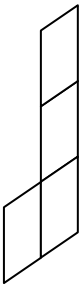
- Some students may draw the top view as shown by the following pictures



- Some group my draw something like this



Front view



right view

5.5.5. Lesson 5: Finding the Treasure

Starting point

- Students have sense of direction
- Students know about the term side views and top views
- Students are familiar with the cubes
- Student have experienced learning in activity 4
- Students can differentiate the bird eye view drawing and the side views drawing

Learning Goal

- Students can identify cubes arrangement from different views
- Students can make connection between different views of the same object
- Students can interpret, recognize, and communicate about two dimensional drawing or pictures of three dimensional shapes
- Students can construct the cube building from the its given three different views.

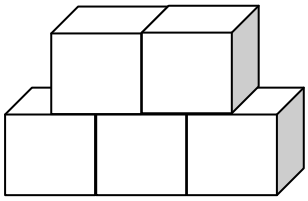
Description of mathematical activity and teacher's role

Students are given three problems that they have to discuss in their group. They will work in the worksheet, in which there are 3 problems or puzzles related to the context that they are working with. The problems are about how to unlock the three important things that are needed to get the treasure. The puzzles itself are students have to construct the intended cubes building from three pictures of different views given. We expect students can solve the problem mentally. In general, we expect students can solve these problems by reflecting on what they have done in the previous meeting. Some students may have difficulty to solve the

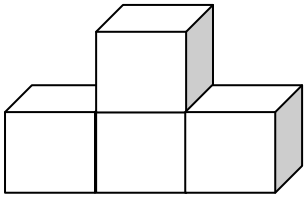
problems, give them the cubes as the tool. If it is possible, teacher may encourage students who can solve the problems quickly to draw their construction from bird eye view.

There are some important things that teacher should emphasize

- Teacher may and may not use the cubes when they are dealing with the task
- Student will construct the cubes on the playground given.
- The black arrow indicate the front view
- In this activity, students are not allowed to constructs the cube house as shown by the following picture



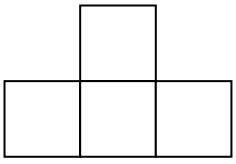
But, the cube house only can be constructed as the following picture



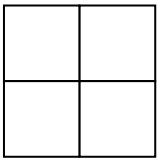
In this lesson, the students are asked to solve three problems. They are asked to construct the cube house from three given views and draw the other two views. The problems and the conjecture of students' reaction will be discussed as follow.

Problem 1

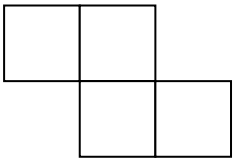
In problem 1, the students are given the following drawing.



front view



left view

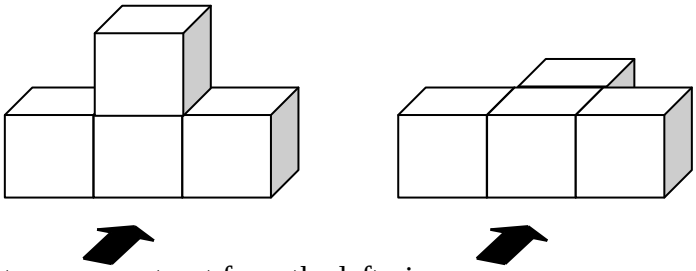


top view

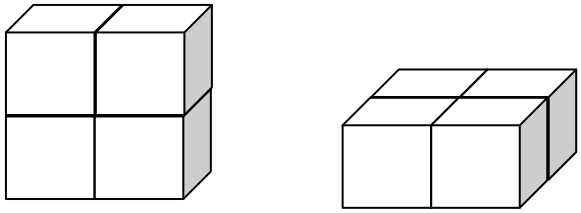
Conjecture of students' reaction

We try to elaborate the possible students' reaction in solving this following problem. Based on the literature and the experience, most of student will construct the cube as the following picture:

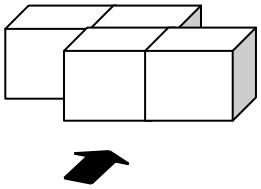
Some students may construct from the front view



Some students may construct from the left view

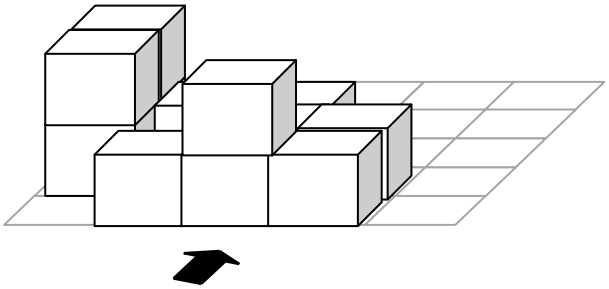


Some students may construct from the top view

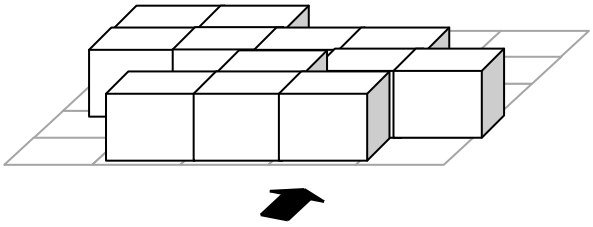


After constructing those three views,

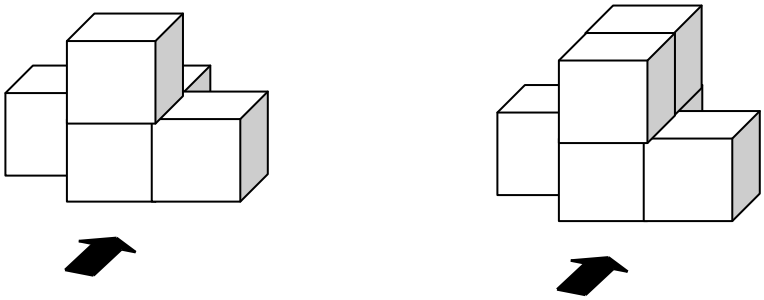
Some students may combine it as shown as the following picture



Some students may also combine it as shown as the following picture



Some students who construct the cube house from top view may continue the construction by doing the following steps

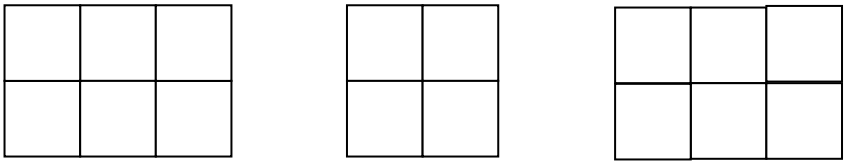


Based on the pilot experiment, we find that this task is really difficult for students. Therefore, there may be no group that is able to solve the first task. In order to support the students in solving this problem, we plan to have a discussion session after the students finish in answering this problem. The teacher and the students are then working together to construct the first cube house. The teacher may clarify the correct answer, and discuss about what is the most effective first step to construct the cube house.

After discussing the correct answer, the students are asked to finish the last two problems. The learning activity is continued by discussing students' answers on problem 2 and problem 3.

Problem 2

In problem 2, the students are given the following drawing.

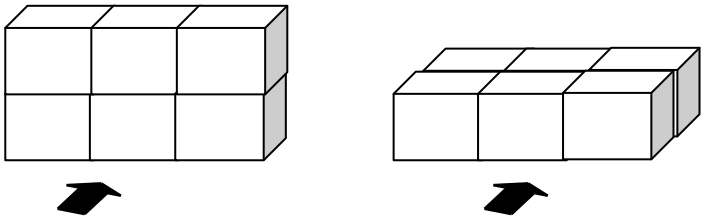


front view left view top view

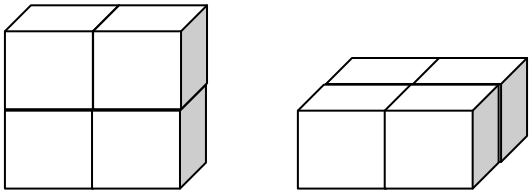
Conjecture of students' reaction

We try to elaborate the possible students' reaction in solving this following problem. Based on the literature and the experience, most of student will construct the cube as the following picture:

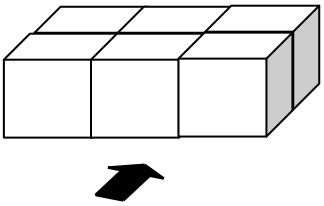
Some students may construct from the front view



Some students may construct from the left view

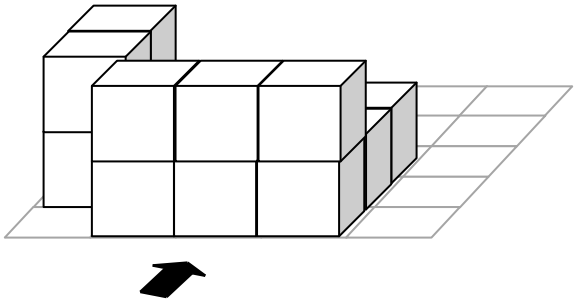


Some students may construct from the top view

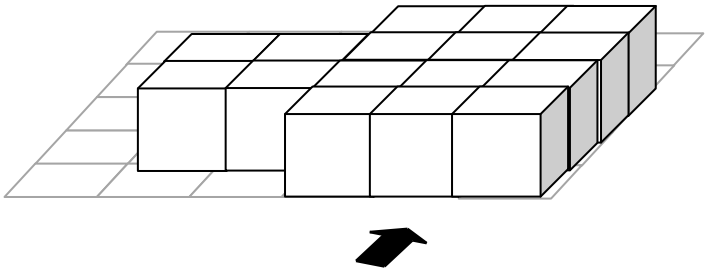


After constructing those three views,

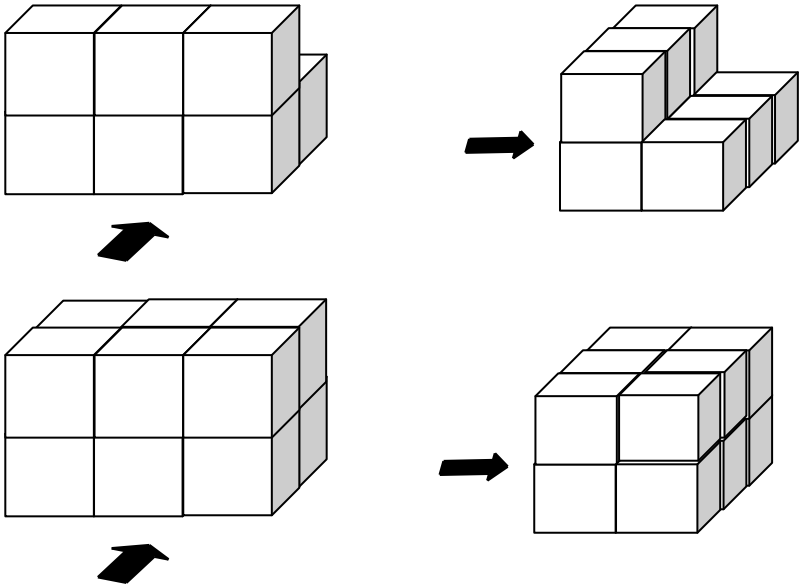
Some students may combine it as shown as the following picture



Some students may also combine it as shown as the following picture

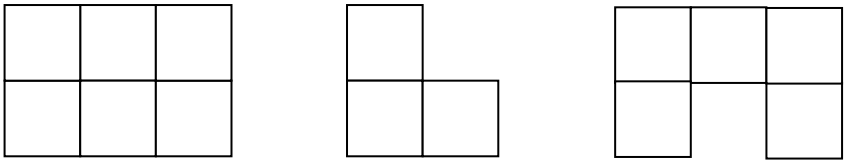


Some students who construct the cube house from top view may continue the construction by doing the following steps



Problem 3

In problem 3, the students are given the following drawing.

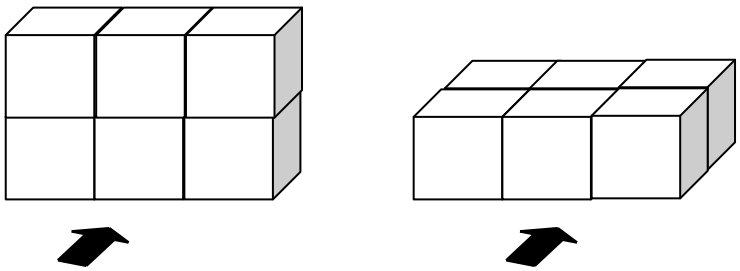


front view left view top view

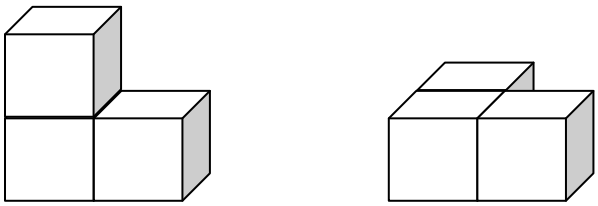
Conjecture of students' reaction:

We try to elaborate the possible students' reaction in solving this following problem. Based on the literature and the experience, most of student will construct the cube as the following picture:

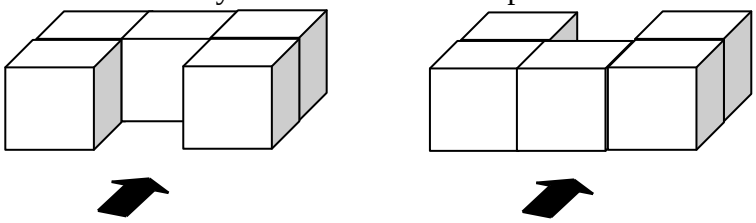
- Some students may construct from the front view



- Some students may construct from the left view

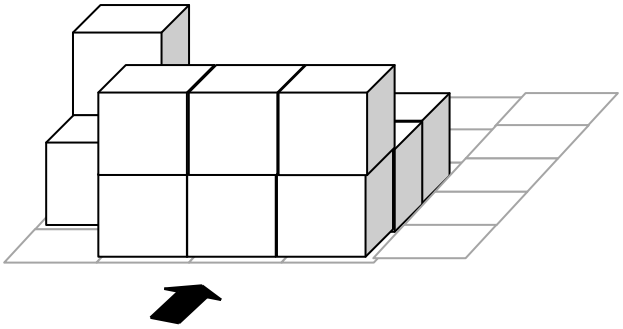


- Some students may construct from the top view

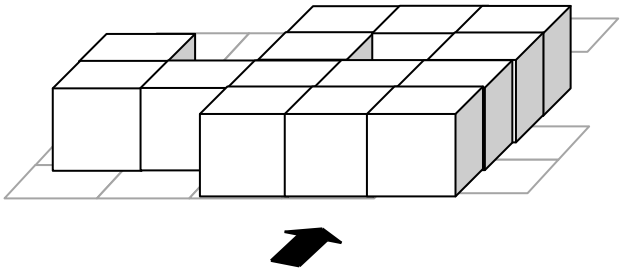


After constructing those three views,

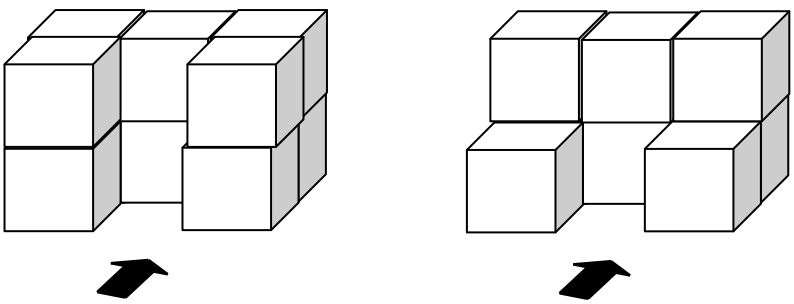
- Some students may combine it as shown as the following picture



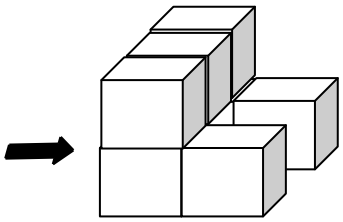
- Some students may also combine it as shown as the following picture



- Some students who construct the cube house from top view may continue the construction by doing the following steps



- Some students may disorient in reading the drawing, so they will construct the cube house as shown in the following picture.



5.6. Analysis on the Second Cycle of Hypothetical Learning Trajectory Implementation

The teaching experiment involves 39 students of third grade and a third grade teacher of SD Negeri 117 Palembang. During learning in this series of activities, those students are grouped into 10 small groups. However, in the analysis we will focus on describing a group which consist of four students namely Najwa, Aliya, Ajeng, and Alycia. In this section, we will compare between the conjectures of students' thinking and learning made in the improved HLT version and the students' actual work in the series of activities.

5.6.1. Pre-Assessment

The pre-assessment is aimed to know students current understanding and knowledge, and to make sure that the students have no problem in differentiate the left side and the right side. In this pre assessment, we use the same questions that are used in the first cycle.

Based on the analysis of students' work on task 1, we find that none of the students have problem in differentiate the left side and the right side. Thus, we assume that the students will have no disorientation problem. We notice that some students probably do not know the term PC computer, keyboard, monitor computer, and mouse. That is probably the reason why we still find some student make a wrong choice in solving the first task.

Based on the analysis of students' work in task 2, we find that some students do not give a correct answer. We observe that they only pick up a choice. We find that there are 8 students who answer problem 1 correctly and there is no student that answers the problem 2 correctly. Surprisingly, we also find 12 students who

give correct answer both for problem 1 and problem 2. Based on our observation we find that some students, who give correct answers in both problem 1 and problem 2, observe and rotate the worksheet while findings the answers. Some of them are caught cheating on their friends' work.

5.6.2. Teaching Experiment

5.6.2.1. Lesson 1: Finding the Best Place to Build the Control Station

The learning activity in lesson 1 is started by constructing the miniature of the island. In order to do so, the students are provided with Lego® bricks and the bird eye picture of the miniature. At the time, there is only one picture of the miniature that is put on the blackboard. This condition make the students have to walk to the blackboard to see the picture. In general, the students have no difficulties in constructing the miniature. They are able to locate the position of the wagon, the gate, and the wall in the appropriate place.

The teacher then continues the learning activity by telling the students about the context and the problem that the students will work with. The teacher asks the students to observe the miniature of the island, to find the best location to build the control station, and then draw the miniature of the island as what they see from the location. While the students are working with the task, one of the students from the focus group, Ajeng, calls the teacher.

1. Ajeng : Ma'am, it (pointing the gate) supposes to be drawn like this (pointing her drawing), doesn't it? And this one (pointing the wagon) should be drawn as it is?
2. Teacher : Yes, it is.
3. Ajeng : Is that ok if I draw this part (pointing the top view of the wagon)? Is that ok if I don't draw this part?
4. Teacher : Why don't you try to see it from here (ask Ajeng to see it from the side view), can you see this part? (Pointing the top part of the wagon)

5. Ajeng : (She then crouched and observed the miniature once again). I can only see this part (pointing the front part of the wagon).
6. Teacher : If you cannot see it, you need not to color it. Eeh… (and then repeating her statement) draw it. So, which part can you see?
7. Ajeng : This part (pointing the front part of the wagon).
8. Teacher : It means you only need to draw this part (pointing the front part of the wagon).

From the dialogue we can see how she realizes that the part that is possibly seen from her point of view is only as shown in her drawing (see figure 5.20.). Although we conjecture that some students may draw the wall as Ajeng does, yet it is something surprising for us. In general, students tend to draw the wider part of the wall even though they see the narrow part not the wider part. As a matter of fact, we find that Ajeng is the only one who draws the wall from the narrow part.

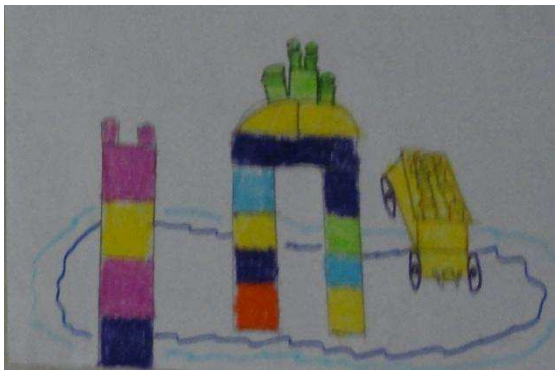


Figure 5.20. Ajeng's drawing

Furthermore, Even though from the conversation Ajeng says that she only see the front view of the wagon, in fact she draws it as the parallel projection of the wagon. She draws the wagon as 3-dimensional drawing. This fact is contradicted with her statement.

Before working on this task, the teacher suggest the students to use navigational term such as left and right in discussing their work. However, we find that some students avoid using these terms in communicating their work. The

following conversation show an example how Aliya avoids using the term left and right in describing her work.

1. Researcher : From which position you see it? (pointing Aliya's work). Is it from here? (pointing Aliya's right position)
2. Aliya : (pointing her front position)
3. Researcher : From which position do you draw it?
4. Aliya : (give direction by her hand)
5. Researcher : From here?! So, if you see it from this position (repeating the direction that is just shown by Aliya) what picture is it? (pointing the unfinished drawing of the wall in Aliya's work)
6. Aliya : (pointing the wall on the miniature)
7. Researcher : From which side it is supposed to be? In the left or the right side?
8. Aliya : (laughing)
9. Researcher : come on!
10. Aliya : right side.
11. Researcher : haa? In the left side or the right side?
12. Aliya : right side.
13. Researcher : is it correct that it is on the right side?
14. Aliya : (smile and thinking)
15. Researcher : ask it to your friend. Is it correct that it (pointing the wall) is on the right?
16. Aliya : incorrect
17. Researcher : (showing Aliya's work to her friends within her group). Is it correct that it is on the right side?
18. Najwa : is it correct or not? (thinking)
19. Alycia : it is correct
20. Najwa : But ma'am it is because you see it from here (holding Aliya's work and show it from the position where Aliya draw it), but if it is like this, it suppose to be incorrect (show Aliya's work from the opposite position).

From dialogue number 2, 4, and 6 we can see how Aliya uses pointing strategy in discussing her work. The navigational term such as left and right does not come up until the researcher mentions these terms. We find that instead of doing what her teacher suggests, she prefers to use the strategy that is more comfortable for her since she is a less talking student. Based on this finding, we conclude that teacher's instruction is not enough to encourage students in using the terms.

Another interesting finding is that there is no student who is disorientation the drawings. They are considering the position of the objects in drawing. As the results, no student draws the objects in the miniature in reverse position as what we found in the preliminary experiment. Furthermore, in students' works we may find that an object is drawn in front of another object. These drawing are made because at the time the students have no more space to draw the objects.

The learning activity is continued by gathering students' works. Each group should put their team's work on the blackboard. The teacher then instructs the students to give mark on their friends' work. This activity is out of the HLT. Students are asked to choose an interesting drawing and vote them to be the winner of today's 'mission'. This activity spends 20 minutes to finish. As the result, we only have less than 5 minutes to discuss students' work.

The discussion is done in very short period of time. The teacher shows 5 pictures of the miniature which are taken from different side views. Each picture is labelled by number from 1 to 5. Picture number 1 shows the best place to observe the island. Teacher asks the students which picture shows the best place. All of the students raise their hands and tell their answer. However, only one student comes up with number 1 as his choice, namely Adam. The teacher just calls him and asks his reason. "Because it enables us to see more area", he said. Without asking him further, the teacher confirms that the best place is showed by the picture number 1. Teacher does not elaborate more the answer or explain why picture number 1 is better than the other four pictures. The teacher ends the learning activity by summarising what students have done in this lesson.

Discussion

We find different strategies and drawing. Most of the drawings are fixed with our conjectures and some of the conjectures do not appear in the Actual Learning Trajectory (ALT). Table 5.5 show the comparison between some conjectures of students' thinking and reaction in the HLT and in the ALT in Lesson 1. The fact that the students can differentiate the drawing by indicating which object is in their left side and which objects in their right show that the students consider the position of the object in their left side and their right side. It also indicates that the students are able to make connection between the real situation in three-dimensional space and two-dimensional drawing. This conclusion is supported by our findings that is some students even consider the location (far and near) of the objects in their drawing (see figure 5.21). We have seen that these students develop their spatial orientation and spatial visualisation skill after experiencing this lesson. Yet, from the dialogue with Aliya we find that she do not use the navigational term in communicating her work. Presumably, these navigational terms are also not used by some other students while communicating their work.

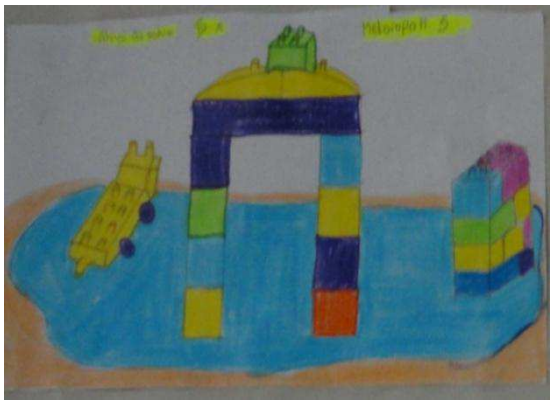


Figure 5.21. Students' drawing that considers the position and the location of the objects on the miniature

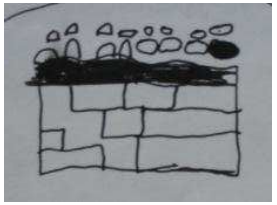
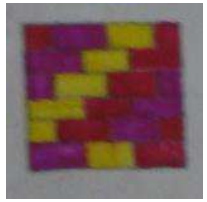
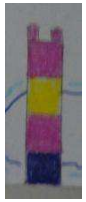
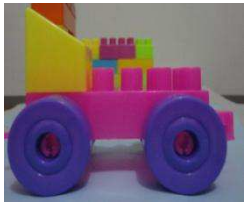
From table 5.5 we can see that some students draw a 3-dimensional representation drawing. Some students state that it is because they see the objects as what they draw. Based on our observation, we find that most of the students who draw a 3-dimensional representation drawing do not close one of their eyes while observing the island.

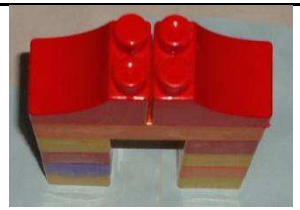
The fact that some students draw the top view of the wagon gives us some assumption. The first assumption is because the students misinterpret teacher's instruction. In the beginning of learning activity, the teacher have emphasised the condition that they are observing from the ship, so the drawing expected should be make from side view. At the same time, it also gives us knowledge that students in this age have developed their idea on top view.

After experiencing this lesson, students start to consider about the relation about the drawing (the position of the object whether it is on the left side or right side) and the real object. Apparently, in this activity they have learnt the relation between two-dimensional representation and three-dimensional objects.

Table 5.5

Table of Comparison between Conjecture of HLT and ALT in Lesson 1

No	Description	The wall		The wagon		The gate	
		HLT	ALT	HLT	ALT	HLT	ALT
1	Some students may draw the object from its side view with its top view		Does not appear				
2	Some students may draw the object from its side view without its top view	 	 			 	

3	Some students may draw the top view of the object		Does not appear				Does not appear
4	Some students may draw the 3D representation of the object						Does not appear

5.6.2.2. Lesson 2: Locating the Pictures

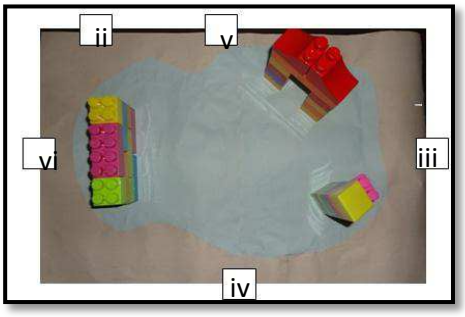
After the students experienced the first activity in which they have to draw the side views of the miniature, in this activity they will be introduced to term top view. This spatial term will be explicitly introduced in the classroom discussion session. In this activity, students are given 2-dimensional representations of 3-dimensional objects (the pictures of miniature of the island) taken from different sides. The pictures will then be placed on pictures of the top view of the miniature (the map).

The learning activities were started by asking the students to construct the miniature of the island from the bricks or the blocks provided. In constructing the miniature, students can look at the side view pictures of the miniature of the island, and the map (the top view picture). After finishing the construction, the students can raise their hand as a sign. As well as what teacher said, the focused group; Ajeng, Aliya, Alycia, and Najwa, raise their hand and then the teacher comes to check their work. The teacher finds that the focused group's construction is not suitable with the pictures. Therefore, Ajeng and her friends should fix the miniature. Ajeng and Alycia are working together to fix it, meanwhile Najwa and Aliya are observing what their friends are doing. Those students face some difficulties in arranging the gate, the tower, and the wall. Suddenly Najwa comes up with the idea of using the map. She shows the map and tells her friends to reconstruct the miniature as shown in the map.

1. Ajeng and Alycia : (reconstructing the miniature)
2. Najwa : See! The photograph is looked like this. The photograph! The photograph! Like this! This! (Holding the map)
3. Ajeng and Alycia : (see the map and rearrange the objects)
4. Aliya : (see the picture and then help her friends)

This conversation shows us how the students consider about the top view of the island while they are reconstructing the miniature of the island.

After all the students construct the miniature of the island, the teacher tells the context and problems that they have to solve. The idea of giving the miniature is to help the students who have difficulties in solving the problem. As a matter of fact, some of the students did not need to use the miniature of the island. As well as the other groups, this group is also locating the pictures without using the miniature of the island. The pictures that the students supposed to locate can be seen on following figures.



(i) The map

(ii)

(iii)

(iv)

(v)

(vi)

Figure 5.22 The pictures of the students' task in lesson 2, (i): the map, (ii)-(vi): the side view pictures of the miniature

The following dialogue shoes the strategies used by the students in solving the problem.

1. Researcher : How do you know that this picture is in here?
2. Ajeng : Oh yes, it is incorrect
3. Researcher : how do you do it?
4. Ajeng : it is in here (pointing figure 5.22(vi) and then pointing its location in figure 5.22(i))
5. Researcher : How do you know?
6. Ajeng : I know it from here (pointing the picture of the wall on the map). This one is this (pointing the picture of the wall on the map and then showing figure 5.22(vi)). So, from the top, the location should be like this. (she means the wall should be looked like on the map if she see it from the top view, thus she decide that the picture of 5.22(vi) should be on ii)
7. Researcher : hmm..
8. Ajeng : If this one (Show the figure 5.22(iv)) I consider its direction.
9. Researcher : How about that one? Where it suppose to be? (pointing figure 5.22(iv))
10. Ajeng : Consider its direction (see figure figure 5.22(iv)) and then put it on iv). Here!
11. Researcher : Why is it there?
12. Ajeng : This is in here (pointing the picture of the gate in figure 5.22(iv)) and then pointing the picture of gate on the map)
13. Researcher : How about this one? (pointing the picture of the gate on figure 5.22(iv)) on the right side or on the left side?
14. Ajeng : Right!
15. Researcher : How about this one? (pointing the picture of the tower on figure 5.22(iv)). Where is this?
16. Ajeng : Left!
17. Researcher : Yes, left. So, if this one is on the right (pointing the gate) and this one is on the left (pointing the wall)…
18. Ajeng : (silence and thinking)
19. Alycia : You suppose to put it in here! (taking the picture from Ajeng's hand and put it on the correct position)
20. Ajeng : Oh, yes.

Ajeng does use the notion of 'direction' in solving the problem. The notion of 'direction' shows that the students do understand something. Yet, from the dialogue we cannot see how the notion of 'direction' helps her in solving the

problem. The fact that she chooses the pictures twice wrong indicates that she still cannot relate her understanding in solving the problem.

From the dialogue we can see how the navigational term are not used in her explanation. The terminology is started to use after the researcher mention it. Soon when the students start to use the navigational term, we find that the students are able to finish the task easily.

The learning activity is continued by gathering all students' work and glues it on the blackboard. Then the teacher checks students' work and tells which groups match the pictures correctly. There is no further discussion about why a picture should be located in a certain position. What teacher does in the discussion session is just clarify which group match the pictures correctly and introduce the map as the top view of the miniature. The learning activities are closed by introducing the term "top view" and "side view". The way teacher introduce the side view and the top view was out of the HLT. She takes a rectangular cuboid and then showing it to her students. Due to some technical problem, the conversation is transcribed in the field notes. The following transcript is noted from the research field notes.

1. Teacher : Does anybody know what the name of this object is?
2. Students : RECTANGLE! SQUARE! RECTANGULAR CUBOID!
3. Teacher : Does anybody know?
4. Students : (silent)
5. Teacher : I hear somebody said the correct answer!
6. Students : (silent)
7. Teacher : Its name is rectangular cuboid. Well, since we have never learnt about it, let us call it as block. Today, we have already learnt about top view and yesterday we learnt about the side view. Now, if I show this part of block, what plane figure can you see?
8. Students : SQUARE!
9. Teacher : What about in the top?
10. Students : RECTANGLE!

11. Teacher : Well, the view of the object if we see it from the top is called top view. Meanwhile, the view of the object if we see it from its side is called side view. So, today we have already learnt about two terms: top view and the side view. From now on we will use those two terms. What was that?
12. Students : the top view and the side view
13. Teacher : So, what is the top view of this book? (Shows the binding of absence book)
14. Students : RECTANGLE!
15. Students : NO! A LINE!

For this moment teacher stopped the activity and leaved the question for students to thinking.

Discussion

Based on the observation and the analysis of students' works, we find that there are many different strategies used by the students in solving this problem. Almost all of the groups do not use the miniature in solving the problem. We only find a group who compare the pictures with the real situation (miniature). For the groups who do not use the miniature, we find many different strategies. The comparison between the prediction of students' strategy in the HLT and in the ALT can be seen on table 5.6.

Table 5.6.

Table of Comparison between Conjecture of HLT and ALT in Lesson 2

No	HLT	ALT
1	Some students may do trial-error	Some students use the trial and error strategy
2	Some students may consider the position and the location of the objects that are shown by the pictures	Some students consider the position and the location of the objects that are shown by the pictures

3	Some students may only consider the position of the objects by ignoring the location of the objects	Some students only consider which object is in the left and which object is in the right
4	Some students may only consider the location of the objects by ignoring the position of the objects	do not appear

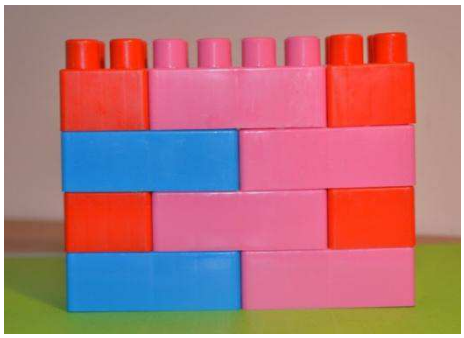
From table 5.6 we can see that some students consider the position of the object on the pictures. This fact indicates that students learn about the concept of parallel projection. We even find that some students consider both its location and position. It shows that the students learn about the parallel projection and perspective projection. In this lesson, the students are introduced to one of the important idea and concept in geometry, namely top view. After the students experience this lesson, they start to use and develop the idea of side view and top view.

5.6.2.3. Lesson 3: Exploring the Wall

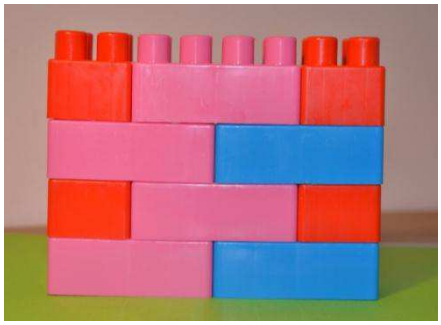
Exploring the wall is the zoom-in of the first and the second activities. The main goal of this activity is to introduce the other important visual terms, namely front view, left view, back view, and right view. The learning activity is started by showing the wall used in the previous activity and then asking them what they see from a specific view. Since in the previous meeting they have already known that the top view of the wall is as shown in the figure 5.24, it is easy to convince them that if they see the wall from the top, they will only see the bullets. But when the teacher asks the students about which part of the wall that they can see from the left side, some of them seem confused. The following conversation shows the discussion between the teacher and the students.

1. Teacher : If I show this part of the wall, which side that can you see? (showing the part of the wall as shown in figure 4…)
2. Students : Only the small part!
3. Students who were sitting in the corner: No, we can see the wide part as well!
4. Teacher : Ok, how if I turn the wall to be like this? (turning the small part of the wall to those students)
5. One of students who were sitting in the corner : yes, I only see the small part!
6. Teacher : Suppose that this part is the front of the wall, if I asked you to draw its front view, which part will you draw?!
7. Students : the small part!
8. Teacher : so, do you need to draw the wide part?
9. Students : NO!

The fact that some students state that they can see the wide part of the wall show that the students still do not fully get the idea of front view. Based on our observation, this presumably happen because the idea of closing one of the eye while observing are left. The teacher does not mention or suggest the students to close one of their eyes in observing the wall.



(i)



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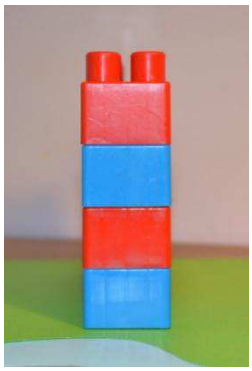

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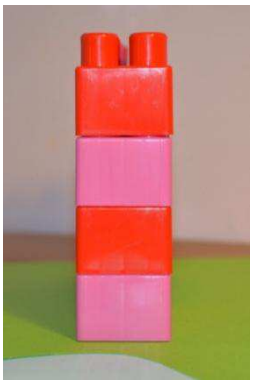

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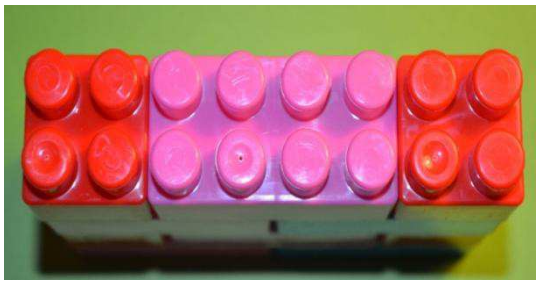


(v)

Figure 5.23 The pictures of the wall which are taken from different view: (i) front view, (ii) back view, (iii) left view, (iv) right view, (v) top view

Then the teacher shows the pictures of the wall (see figure 5.23). The picture of the wall showed are taken from top view, front view, left view, back view, and right view. While showing the pictures, the teacher introduces the term front view, left view, back view, and right view. After that, the teacher continues the learning activity by telling the students about the problem that they would work with.

In the beginning, Ajeng, Aliya, Alycia, and Najwa solve the problems given without using the cubes and the blocks until the teacher told them to use the cubes and the blocks. Before they use the cubes and the blocks, they draw the left view and the right view of the wall just from a wall that is arbitrary constructed. After the teacher asks them to construct the wall as shown in the worksheet, they then start to redo their task. This group has no difficulty in solving the first problem; it is probably because the first wall has the similar characteristic with the wall shown in the beginning of learning activity. The students could easily identify the right view, the left view, and the top view of the wall.

As described in the revised HLT part, the difficulties of the problems are gradually increased. We modified the second and the third problem as such way so that the students will grasp the idea of drawing the part that is immersed. There is a small debate between Ajeng and Alycia when they were solving the second problem. This conversation happen when they are about to answer the second question of the second problem, namely to draw the left and the right view of the wall.

1. Ajeng : The right view and the left view. This is it. All of them should be square.
2. Alycia : (Keep drawing and ignore Ajeng's statement)
3. Ajeng : Square!
4. Alycia : The drawing is not something like that.
5. Ajeng : It is square, isn't it? (Trying to get Alycia and Aliya's support). It supposed to be square, just exactly like this (pointing the square). It is little immersed.
6. Alycia : It is goes into, isn't it? (keep drawing)
7. Ajeng : Yes
8. Alycia : Well, it is clear now! Haa… I make a mistake (putting her pencil)
9. Ajeng : Wait a minute! … Wait a minute! (She seems unsatisfied with Alycia's drawing)
10. Alycia : ERASER! (She is looked sullen)
11. Ajeng : (open her pencil case and give the eraser to Anisa).

From the conversation we can see different level of students' interpretation. Ajeng does understand that the side view of the wall should be square, but Alycia has different interpretation. Alycia interprets the left view as the front view of the bricks that is visible from the left view. Alycia seems affected by the drawing on the worksheet. In here opinion the drawing has shown everything, so she does not ned to see the "real" wall constructed by her friend, Aliya. Apparently, she drew the left side and the right side of the wall just by seeing the picture on the worksheet. Meanwhile, Ajeng interprets the left view of the wall as the part of the wall that is visible from the left side. Even though they have different ideas, both Ajeng and Alycia agreed that they should draw the immersed part.

Although Alycia said that her drawing is incorrect, she does not change her drawing. After she erases the drawing, Alycia made the same drawing as the previous one with the larger size. Figure 5.24 shows how Alycia draw the right and left view of the second wall.

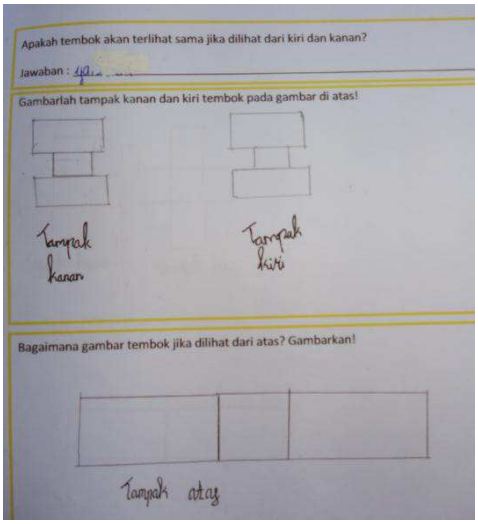


Figure 5.24 Alycia drawing on problem 2.

If in the second problem the immersed parts are only in the left and right side, in the third problem the immersed parts are also in the top. How Ajeng and

friends draw the left view, right view, and the top view of the third wall is shown in figure 5.25. In order to get the confirmation about this drawing, we conducted an unstructured interview after the learning activity. Aliya, the student who draw the left view and the right view, says that the squares on the top and the bottom represent the block on the third and the first layer respectively. If you see the figure 5.25, you will find that Aliya draw three squares. According to Aliya, the square in the left and the right represent the top and the bottom part of the goes out block. In accordance, the square in the middle represent the side view of the goes out block.

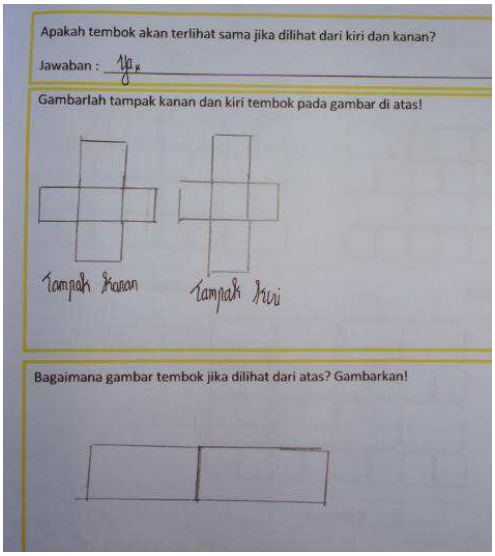


Figure 5.25. Students' drawing on problem 3

The students find no difficulties on drawing the top view of the walls. When they drew the top view of the first wall, they see the wall from the top. In order to draw the wall precisely, Alycia even uses the ruler to measure the bricks. They kept on drawing on that way until Alycia suggests them to make a representative drawing. When they draw the top view of the second wall, they no longer see the wall from the top as they did before. Those students can draw it just by seeing the

wall from the bird eye view. However, this strategy does not help them when they solve the third problem correctly. Those students ignore the fact that there are some parts of blocks on the second layer which can be seen from the top. This Indeed, these parts should be drawn as well.

At the end of the activity, the students have classroom discussion. During the discussion session teacher shows the picture of those walls which show the right view, left view, back view, front view, and the top view of the walls. She just shows the students the correct drawing for problem 1, problem 2, and problem 3, without any discussion why the drawing should be drawn as such way. The teacher ends the learning activity by asking which group answer all the problem correctly.

Discussion

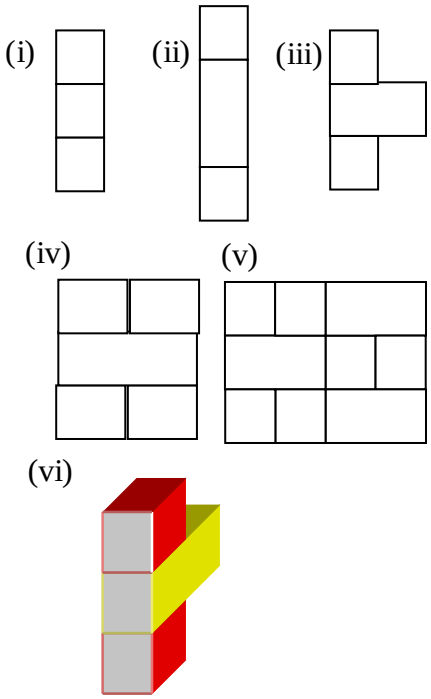
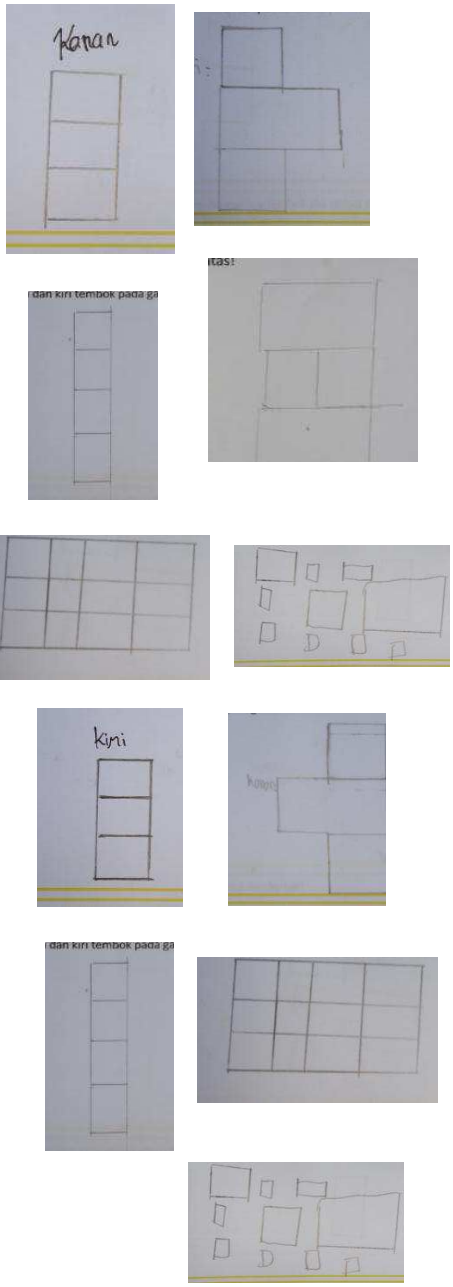
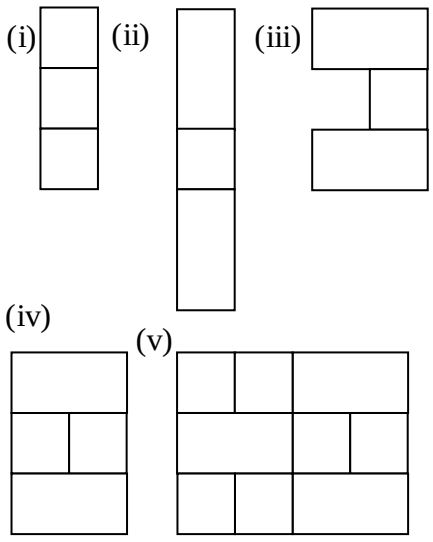
In this activity, we find that the students have difficulties when they are dealing with problem 2 and problem 3. Those students have different interpretation and different argumentation in drawing the left view, the right view, and the top view of the wall. As the result, the students' works are varies. Some students draw the immersed part of the wall and some others do not. The students who draw the immersed part of the wall think that because there are the immersed parts, so the drawing of the immersed part should be shown on the drawing. Thus, people can see how those three walls are different. Meanwhile some students have really abstract thinking, the just draw the left view, right view, and top view of the wall by squares and rectangles.

Different interpretation that is supported by different arguments creates variation in students' works. Most of them are fixed with the conjecture of

student's thinking and reaction in HLT part; some others are completely out of our predictions. Table 5.7 shows the comparison between the conjecture of students' thinking and reaction in HLT and the ALT.

Table 5.7.

Table of Comparison between Conjecture of HLT and ALT in Lesson 3

VIEW	HLT	ALT
	PROBLEM 1	
Right		
Left		

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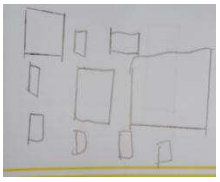

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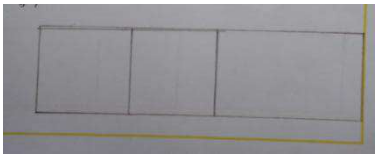

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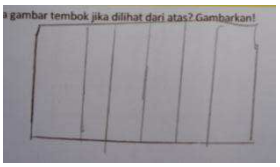

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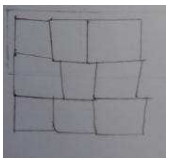

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PROBLEM 2

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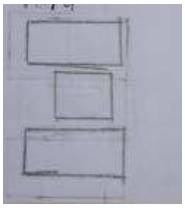

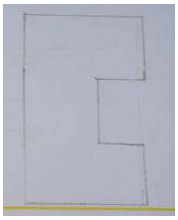

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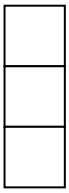

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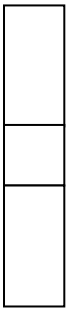

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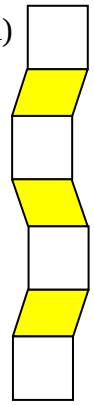

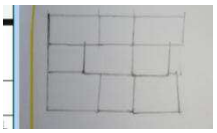

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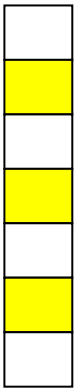

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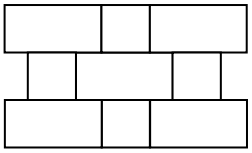

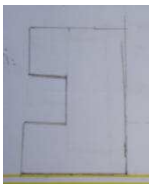

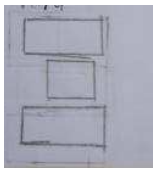

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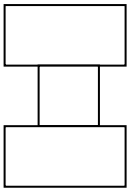

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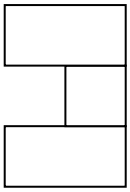

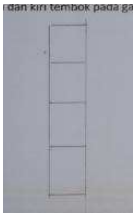

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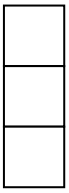

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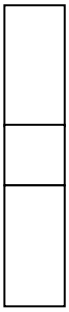

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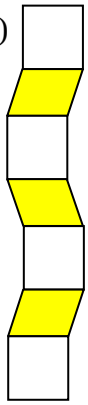

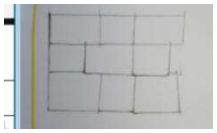

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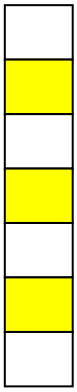

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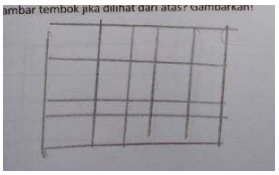

PROBLEM 3

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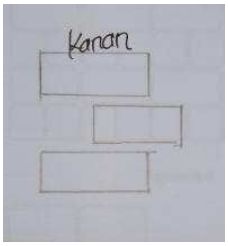
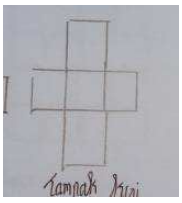
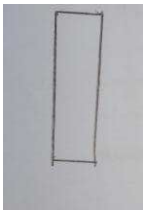
(viii)







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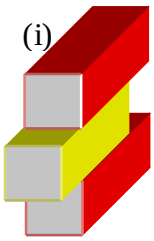
(i)



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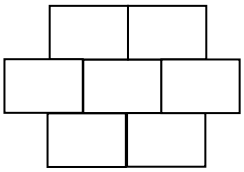

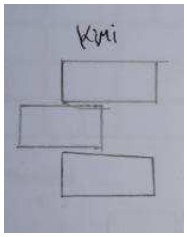

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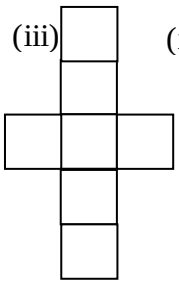

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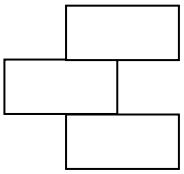

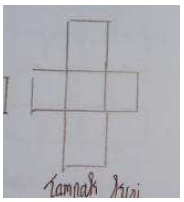

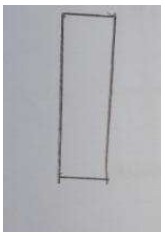

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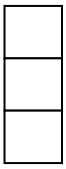

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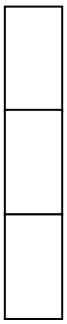

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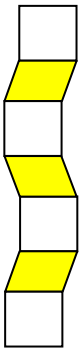

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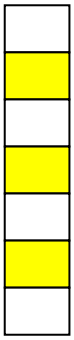
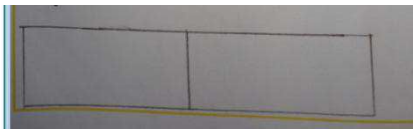


Top

(i)



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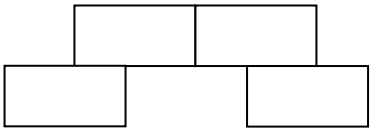

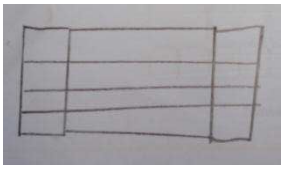

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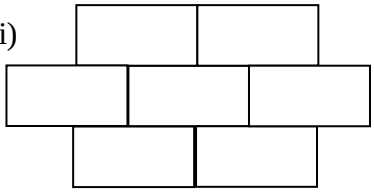

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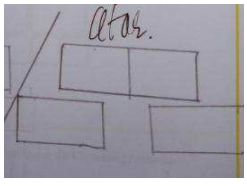


(v)

In general, we find that the strategy used by the students while drawing the top view is gradually increased. In solving the first problem, the students still need to see the wall from the top. In solving the second problem, the students just see the wall from the bird eye view. In solving the third problem, they just see the wall from the front view. After experiencing this lesson, the students start to use the spatial term such as left view, right view, front view, right view, and top view.

5.6.2.4. Lesson 4: The Adventure in the Cube Houses

Lesson 4 is done in two different meetings. The first meeting is conducted in the same day of the 3rd lesson, and the second meeting is conducted 10 days later. The first meeting is started by telling the student about the context and the problems that they will work with. In the first meeting students are asked to solve the first and the second problem. In the first problem, the students are asked to construct the cube house as shown in the students' worksheet. We notice that the instruction given to the students are not clear enough. Therefore, the first 10 minutes are spent just to discuss about what the tasks.

Regarding to this problem, the teacher then explain once again about the task. We find various kinds of students' drawing. Most of them are fixed with the conjecture of students' thinking and reaction in the HLT, and some of them are out of our prediction.

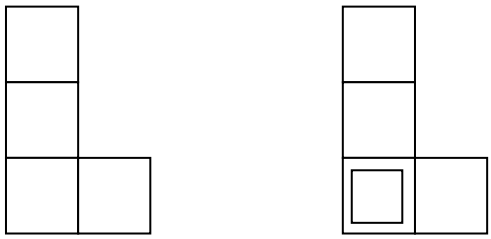
While the students are dealing with the second task, we observe that there are some group who do not construct a new cube house. Those students use the cube house that is used in the first problem as the second task. Due to the 6th grade examination issues, at the time the headmaster announce that whole of the school is having a cleaning activity. This announcement disturbs students' concentration in learning. Furthermore, when the other classrooms are starting the cleaning activity, the school suddenly become so noisy. Therefore, the students cannot focus on doing the task anymore. This non-conducive learning activity makes us decide to stop the learning activity on this stage.

Based on the students' works on the first meeting of the fourth lesson, we find that some students are really struggling with the first and second problem.

Some of them even cannot finish the second problem. We notice that it because of the instruction given is not clear enough. From the students' work, we also find that some students draw the cube house as a three-dimensional representation.

The learning activity is continued ten days later. We are afraid that this fact will bring some disadvantages in the learning process since ten days may create a gap in students' understanding. Considering the time gap and the result shown by students' work, we decide to change the learning trajectory. Instead of continuing students' working on the third problem, we have discussion session. The discussion is aimed to remind the students about the tasks that the students dealt in the previous meeting and to discuss about students' work.

In the beginning of discussion, the teacher asks one of the students to construct the first cube house as they remember. One of the students, Rafi, raises his hand and constructs the cube house on the play ground. We find that Rafi and his friends remember well the tasks. The teacher then asks the students to draw the right view of the wall as what the students drew in their worksheets last meeting. Kharisya raises her hand and draw the right view of the cube house. All of the students agree with Kharisya's drawing. It is because of Kharisya draws it correctly. Rafi raises his hand and draws the right view as shown in figure 5.26 (i). Next, the teacher asks whether any students have different opinion. Kharisya raises her hand and then draws the right view of the cube house as shown in figure 5.26 (ii). Teacher asks whether any students have different opinion once more. However, there is no other students raise their hands.



(i) (ii)

Figure 5.26. Students' drawing in the discussion: (i) Rafi's drawing, (ii) Kharisya's drawing

The discussion is started by asking the students who agree with Kharisya's drawing and who do not. We find that all the girls agree with Kharisya's. Meanwhile all of the boys choose Rafi's drawing. The following discussion show how the students' discuss about the right view of the first cube house.

1. Teacher : Now who can draw the front view?
2. Rafi : (raises his hand)
3. Teacher : Yes, Rafi! (pointing Rafi)
4. Rafi : (drawing the front view)

The classroom is too noisy. Rafi seems affected by his friends, so the teacher tries to get back the other students' attention and make them silent. While drawing the front view, Rafi frequently sees the cube house to make sure that he draws it correctly. While trying to finish his drawing, Kharisya interrupts Rafi.

5. Kharisya: You should draw the goes out part! Your drawing is not looked like the cube house! (pointing Rafi's drawing by her right hand and the cube house by her left side at the same time)
6. Rafi : (see the cube house and continuing his drawing)
7. Teacher : Have you finish, Rafi?! Who do agree with Rafi's drawing?
8. Boys : I do!
9. Teacher : Who don't agree with Rafi's answer?
10. Rizki : I don't agree!
11. Teacher : Why don't you agree?
12. Rizki : Because the drawing is ugly!
13. Students : Huuuu...!!!
14. Teacher : Salsabila, do you think that Rafi's drawing is correct?
15. Salsabila : (silent)
16. Liza : It is ..... (inaudible)!
17. Teacher : Why it is incorrect, Liza?
18. Liza : It is correct, I agree with Rafi's drawing!

19. Suddenly the students become so noisy, so the teacher has to make the students be quite. The teacher continues the discussion by asking who has different opinion.
20. Teacher : Why it is incorrect?
21. Najwa : (raises her hand) Because it is similar with Kharisya's drawing.
22. Teacher : So, how should be the drawing? You are free to give your opinion!
23. Kharisya : It is incorrect because there is the goes-out part in the cube house!
24. Teacher : So, how should be the drawing? Who want to draw it? If there is a mistake you may revise it. Iqbal, do you want to try it?
25. Iqbal : (shake his head)
26. Kharisya : (raises her hand)
27. Teacher : Come on Kharisya!

Kharisya draws the front view of the cube house and explain her reason

28. Kharisya : Because there is goes-out part, we should draw it. But this one (pointing Rafi's drawing) does not show it.

Soon after Kharisya gives her reason, the students are involved in the discussion. The students start arguing Rafi's drawing. Kharisya's statement successfully evokes the students' argumentation. Some students discuss this issue with the students who sit next to them; even Rafi seems doubt on his drawing but he does not change his answer. The teacher then show the picture of the cube house which is taken from front view, and explain whose answer is correct, and why it is incorrect. Some students cannot accept the teacher's explanation and keep arguing it. However, the teacher stops the discussion and tells the students to do not protest anymore.

From the discussing we can see how the students develop their understanding on the concept of front view. Both Rafi and Kharisya show different level of understanding and interpretation. Rafi interprets the front view as the part that is visible if we see it from the front and ignores the fact that there is a goes-out part. Meanwhile, in Kharisya's opinion, we should draw the goes-out part in order to show how it is different with the others view. It gives us clearer

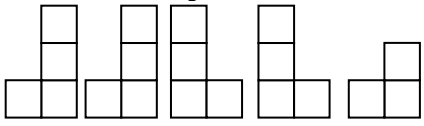
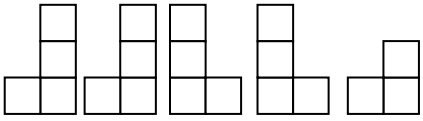
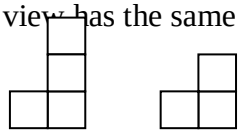
description why some students draw the immersed part of the cube house. We observe that during working on the first and second problems, most of the students do not close one of their eyes in observing the cube house. The way Kharisya reason her answer show that what she 'see' the front view from the fact, not based on what she observe.

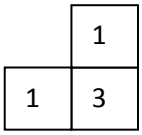
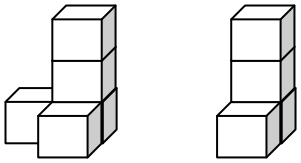
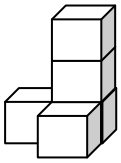
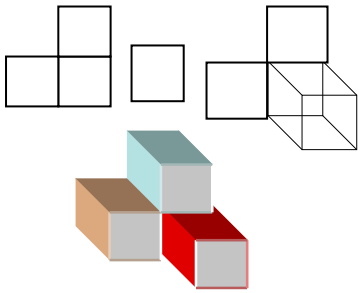
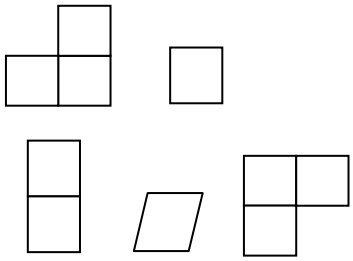
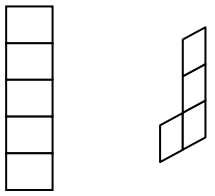
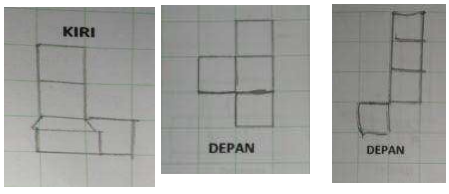
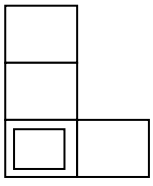
The learning activity is continued by giving exercise for the students to construct the cube house from 4 wooden cubes and draw its view. After the students finish the task, the teacher ends the learning activity.

Discussion

We see various of students' work in all three problems given. Because the second and the third problem are open problems, in this part we will only compare the first problem (see: Table 5.8). We also see that the students come up with different interpretation that is supported by certain arguments. The different way of interpretation make the result of students' working are various.

Table 5.8.
Table of Comparison between Conjecture of HLT and ALT in Lesson 4

NO	HLT	ALT
1	Some groups may draw exactly as what we expected  FV RV BV LV TV	Some groups may draw exactly as what we expected  FV RV BV LV TV
2	Some groups may draw all the side views as the same drawing because they state that all of the side view has the same drawing.  SV TV	Does not appear

3	Some students may draw the top view of the cubes building and indicate the height numbers 	Does not appear
4	Some students may draw the three dimensional representation of the cubes 	Students draw the three dimensional representation drawing. 
5	Some students may draw the top view as shown by the following pictures 	Students draw the top view as shown by the following pictures 
6	Some group my draw something like this 	Does not appear
7	-	some students draw the side view as shown in the following pictures  

In Table 5.8 we can see that some students draw the three dimensional-drawing of cube house. It indicates that these students do not understand the instruction given. If we see the more detailed, the students do not have any difficulty in identifying the right view and the back view. The difficult part is indentifying the front and the left view, because there are some goes-out cubes.

In general, we see that the students tend to draw the top view of the cube house as one square and three combined squares. The differences appear because of different level of understanding and interpretation. For those students who draw a square as the top view, this probably because in their thinking the top view is the part the upper part of the cube house. The students who draw three square have higher level of understanding and interpretation. They define the top view of the cube house as the part of the cube house that is visible if they see it from the top.

We have seen that during this lesson, the students actively use the spatial terms in discussing their work. In this lesson, the students also start to develop their understanding in identifying and observing the three dimensional object.

5.6.2.5. Lesson 5: Finding the Treasure

Lesson 5 is started after the students finish solving problem 3 in lesson 4. The learning activity is started by telling the students about the context and the problems that they will work with. The students are struggling in solving the tasks. We observe that for the first problem, almost all of the groups come up with the construction that is shown by figure 5.27. As well as the other groups, the focus group is really struggling in solving this task. At the time, they start by constructing the top view and leave it out. They do not continue their work and seem confused. When we ask them why they stop working, they just say “this is difficult”.

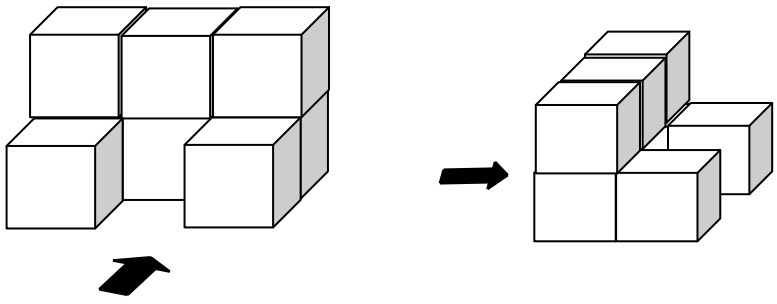
Figure 5.27. Students construction on the first cube house

We then leave the focus group and observe Khalisya’s group. Khalisya and friends construction is similar with other groups. They start the construction from the front view, and then construct the left view by using other cubes. The students continue constructing the top view cube house. Figure 5.27 shows how Khalisya and her friends construct the first cube house. After constructing the front, left, and top view of the cube house, the students stop working.

Because all of the students are really struggling in solving the first problem, the teacher then asks all of the students to solve the problem together. Teacher demonstrates the way to solve the first problem, namely starting from the top view. Teacher also discusses why they should not put a cube next to the other cubes. We find that the teacher starts the construction from top view of the cube house, but she says that the students may also start from left and front view. After demonstrating, the teacher leaves the second and the third problem to the students.

We see that after the students know how to deal with this task, they are able to solve the second and third problem. However, there are some groups who still need to be guided. For this group, the teacher and researcher assist them in solving this problem.

We then observe the focus group. We find that they have finished the tasks. When we ask them to demonstrate the way they constructing the third cube house, we find that they start the construction from the top view. The students say that by starting from the top view, they will know which part that should be added by the cubes and which part should not be added. Furthermore, the students say that it will be more effective. Considering the immersed part, the students say that the front view sometime does not tell what exactly they want to know.



(i) (ii)

Figure 5.28. The third problem of lesson 5: (i) the correct construction, (ii) the focus group construction

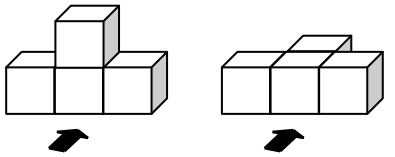
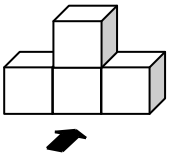
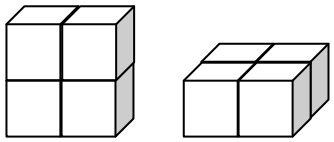
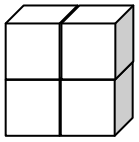
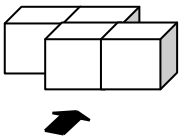
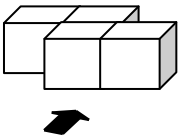
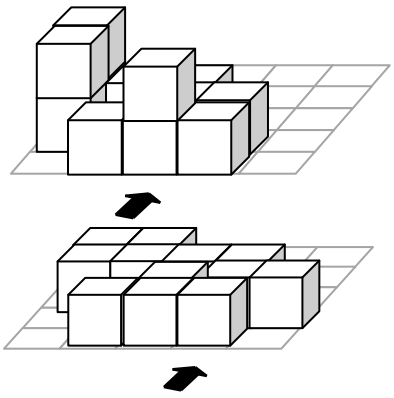
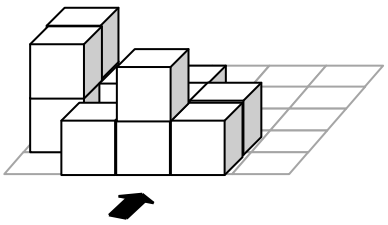
Ajeng and her friends (the focus group) construct the cube house as shown in 5.28 (ii). It is the reversed one. We notice that it is because of these students ignore the role of black arrow. The black arrow indicates which direction is the front view. In the end of learning activity we discuss with the teacher and we find that we miss the part of introducing the role of black arrow. The learning activity is stopped after the students finish working on the third problem.

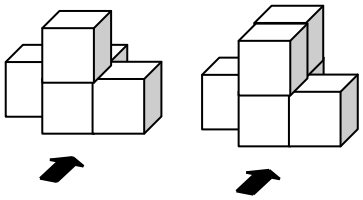
Discussion

In this lesson, we find that the students are struggling with the tasks given. This task is considered difficult for the students. In the first problem, most of the students come up with the similar strategy as shown in the figure 5.27. We notice that some groups make similar mistake with the focus group in solving problem 3. Based on the analysis we notice that it is because we do not introduce the role of the black arrow. As the result, instead of having cube house as shown as figure 5.28 (i), the students construct the cube house as shown in figure 5.28 (ii). Since the teacher have demonstrated the way of constructing the cube house in the beginning, it will be not efficient if we describe the way of the students solve the problem in detail. Therefore, in this part, we will focus on comparing the conjecture of students' thinking and reaction in solving problem 1. Nevertheless, we still compare students' final solution in problem 2 and problem. Table 5.9 show the comparison between the conjecture of students' thinking and reaction in HLT, and the ALT.

Table 5.8.

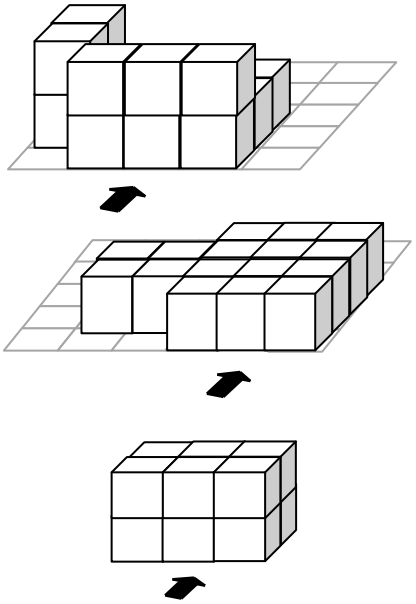
Table of Comparison between Conjecture of HLT and ALT in Lesson 5

NO	HLT	ALT
	PROBLEM 1	
1	Some students may start the construction from the front view 	Some students start the construction from the front view 
2	Some students may start the construction from the left view 	Some students start the construction from the left view 
3	Some students may start the construction from the top view 	Some students start the construction from the top view 
4	Some students may combine the cubes as shown by the following drawings 	Some students combine the cubes as shown by the following drawings 
6	Students may construct as shown in the following construction	Does not appear

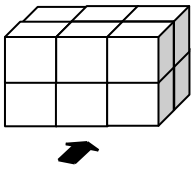


PROBLEM 2

7 Students may come up with the following construction

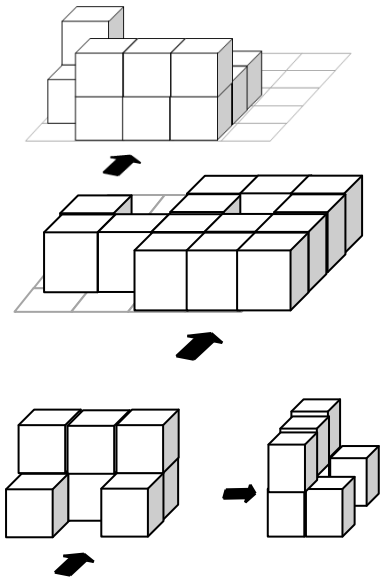


Students come up with the following drawing

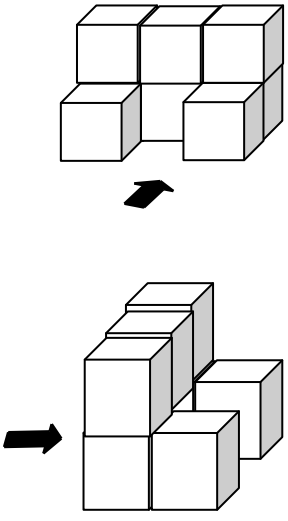


PROBLEM 3

8 Students may come up with the following construction



Students come up with the following drawing



5.6.3. Post-Test

The post-test is aimed to know the development of students' spatial ability after experiencing the learning sequence. We use the same task that is used in the pilot experiment.

Task 1

The task 1 in the post-test is the second task of the pre-assessment. Task 1 consists of two problems. Based on the analysis of students' works, we find that there are 12 students who answer the first problem correctly and there are 1 student students who answer the second problem correctly. Surprisingly, the number of students who answer both problems correctly is decreased become 9 students.

Although the number of students who are able to answer task 1 correctly is decreased, we see the improvement of strategy used by the students in solving this problem. The students start to analyse the pictures and the drawing. If we compare the way of students in solving the pre-test and their way in solving the post-test, we see that they treat the pictures differently. All of sudden, the pictures become meaningful for them. We see that almost half of the students make mistake, but they do different kind of mistake. The mistake that the students make in the pre-test is because they just pick an answer; meanwhile the mistake that the students make in the post test is because of the wrong analysis. In conclusion, after the student experience the learning sequence, the students start to use their spatial ability in solving task 1.

Task 2

In task 2, the students are asked to count the number of cubes that is used to construct the cube houses and draw its side view and its top view. In solving this

task, the students are not provided by the wooden cubes anymore. They just rely on the three-dimensional drawing of the cube house. We see that the strategy used in solving this strategy is unique. Since they do not have the real cube house they try to see the drawing from the top as if they see the real cube. Figure 5.29 show how Ajeng observe the cube house. We find various of students drawing in solving this problem. Yet, there is no students come up with three-dimensional drawing. It shows that the students start to develop their ability in representing the three dimensional drawing.

Figure 5.29. Ajeng is observing the drawing of cube house

We see that there is some strategy use by the students in counting the cubes. All of the strategy used show that the students understand that even though they cannot see some cubes, they understand there are some invisible cubes. Being able to understand this fact means that the students develop their ability in reading the drawing and relate their spatial ability in reasoning their answer. However, there are some students who miscount the number of cubes. This is because they cannot 'read' the drawing correctly. These students need more guidance in supporting their spatial ability development.

CHAPTER VI

CONCLUSION AND SUGGESTION

In this chapter we will answer the research question based on some findings in retrospective analysis and we will reflect our findings based on some findings in the previous study. In this chapter we will also elaborate recommendation for further studies in this domain.

6.1. Conclusion

Before elaborating the general conclusion to the result of this study, it should be noticed that this study is implemented in limited setting and scope. The conclusion on this study is restricted on the specific target group. Therefore, different classroom and environmental setting may bring different results.

This research is aimed to support the development of students' spatial ability. In order to reach this aim, we pose How can the spatial visualisation and *spatial orientation tasks support the development of students' spatial ability*? as the research question. Based on the retrospective analysis, we find that after experiencing the learning activity the students are start to use their spatial ability in solving the problems. We answer our research question by describing the development of students' strategy in solving the problem during the sequence of students' learning and based on the analysis of the result of pre-test and post-test.

To get a general conclusion on how the development of student' spatial ability is occurred. We firstly describe the comparison of the result of the pre-test and the post-test. Based on the analysis of students' answer in pre-test and post-test, we find that the students use their spatial visualisation and spatial orientation sense in answering the problems. All of the sudden, the pictures which was not

important become important. The students start to analyse those pictures. The students also start to consider the position of the objects and use the navigational terms such as left and right in solving the spatial problem. We also see that after experiencing the sequence of learning activities, none of the students draw the side view and top view of the cube house as three-dimensional representation drawing. Nevertheless, the students also develop their sightseeing idea such as left view, front view, right view, back view, and top view.

In conclusion, after experiencing this series of activity, the students develop their ability in reading, interpreting and reasoning a 2-dimensional drawing. The result of this study also shows that after experiencing the learning activities, the students relate their knowledge in read, interpret and count the three-dimensional drawing of cubes house. This finding supports the result of Pittalis & Christou (2010) study which suggested that preferences and experiences in spatial visualisation significantly related to students' practical abilities in three-dimensional arrays of cubes.

We also find that the last two lesson (cube houses) support the development of both students' spatial visualisation ability. It is showed by the fact that the students are able to relate their experience in lesson 4 and lesson 5 in counting the number of cubes in the cube arrays. This finding supports the result of Revina et al. (2011) study.

6.2. Reflection on Important Issues

In this study we do not only focus on describing how the development of students' spatial ability through experiencing the spatial visualisation and spatial orientation task, but also on describing how the classroom discussion support in developing

students' understanding. We also observe how the role of teacher in supporting the learning activity and bridging the students in grasping the concepts.

This design underlies RME as a teaching and learning approach. Thus, we are also interested to know how this approach supports the development of students' spatial ability. In this part, we will reflect on how these issues affect this study. These important issues will be discussed in the following separated sections.

6.2.1. Realistic Mathematics Education

In designing the learning design, we use RME as an approach in the learning activity. Thus, the ideas in the instructional activities are developed based on the RME principles. The RME emphasises the bottom-up principle, in which the learning activity is suggested to be started from the students' experientially situation to the abstract level. In this study, the lesson series developed are aimed to develop students' spatial ability from the situational problem to the higher level problem. So, the levels of difficulty of the tasks are gradually increased. Each lesson brings different goals that are supporting each other.

Furthermore, one of the tenets in RME is the use of context. In this study we also use contexts that help us to engage the students to the material. The context facilitates the observing activity and students' analysing activity. However, we realise that the context does not enable the students to come up with navigational terms. Therefore, we need to modify the context or adding more instructional guidance for teacher to enable the idea of using navigational term raises.

6.2.2. Classroom Discussion

We find that these students get used to have classroom discussion. However, we observe that there is unsupportive environment and social norm in this classroom. We have seen that most of the students cannot easily give their opinion. This fact make the classroom discussion become less fruitful. As well as the typical classroom situation, only the higher achiever students are actively involved in the classroom discussion. We also see that these students cannot elaborate their reasons well. This is because they are not accustomed to do so. In contrary, even though the students cannot actively give their opinion, these students are always being criticised in receiving an answer and opinion. Those students are accustomed to ask why an answer is correct or incorrect. This is a good socio-mathematical norm that has already existed before we conduct this study.

During working on the small group, we observe that there are some students who do not actively participate in the discussion. These students are relied the tasks on the higher achiever students without giving a significant contribution.

6.2.3. The Role of Teacher

Teacher plays a really significant role in the learning process. The teacher that is involved in this study has 28 years experience in teaching. She has experienced involving in some studies, therefore she are not looked awkward to be observed in the video. However, working on the design research is something new for her. She is also not familiar with the topic of spatial ability. But even so, she has shown a good performance in supporting the learning activity and to make sure that the students understand the problems.

We observe that managing the classroom discussion is not easy for the teacher. The teacher frequently stops the discussion when the students seem unsatisfied with teacher's explanation. She ends the discussion by stating that what she shows is the correct answer. She does not elaborate or try to compare why an answer is correct instead of the others. It happens because the teacher is not familiar with the topic. However, she has been trying to promote the development of students' spatial ability.

6.3. Suggestion

In this section we will give some recommendation on the implementation of RME approach in learning activity in the classroom, on how we can develop student's spatial ability and some recommendation for further studies in this research domain. The recommendation will be elaborated on the following separated sub-section.

6.3.1. Realistic Mathematics Education

Reflecting on how the RME approach support the learning activity on this study, we think that these approach may also support the students in learning other mathematics materials. This conclusion is made based on how the RME principles help to occupy the gap that probably creates on this study. We realise that students need reason to do something; they need to know what the important idea of doing something is. The use of context principle helps us to solve this problem. Not only to engage the students, the context used in this study is also to facilitate the students' learning process.

The idea of starting the learning activity from the situational problem also enables the students to see that geometry is not completely an abstract subject. The

idea behind of the mathematics comes up from the human situational problem. This enables the students to see the mathematics as a human activity, not only about the rules and procedures that should be memorised.

6.3.2. Developing Students' Spatial Ability

The topic of spatial ability is still lack of attention in Indonesia. It is because of our learning style is more centred on numeration. Therefore, the space for this topic that is provided for students is limited. We have seen how some spatial visualisation and spatial orientation task promote the development of students' spatial ability. A lot of studies have shown the emerging of spatial ability in both students' education and in their occupational life. Therefore, we recommend giving more exercise to the students in order to let our students optimally develop their spatial ability.

6.3.3. Further Studies

We realise that the tasks that we developed in this study is aimed to help the students in grasping the geometry concept on the higher grades. Therefore, we suggest a further study on how this design promotes students' understanding in solving the geometry problem. To be precise, we suggest a further study about how the spatial ability that students has been developed after experiencing this learning sequence support students understanding on the geometry.

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APPENDICES

APPENDIX I

List of observation scheme

Classroom culture and atmosphere of the classroom

- How the interaction between students and the teacher
- How the interaction among the students
- How the classroom is set up?
- Do the students enthusiastic on the learning?
- Does the students look enjoy the learning activity or look stress?

Role of students

- Who are the active learners?
- Who are the passive learners?
- Who always do make a noise in the classroom?
- Who are the silence students?
- What do students do when teacher explaining something?
- How the students deal with the material?
- How students response when teacher asking something?
- How students' response when they find difficulties on doing the task, do they ask to their friend, or ask directly to the teacher?

Role of teacher

- How the teacher starts the learning activity
- How the teacher teaches the material, what methods she/he use
- Do the students always rely on her/him (she/he is the only trusted source)?
- How the teacher ends up the learning activity

Mathematical activity

- What type or questions the students have, is it open ended question or closed question
- Do the students criticize what the teacher says?
- Do the students use one strategy or they use different strategy
- Is there any discussion about how the way students solve the problem?
- How they discuss about the difference strategies and answer

Classroom Discussion

- Do the students have the discussion?
- How the role of teacher in the discussion?
- Do all the students participate on it?
- How the responses of the students if they have discussion?

List of interview scheme

About the personal information:

- How long have you been teaching?
- Are you specialized in teaching mathematics or the entire subject?
- Would you like to tell me about your background education?

The system of learning process:

- What method do you frequently use in teaching mathematics?
- Do the students always have discussion in the classroom?
- How do you manage the discussion?
- Are the students accustomed in telling their opinion or idea?
- Have you taught the students by giving the worksheet?

The social norm in the classroom:

- What students always do if they want to say something or ask something? Do they come to your desk or raise their hand and then wait until you come?
- If the students make a noise, how do you always do to get their attention?
- Are they accustomed with peer review, and peer study?

About the PMRI:

- What do you know about RME?
- Do you always use this approach in teaching mathematics?
- How the responses of the students when learning mathematics by this approach?

About the students:

- How many students in your classroom? (please mention the number of girls and boys)
- What are their ages?
- How are their grades in general?
- Who are the higher achiever, medium, and lower achievers?
- Who are the active and the passive students?
- Who always do make a noise in the classroom?
- Are they accustomed to think critically and giving their opinion?
- Do they have problem in reading and understanding the text?
- Are they accustomed to work with worksheet?
- Are they accustomed to work in group?
- How do you group them? How many students that you always grouped in one group?
- How they response when they work in group?
- Do they really solve the problem together or just solve it by individually?

About my topic and design:

- Have you experienced teaching in this kind of research?
- Do you know about spatial ability?
- Do the students familiar with spatial activity such as map making, work with cubes?
- Are the students familiar with this kind of activity?
- Are they familiar with the context?

APPENDIX II

Pre - Test

Bagian A

Gambar di bawah ini adalah gambar Anita yang sedang belajar di kamarnya. Pada gambar terlihat kalender, jendela, tempat sampah, tempat pensil, monitor computer, mouse, keyboard, dan PC computer.

1. Bayangkan kamu duduk di tempat Anita. Dimanakah letak jendela, di kanan atau di kirimu?

   .....

Lingkarilah jawaban yang sesuai! Kamu bisa melingkari jawaban lebih dari satu.

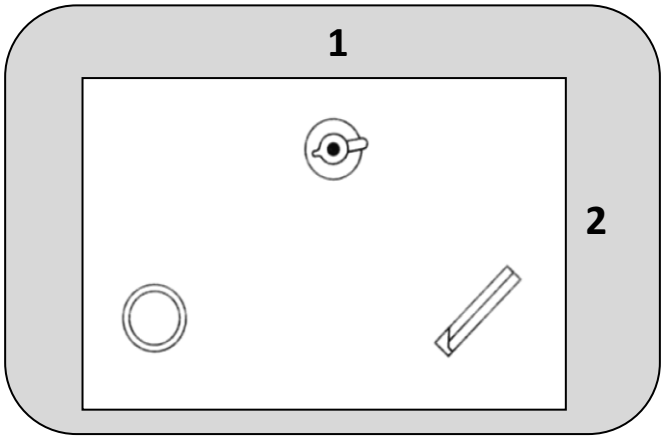
Bayangkan kamu sedang berdiri di depan Anita!

2. Benda apa sajakah yang terdapat di sebelah kananmu?
   a. kalender
   b. jendela
   c. tempat sampah
   d. tempat pensil
   e. monitor computer
   f. mouse
   g. keyboard
   h. PC computer
3. Benda apa sajakah yang terdapat di sebelah kirimu?
   a. kalender,
   b. jendela,
   c. tempat sampah
   d. tempat pensil
   e. monitor computer
   f. mouse
   g. keyboard
   h. PC computer

Bagian B

Berikut ini adalah gambar tiga buah benda yang diletakkan di atas meja.

Gambar berikut ini adalah gambar tiga buah benda tersebut apabila dilihat dari atas.



Adi berjalan mengelilingi meja tersebut kemudian mengambil beberapa foto berikut ini.

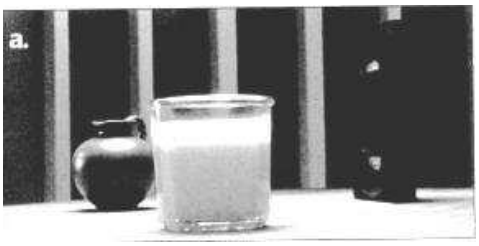


foto a

foto b

foto c

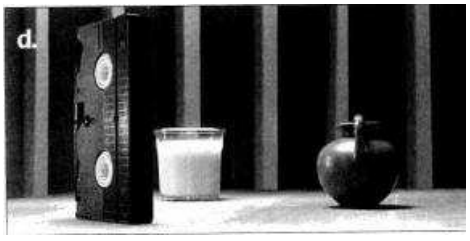


foto d

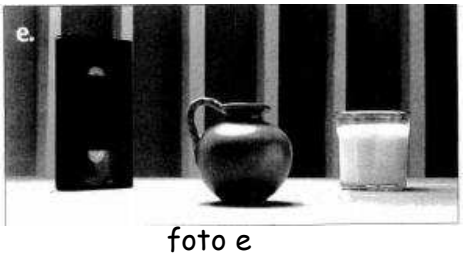


foto e

Untuk pertanyaan berikut ini, lingkarilah satu jawaban yang kamu anggap benar!

Bayangkan kamu juga sedang berjalan mengelilingi meja tersebut.

Dari foto-foto di atas:

1. Foto manakah yang diambil Adi saat sedang berdiri di titik 1?
   a. foto a
   b. foto b
   c. foto c
   d. foto d
   e. foto e

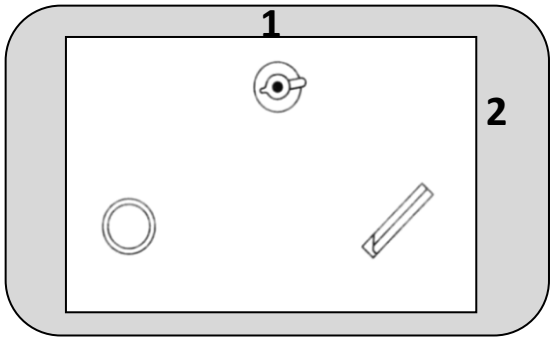
2. Foto manakah yang diambil Adi saat sedang berdiri di titik 2?
   a. foto a
   b. foto b
   c. foto c
   d. foto d
   e. foto e

Post-Test

Bagian A

Berikut ini adalah gambar tiga buah benda yang diletakkan di atas meja.

Gambar berikut ini adalah gambar tiga buah benda di atas apabila dilihat dari atas.



Adi berjalan mengelilingi meja tersebut kemudian mengambil beberapa foto berikut ini.

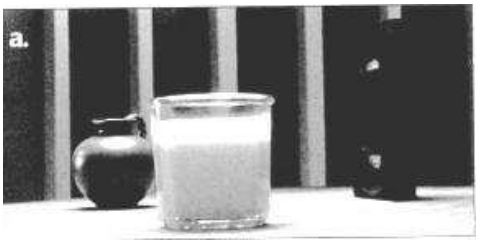


foto a

foto b

foto c

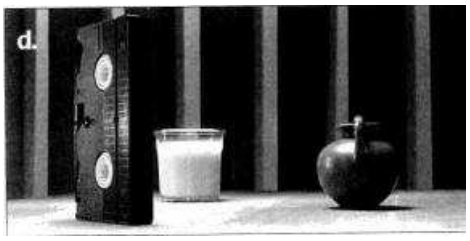


foto d

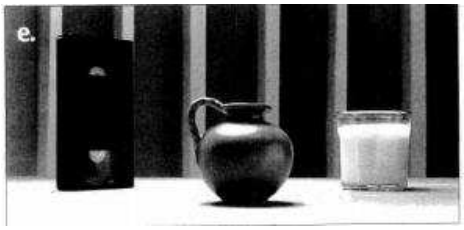


foto e

Untuk pertanyaan berikut ini, lingkarilah satu jawaban yang kamu anggap benar!

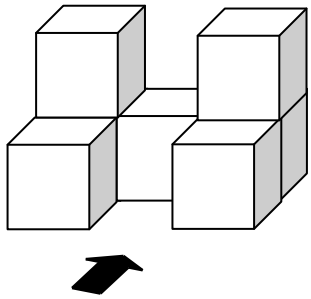
Bayangkan kamu juga sedang berjalan mengelilingi meja tersebut.

Dari foto-foto di atas

1. Foto manakah yang diambil Adi saat sedang berdiri di titik 1?
   a. foto a
   b. foto b
   c. foto c
   d. foto d
   e. foto e
2. Foto manakah yang diambil Adi saat sedang berdiri di titik 2?
   a. foto a
   b. foto b
   c. foto c
   d. foto d
   e. foto e

Bagian B

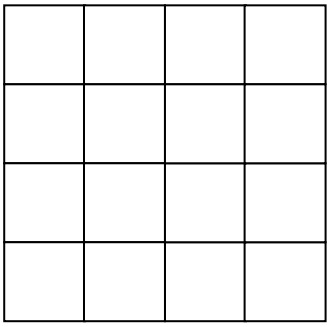
Perhatikan gambar rumah kubus berikut ini.



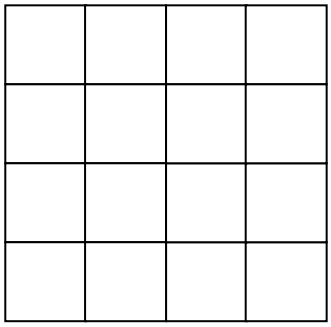
1. Tanpa menggunakan kotak kayu, berapakah jumlah kotak kayu yang terdapat pada gambar tersebut?

   Jawaban: _____

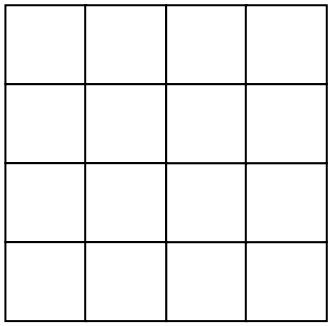
2. Gambarlah **tampak atas, tampak depan, tampak belakang, tampak kiri** dari rumah kubus di atas pada kotak di bawah ini!



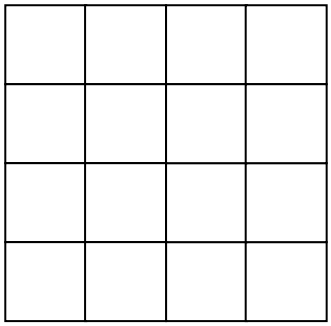
tampak atas



tampak depan

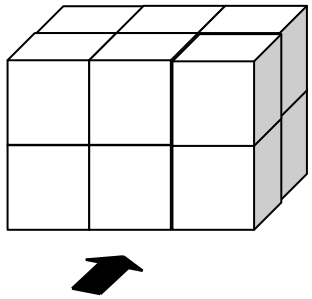


tampak belakang



tampak kiri

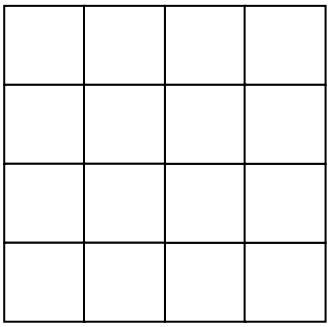
Perhatikan gambar rumah kubus berikut ini.



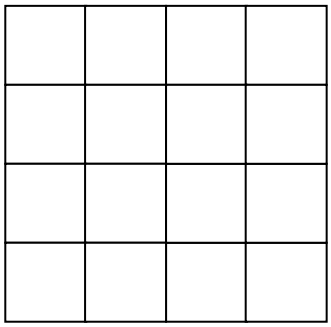
1. Tanpa menggunakan kotak kayu, berapakah jumlah kotak kayu yang terdapat pada gambar tersebut?

   Jawaban: _____

2. Gambarlah **tampak kiri** dan **tampak depan** dari rumah kubus di atas pada kotak di bawah ini!



tampak kiri



tampak depan

APPENDIX III

RENCANA PELAKSANAAN PEMBELAJARAN

Nama Sekolah : SD Negeri 117 Palembang
Mata Pelajaran : Matematika
Kelas/Semester : III/2
Pertemuan : 1(Pertama)
Alokasi waktu : 2 x 35 menit
Standar Kompetensi : Memahami unsur dan sifat-sifat bangun datar sederhana

A. Tujuan Pembelajaran

1. Mengembangkan kemampuan spatial visualisation siswa
2. Merepresentasikan miniatur dalam gambar 2-dimensi
3. Menceritakan gambar 2-dimensi dari miniatur
4. Mengintrepetasi, mengenal dan menceritakan gambar dua dimensi
5. Mengidentifikasi objek pada miniatur berdasarkan lokasinya

B. Indikator

1. Siswa menggambarkan gambar 2-dimensi dari miniatur
2. Siswa mampu menceritakan gambar 2-dimensi dari miniatur
3. Siswa mampu mengidentifikasi objek pada miniatur berdasarkan lokasinya

C. Materi Pembelajaran

Spasial visualisasi adalah kemampuan untuk memahami/mengerti/mengimajinasikan pergerakan benda dalam ruang 3-dimensi atau kemampuan untuk memanipulasi objek dalam pikiran (Lohman, 1988, 2000). Spasial visualisasi merupakan salah satu faktor penting yang harus dimiliki siswa dalam menyelesaikan masalah geometri.

D. Metode Pembelajaran

Kerja kelompok dan diskusi

E. Pendekatan pembelajaran

Pendidikan Matematika Realistik Indonesia (PMRI)

F. Kegiatan Pembelajaran

Kegiatan	Uraian	Waktu (menit)
Kegiatan Awal	**Motivasi:** 1. Guru membagikan siswa ke dalam beberapa kelompok	5 – 10

	yg terdiri dari 4 orang siswa 2. Guru menanyakan pengetahuan siswa tentang bajak laut 3. Guru menyampaikan aktivitas pembelajaran pada hari ini: bahwa siswa akan melakukan observasi 4. Guru menyampaikan tujuan pembelajaran	
Kegiatan Inti	**Eksplorasi** 1. Siswa menyusun miniatur pulau berdasarkan gambar yang diberikan. 2. Guru memeriksa miniatur pulau yang telah dibuat oleh siswa 3. Guru menyampaikan konteks dan pemasalahan yang akan dikerjakan oleh siswa 4. Guru memfasilitasi peserta didik melakukan pengamatan atau observasi terhadap miniatur pulau. Guru mengingatkan bahwa ketika sedang melakukan observasi, posisi mata harus sejajar dengan objek yang ada di atas miniatur. Oleh karena itu, siswa harus berjongkok. Hal lain yang harus diperatikan adalah, guru harus memastikan bahwa siswa menutup salah satu matanya ketika sedang mengobservasi miniatur. Sangatlah penting bagi siswa untuk memahami bahwa gambar yang mereka buat boleh jadi berbeda dengan gambar yang dibuat oleh teman mereka. Oleh karena itu, siswa disarankan untuk menggunakan istilah kiri dan kanan dalam mendiskusikan perbedaan posisi objek-objek yang mereka gambar.	15 - 20
	Elaborasi 1. Siswa menyelesaikan permasalahan yang diberikan Siswa diminta untuk menggambarkan objek-objek pada miniatur sesuai dengan posisi mereka pada saat mengobservasi miniatur. 2. Siswa mempersiapkan poster Siswa menempelkan hasil kerja masing-masing anggota kelompok pada karton yang disediakan. 3. Walking gallery Yang dimaksud dengan kegiatan walking gallery adalah siswa diberikan kesempatan untuk melihat hasil kerja teman-teman mereka. Siswa diberikan waktu 3 - 5	25 – 30

	Teknis pelaksanaan kegiatan walking gallery adalah sebagai berikut: • Masing-masing kelompok menampilkan poster mereka • Salah satu dari anggota kelompok harus tinggal di poster mereka, tujuannya adalah untuk menjelaskan kepada anggota kelompok lain yang melihat poster mereka. Dua anggota kelompok yang lainnya melihat dua poster kelompok lain, dan memberikan pertanyaan mengenai apa yang dilakukan kelompok tersebut. Siswa diminta untuk membandingkan hasil kerja kelompok mereka dengan kelompok lain. 4. Diskusi Diskusi kelas dimulai dengan guru menampilkan foto tampak samping dari miniature pulau yang diambil dari posisi yang berbeda, dan foto tampak atas dari miniature pulau tersebut. Masing-masing foto tampak samping diberi label huruf. Pada gambar tampak atas juga telah diberikan tanda pada posisi tertentu. Tanda-tanda tersebut masing-masing diberi label sesuai dengan label yang ada pada foto tampak samping miniature pulau. Tanda tersebut menunjukkan dari posisi mana foto tersebut diambil. Diskusi difokuskan pada tiap-tiap gambar yang ditampilkan. Pada masing-masing foto, guru akan memberikan pertanyaan seperti: • Apakah yang ada di kanan dan kirimu? • Bangunan apakah yang letaknya paling jauh dari posisi ini? • Jika kamu melihat dari posisi ini, dimana sajakah kemungkinan kelompok bajak laut utara dapat bersembunyi? • Apakah yang menyebabkan menara tidak kelihatan? • Bagaimana bentuk menara dan dinding jika dilihat dari posisi ini? • Apakah menara dan dinding terlihat sama jika dilihat dari posisi yang berbeda?	

	Di akhir diskusi, guru akan menanyakan kepada siswa; dari foto-foto yang ditampilkan foto manakah yang menunjukkan posisi terbaik untuk mengamati pulau Intan?	
	Konfirmasi 1. Guru memberikan umpan balik positif dan penguatan dalam bentuk lisan. 2. Guru memberikan motivasi kepada peserta didik yang kurang atau belum berpartisipasi aktif 3. Guru membantu menyelesaikan masalah 4. Melakukan refleksi terhadap pengalaman belajar yang telah dilakukan	5
Kegiatan akhir	Guru menyimpulkan hal-hal yang telah dipelajari Guru menyampaikan rencana pembelajaran berikutnya	5

G. Media/Sumber Pembelajaran

- miniatur pulau
- kertas gambar
- foto miniatur pulau yang diambil dari arah samping
- lembar kerja siswa
- kertas poster
- gunting
- isolasi
- spidol

H. Penilaian

1. Bentuk Tes : Penilaian Diskusi
2. Bentuk Soal : Observasi

Lembar observasi

No.	Nama	Aspek yang dinilai						Skor/jumlah
		1	2	3	4	5	6	

Aspek yang dinilai:

1. Kemampuan menyampaikan pendapat
2. Kemampuan mempertahankan argumentasi
3. Kemampuan bertanya
4. Kemampuan memberikan kritik
5. Kemampuan menggunakan bahasa yang baik dan benar
6. Kelancaran dalam berbicara

Nilai skor:
1 = Tidak baik
2 = Kurang baik
3 = Cukup baik
4 = Baik
5 = Sangat Baik

Jumlah skor
6 – 11 = Kurang
12 – 17 = Cukup
18 – 23 = Baik
24 – 30 = Sangat baik

Palembang, Maret 2013

Wali Kelas IIIa,

Fatmawati, S. Pd
NIP.

Peneliti

Dwi Afrini Risma
NIM. 20112812009

Mengetahui,
Kepala SDN 117 Palembang

Toman Siregar, S.Pd
NIP.

Konteks

Mencari tempat yang paling tepat untuk mendirikan pos penjagaan

Tahun lalu pulau kita diserang oleh bajak laut Utara.

Mereka menyerang kita dari pulau Intan.

Sejak penyerangan itu, pulau tersebut tidak dihuni lagi.

Yang tersisa hanya tiga bangunan, yang ada pulau itu yaitu potongan tembok, dan dua menara.

Semalam ada beberapa masyarakat kita melaporkan bahwa mereka melihat ada bajak laut Utara sekitar di pulau Intan.

Kapten Jack khawatir bahwa mereka akan menyerang kita lagi.

Oleh karena itu, kapten Jack memutuskan untuk mendirikan sebuah pos penjagaan.

Pos harus didirikan dari tempat yang benar-benar tepat, sehingga kamu bisa melihat keseluruhan dari pulau itu, dan tak ada tempat yang memungkinkan mereka bersembunyi.

Sebagai bajak laut muda, kalian diberi tugas oleh Kapten Jack untuk berlayar mencari posisi yang tepat.

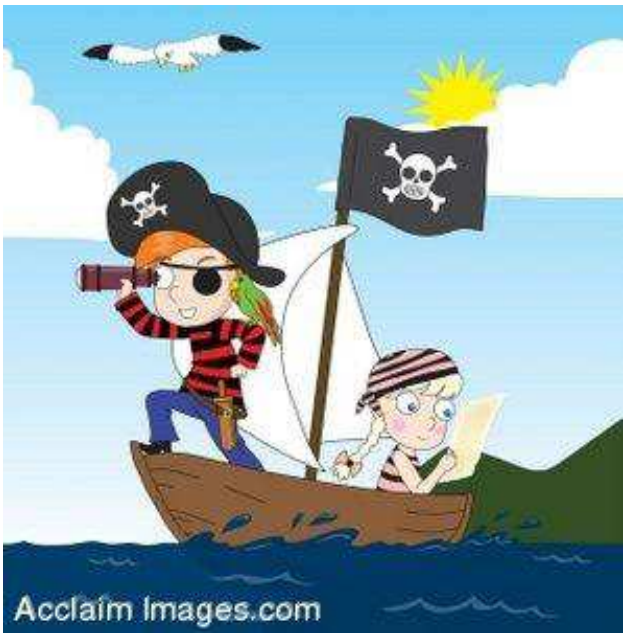
Kelilingilah pulau Intan, dan amati dari jauh dengan menggunakan teropong.

Gambarlah atau buatlah catatan persis seperti apa yang kamu lihat di teropongmu!

Gunakan gambar atau catatanmu untuk meyakinkan Kapten Jack bahwa yang kamu temukan adalah tempat terbaik untuk mendirikan pos penjagaan.

Ini dia misi pertamamu sebagai bajak laut!

Temukan tempat yang paling tepat untuk mengamati pulau itu dari jauh.



RENCANA PELAKSANAAN PEMBELAJARAN

Nama Sekolah : SD Negeri 117 Palembang
Mata Pelajaran : Matematika
Kelas/Semester : III/2
Pertemuan : 2 (Kedua)
Alokasi waktu : 2 x 35 menit
Standar Kompetensi : Memahami unsur dan sifat-sifat bangun datar sederhana

A. Tujuan Pembelajaran

1. Mengembangkan kemampuan orientasi spasial dan visualisasi spasial siswa
2. Memperkenalkan istilah "tampak atas" dan "tampak samping"
3. Siwa mampu menyelesaikan masalah yang berkaitan dengan spasial orientasi dengan memanfaatkan kemampuan spasial visualisasi yang telah mereka kembangkan.
4. Mengintrepretasi, mengenal dan menceritakan gambar 2-dimensi dari miniatur

B. Indikator

1. Siswa mampu menyelesaikan masalah yang diberikan
2. Siswa mampu menjelaskan/menceritakan gambar 2-dimensi dari miniatur
3. Siswa mengenal dan menggunakan istilah "tampak atas dan "tampak samping"

C. Materi Pembelajaran

Spasial orientasi adalah kemampuan siswa untuk tidak keliru dengan perubahan orientasi dari konfigurasi spasial yang ditampilkan. Mampu membedakan arah kanan dan kiri, serta membayangkan lokasi ruangan yang terdapat di rumahmu, merupakan salah satu contoh dari penggunaan kemampuan ini. Pada pertemuan ini, kemampuan spasial orientasi siswa akan lebih diasah melalui latihan yang akan diberikan. Siswa juga diperkenalkan dengan konsep dan istilah pendik pada topik spasial, yakni tampak atas dan tampak samping. Kedua konsep ini merupakan konsep penting yang harus dimiliki siswa dalam menyelesaikan permasalahan di dalam geometri dan konsep sudut.

D. Metode Pembelajaran

Kerja kelompok dan diskusi

E. Pendekatan Pembelajaran

Pendidikan Realistik Matematika Indonesia (PMRI)

F. Kegiatan Pembelajaran

Kegiatan	Uraian	Waktu (menit)
Kegiatan Awal	**Apersepsi:** Pengulangan materi yang telah diajarkan sebelumnya dan mengaitkan materi sebelumnya dengan materi yang akan dipelajari **Motivasi:** 1. Guru menyampaikan aktivitas pembelajaran pada hari ini: bahwa siswa akan melakukan observasi 2. Guru menyampaikan tujuan pembelajaran	5 – 10
Kegiatan Inti	**Eksplorasi** 1. Siswa menyusun miniatur pulau berdasarkan gambar yang diberikan 2. Guru memeriksa miniatur pulau yang telah dibuat oleh siswa 3. Guru menyampaikan konteks dan pemasalahan yang akan dikerjakan oleh siswa 4. Guru memfasilitasis peserta didik melakukan pengamatan atau observasi terhadap miniatur pulau. Hal-hal yang perlu diperhatikan pada saat melakuan pengamatan adalah: • Posisi mata harus sejajar dengan objek pada miniatur • Salah satu mata harus ditutup	15 – 20
	Elaborasi 1. Siswa menyelesaikan permasalahan yang diberikan Permasalahan yang harus diselesaikan siswa adalah mencocokkan gambar-gambar tampak samping pulau sesuai dengan posisi gambar tersebut diambil. 2. Diskusi Diskusi dapat dimulai dengan memilih salah satu kelompok untuk mempresentasikan hasil kerja mereka. Guru meminta siswa untuk menceritakan strategi yang mereka gunakan untuk menemukan jawaban yang benar. Diskusi dilanjutkan dengan membahas detail jawaban siswa. Guru dapat bertanya kepada kelompok yang lain apakah jawaban mereka sama atau berbeda. Guru dapat bertanya apakah kelompok lain memiliki strategi yang berbeda dalam menyelesaikan permasalahan tersebut. Diakhir diskusi, guru menunjukkan jawaban yang benar, kemudian memperkenalkan peta sebagai tampak atas dari pulau. Selanjutnya guru menekankan bahwa selanjutnya	20 – 25

	mereka akan menggunakan istilah tampak atas, tampak kiri, tampak kanan, tampak depan, dan tampak belakang.	
	Konfirmasi 1. Guru memberikan umpan balik positif dan penguatan dalam bentuk lisan. 2. Guru memberikan motivasi kepada peserta didik yang kurang atau belum berpartisipasi aktif 3. Guru membantu menyelesaikan masalah dengan memberikan jawaban yang benar 4. Melakukan refleksi terhadap pengalaman belajar yang telah dilakukan	3
Kegiatan akhir	Guru menyimpulkan hal-hal yang telah dipelajari Guru menyampaikan rencana pembelajaran berikutnya	2

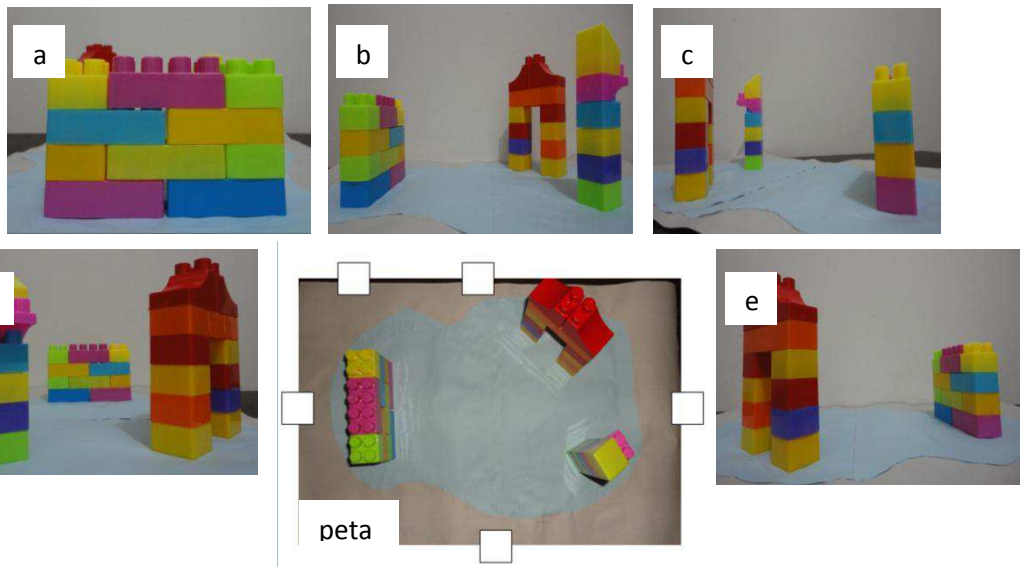
G. Media/Sumber Pembelajaran

- brick
- gunting
- foto tampak samping minatur pulau dan peta
- karton
- lem
- spidol

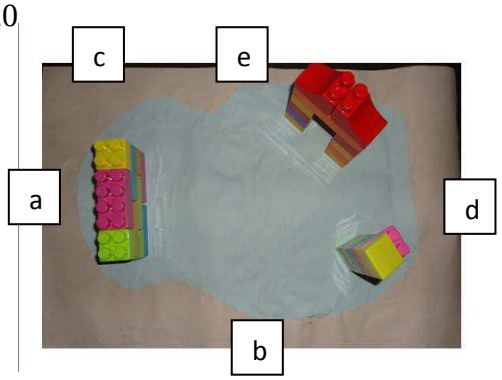
H. Penilaian

1. Bentuk Tes : Kegiatan Kelompok Terstruktur
2. Bentuk Soal :

Tempatkanlah 5 gambar berikut ini berdasarkan lokasinya pada peta di bawah ini.



3. Rubrik Penilaian :

Jawaban	Skor Total
Tiap gambar yang sesuai diberikan skor 20 	100

Palembang, Maret 2013

Wali Kelas IIIa,

Fatmawati, S. Pd

NIP.

Peneliti

Dwi Afrini Risma

NIM. 20112812009

Mengetahui,

Kepala SDN 117 Palembang

Toman Siregar, S.Pd

NIP.

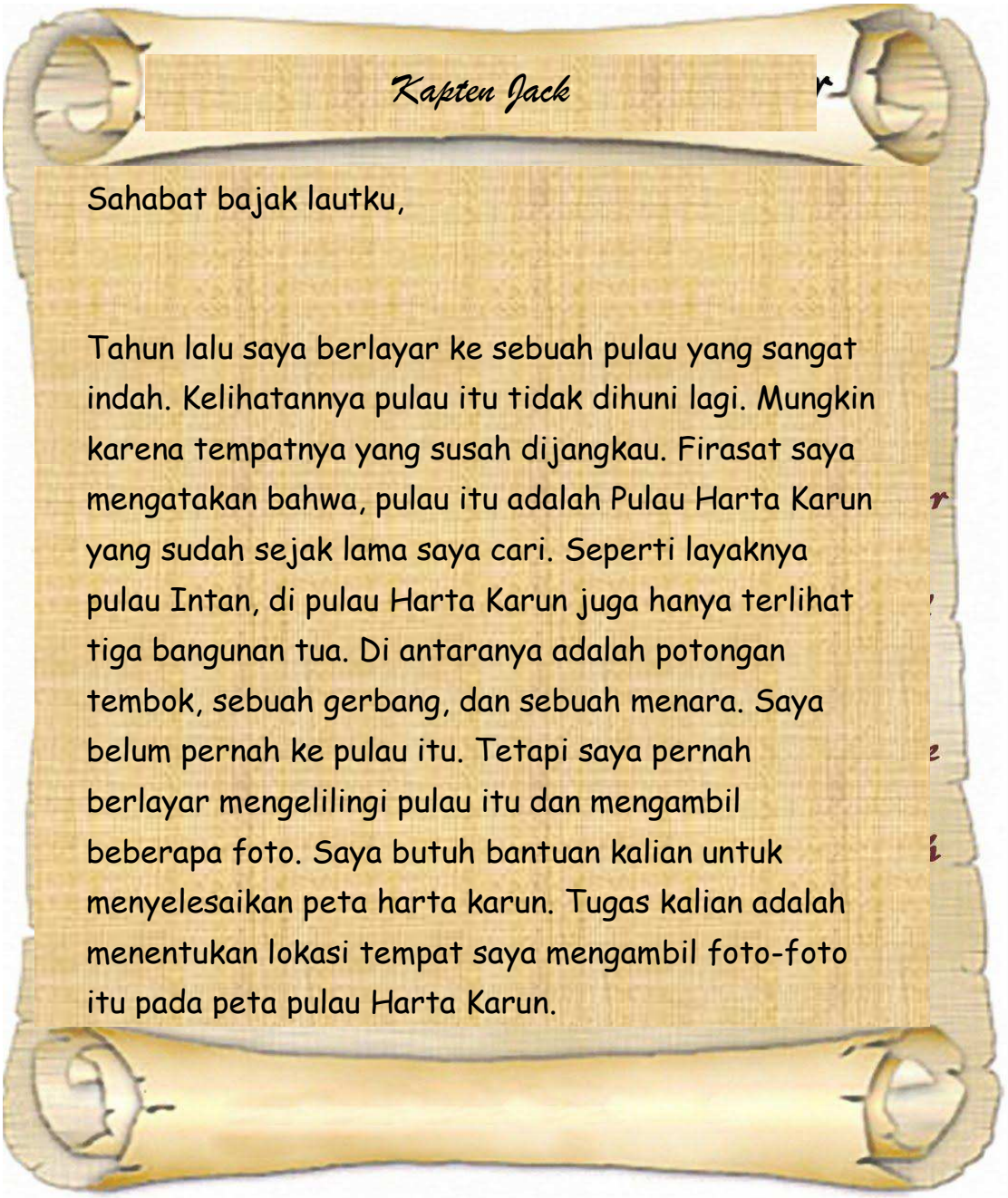
Konteks

Di manakah foto-foto tersebut diambil?

Kalian bekerja dengan baik, kapten Jack bangga dengan hasil kerja kalian.

Misi selanjutnya adalah kalian harus membantu kapten Jack menyelesaikan petanya.

Mari kita baca surat dari kapten Jack.



Petunjuk Kerja

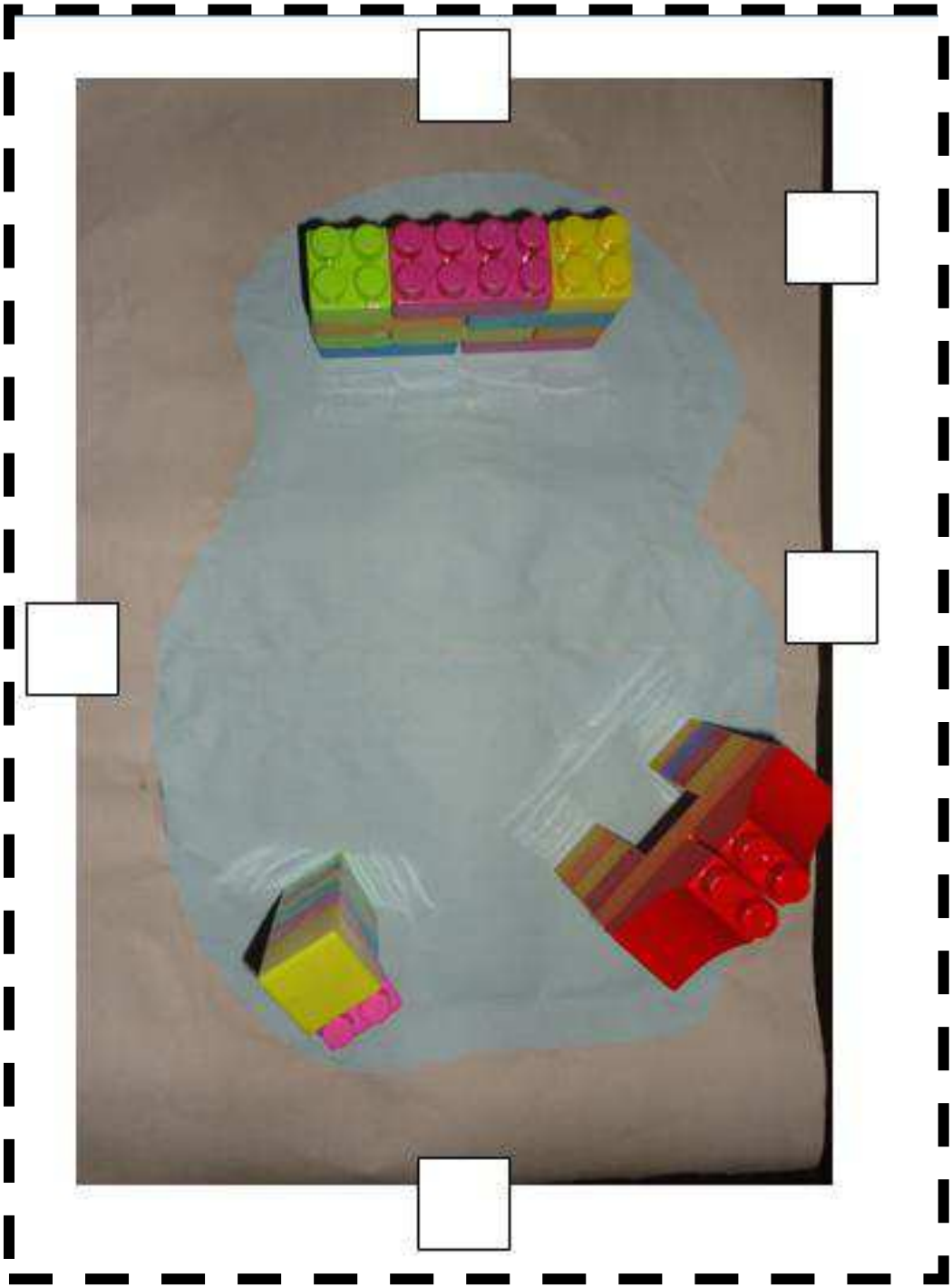
Alat dan Bahan

1. Brick
2. Gunting
3. Foto tampak samping miniatur dan peta
4. Karton berukuran A4
5. Lem
6. Spidol

Petunjuk Kerja

Karena cuaca buruk, kita tidak bisa berlayar ke Pulau Harta Karun. Tetapi jangan khawatir, kalian tetap bisa menyelesaikan misi ini. Ikuti petunjuk berikut ini:

1. Guntinglah 5 lembar foto tampak samping, dan peta miniatur pulau pada garis putus-putus.
2. Ambillah brick atau balok-balok plastik.
3. Buatlah tembok, gerbang, dan menara seperti pada gambar tampak samping pulau
4. Susunlah tembok, gerbang, dan menara sesuai dengan lokasi yang ditunjukkan oleh peta.
5. Tempelkan peta pada karton
6. Cocoklanlah 5 foto tersebut sesuai dengan lokasi Kapten Jack pada saat mengambil foto-foto itu!
7. Tempelkan foto-foto tersebut pada peta!
8. Jangan lupa tulis nama kelompokmu dan nama kalian ya!



RENCANA PELAKSANAAN PEMBELAJARAN

Nama Sekolah : SD Negeri 117 Palembang
Mata Pelajaran : Matematika
Kelas/Semester : III/2
Pertemuan : 3 (Ketiga)
Alokasi waktu : 2 x 35 menit
Standar Kompetensi : Memahami unsur dan sifat-sifat bangun datar sederhana

A. Tujuan Pembelajaran

1. Memperkenalkan istilah tampak kiri, tampak kanan, tampak depan, tampak belakang dan tampak atas.
2. Menggambarkan tampak kiri, tampak kanan, tampak depan, tampak belakang dan tampak atas dari tembok.
3. Menyelesaikan permasalahan dengan menggunakan kemampuan spasial yang telah dikembangkan.
4. Menginterpretasi, mengenal, dan menceritakan gambar 2-dimensi dari benda 3-dimensi

B. Indikator

1. Siswa mampu menggambarkan tampak kiri, tampak kanan, tampak depan, tampak belakang dan tampak atas dari tembok
2. Siswa mengenal dan menggunakan istilah tampak kiri, tampak kanan, tampak depan, tampak belakang dan tampak atas dalam mendiskusikan hasil kerja mereka.

C. Materi Pembelajaran

Pada pertemuan ini, siswa akan diperkenalkan dengan istilah-istilah yang digunakan pada topik spasial, seperti tampak kiri, tampak kanan, tampak depan, tampak belakang dan tampak atas. Siswa diminta untuk memvisualisasikan tembok-tembok yang disusun dari balok-balok kayu kecil dari berbagai arah. Aktivitas ini dilakukan guna mengasak kemampuan visualisasu spasial visual dan kemambuan orientasi spasial siswa.

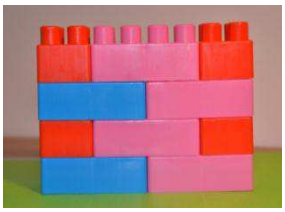
D. Metode Pembelajaran

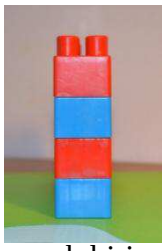
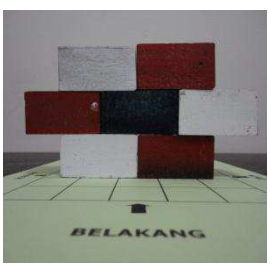
Kerja kelompok dan diskusi

E. Pendekatan Pembelajaran

Pendidikan Matematika Reaslistik Indonesia (PMRI)

F. Kegiatan Pembelajaran

Kegiatan	Uraian	Waktu (menit)
Kegiatan Awal	**Apersepsi:** Pengulangan materi yang telah diajarkan sebelumnya dan mengaitkan materi sebelumnya dengan materi yang akan dipelajari **Motivasi:** 1. Guru menyampaikan aktivitas pembelajaran pada hari ini: bahwa siswa akan mengeksplorasi susunan batu bata 2. Guru menyampaikan tujuan pembelajaran	5 – 10
Kegiatan Inti	**Eksplorasi** 1.Guru menyampaikan konteks dan pemasalahan yang akan dikerjakan oleh siswa Setelah mengeksplorasi miniatur pulau tampak dari samping dan tampak dari atas, aktifitas selanjutnya difokuskan pada pembahasan objek yang lebih spesifik. Aktifitas ini merupakan zoom in dari dua aktifitas sebelumnya yaitu aktifitas 2 dan aktifitas 3. Pada aktifitas ini, siswa akan disajikan dengan gambar susunan batu bata pada tembok yang digunakan pada aktifitas 2 dan aktifitas 3, dan berbagai bentuk susunan batu bata. 2. Guru menampilkan foto tembok yang diambil dari depan, belakang, kanan, kiri, dan atas. Kemudian memperkenalkan istilah spasial seperti tampak depan, tampak belakang, tampak atas, tampak kiri, dan tampak kanan.  gambar tembok  tampak depan  tampak atas	10 – 15

	   tampak belakang tampak kiri tampak kanan 3. Guru memfasilitasis peserta didik melakukan pengamatan atau observasi terhadap tembok. Hal-hal yang perlu diperhatikan pada saat melakuan pengamatan adalah: • Posisi mata harus sejajar dengan objek pada miniatur • Salah satu mata harus ditutup	
	Elaborasi 1. Siswa menyelesaikan permasalahan yang diberikan pada Lembar Kerja Siswa (LKS) Siswa diminta untuk menggambarkan tampak samping dan tampak atas dari tembok. Untuk membantu iswa ddalam menyelesaikan masalh ini, siswa dapat menggunakan balok-balok kayu dan menyusunnya sesuai dengan gambar tembok yang terdapat pada lembar LKS 2. Diskusi Diskusi dapat dimulai dengan memilih salah satu kelompok untuk mempresentasikan salah satu dari hasil kerja mereka. Guru meminta siswa untuk menceritakan strategi yang mereka gunakan untuk menemukan jawaban yang benar. Diskusi dilanjutkan dengan membahas detail jawaban siswa. Guru dapat bertanya kepada kelompok yang lain apakah jawaban mereka sama atau berbeda. Guru dapat bertanya apakah kelompok lain memiliki strategi yang berbeda dalam menyelesaikan permasalahan tersebut, sambil menampilkan foto tampak belakang, kiri, dan atas berikut ini.    Diskusi dilanjutkan dengan pembahasan lembar kerja	30 – 35

	siswa bagian C. Guru meminta siswa untuk menyusun balok-balok kayu berukuran 3 x 3 x 6 cm sesuai dengan gambar yang ditunjukkan. Berbeda dengan permasalahan pada bagian B, pada bagian C siswa akan menyusun balok-balok kayu dari tampak atasnya. Kemudian guru meminta siswa untuk membuat gambar tampak samping dari susunan balok-balok kayu tersebut. Diskusi dilanjutkan dengan menjawab pertanyaan yang ada di bagian C.	
	Konfirmasi 1. Guru memberikan umpan balik positif dan penguatan dalam bentuk lisan. 2. Selanjutnya guru menekankan bahwa selanjutnya mereka akan menggunakan istilah tampak atas, tampak kiri, tampak kanan, tampak depan, dan tampak belakang. 3. Guru memberikan motivasi kepada peserta didik yang kurang atau belum berpartisipasi aktif 4. Guru membantu menyelesaikan masalah dengan memberikan jawaban yang benar 5. Melakukan refleksi terhadap pengalaman belajar yang telah dilakukan	5
Kegiatan akhir	Guru menyimpulkan hal-hal yang telah dipelajari Guru menyampaikan rencana pembelajaran berikutnya	5

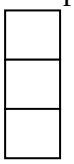
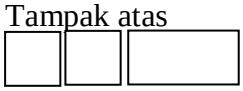
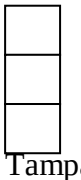
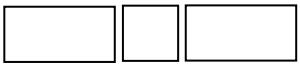
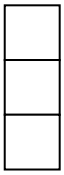
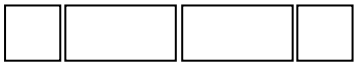
G. Media/Sumber Pembelajaran

- balok kayu berukuran 3 x 3 x 6 cm
- balok kayu berukuran 3 x 3 x 3 cm
- foto tampak samping dan tampak atas dari tembok yang digunakan pada aktifitas 2 dan 3
- lembar kerja siswa

H. Penilaian

1. Bentuk Tes : Kegiatan Kelompok Terstruktur
2. Bentuk Soal : (lihat LKS)
3. Rubrik Penilaian:

NO	Jawaban	Skor
1	Sama, karena apa bila dilihat dari belakan, bentuk, ukuran dan susunan balok kayu adalah sama.	10

2	a. Sama b. Tampak kanan dan tampak kiri tembok  c. Tampak atas 	30
3	a. Sama b. Tampak kanan dan tampak kiri tembok  c. Tampak atas 	30
4	a. Sama b. Tampak kanan dan tampak kiri tembok  c. Tampak atas 	30

Palembang, Maret 2013

Wali Kelas IIIa,

Fatmawati, S. Pd

NIP.

Peneliti

Dwi Afrini Risma

NIM. 20112812009

Mengetahui,

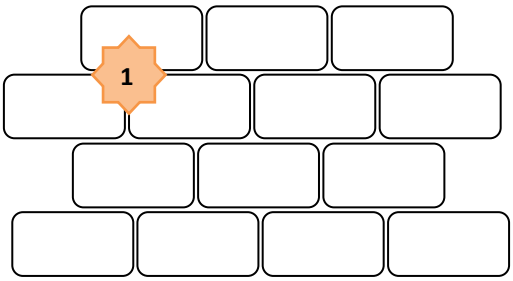
Kepala SDN 117 Palembang

Toman Siregar, S.Pd

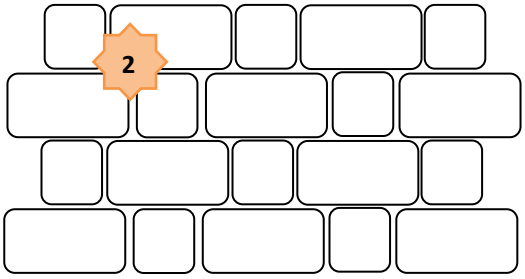
NIP.

Nama Kelompok:_____ Kelas :_____

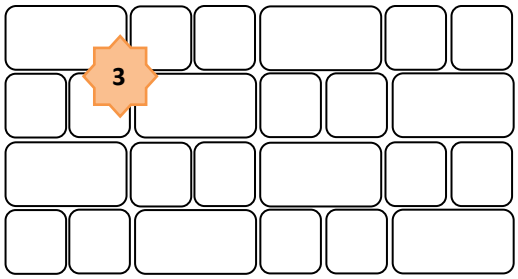
A. Berikut ini adalah gambar-gambar tembok tampak dari depan.



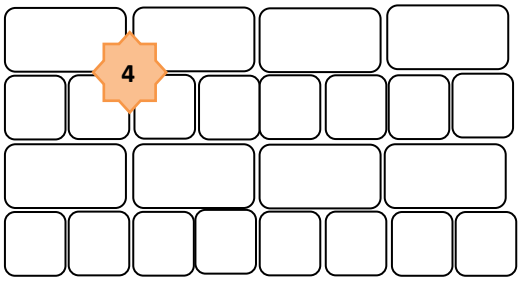
Tembok 1



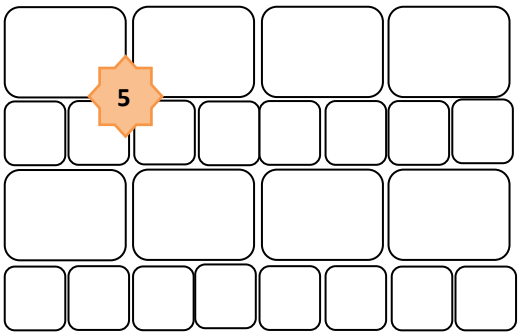
Tembok 2



Tembok 3



Tembok 4



Tembok 5

Apakah menurutmu susunan batu tersebut akan terlihat sama dari belakang? Jelaskan!

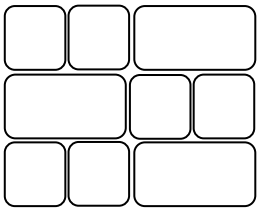
_____

_____

B. Bagaimanakah gambar tembok tersebut jika dilihat dari kiri, kanan dan atas?

Amatilah gambar tembok di bawah ini!

1



Apakah tembok akan terlihat sama jika dilihat dari kiri dan kanan?

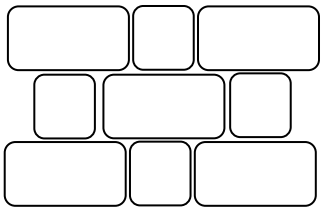
Jawaban : _____

Gambarlah tampak kanan dan kiri tembok pada gambar di atas!

Bagaimana gambar tembok jika dilihat dari atas? Gambarkan!

Amatilah gambar tembok di bawah ini!

2



Apakah tembok akan terlihat sama jika dilihat dari kiri dan kanan?

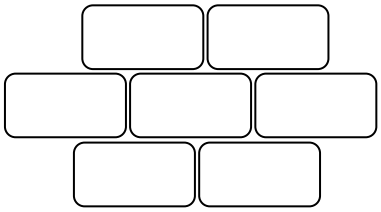
Jawaban : _____

Gambarlah tampak kanan dan kiri tembok pada gambar di atas!

Bagaimana gambar tembok jika dilihat dari atas? Gambarkan!

Amatilah gambar tembok di bawah ini!

3



Apakah tembok akan terlihat sama jika dilihat dari kiri dan kanan?

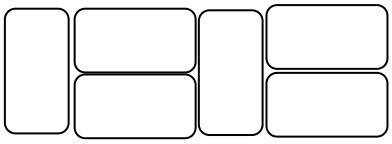
Jawaban : _____

Gambarlah tampak kanan dan kiri tembok pada gambar di atas!

Bagaimana gambar tembok jika dilihat dari atas? Gambarkan!

C. Bagaimana dengan tampak atas tembok?

Jika semua batu yang digunakan memiliki ukuran yang sama,
dari 5 gambar tembok pada halaman 1,
manakah tembok yang mungkin memiliki tampak atas seperti pada gambar di bawah ini?



Jawaban : _____

Berikan alasanmu!

_____

_____

_____

_____

_____

RENCANA PELAKSANAAN PEMBELAJARAN

Nama Sekolah : SD Negeri 117 Palembang
Mata Pelajaran : Matematika
Kelas/Semester : III/2
Pertemuan : 4 (keempat)
Alokasi waktu : 2 x 35 menit
Standar Kompetensi : Memahami unsur dan sifat-sifat bangun datar sederhana

A. Tujuan Pembelajaran

1. Menggambarkan susunan kubus dari tampak tampak kiri, tampak kanan, tampak depan, tampak belakang, dan tampang atas
2. Menginterpretasi, mengenal, dan menceritakan gambar 2-dimensi dari rumah kubus
3. Menyelesaikan permasalahan dengan menggunakan kemampuan spasial yang telah dikembangkan.

B. Indikator

1. Siswa mampu menggambarkan tampak kiri, tampak kanan, tampak depan, tampak belakang dan tampak atas dari rumah kubus dengan benar
2. Siswa mampu mengintepretasi, mengenal, dan menceritakan gambar 2-dimensi dari rumah kubus
3. Siswa menggunakan istilah spasial dalam mendiskusikan hasil kerjanya

C. Materi Pembelajaran

Pada pertemuan ini, siswa bekerja dengan menggunakan kubus kecil yang terbuat darii kayu. Kubus-kubus tersebut akan disusun sesuai dengan jumlah dan susunan yang ditentukan. Siswa kemudian diminta untuk memvisualisasikan susunan kubus tersebut sesuai dengan tampak kiri, tampak kanan, tampak depan, tampak belakang dan tampak atas. Riset yang telah dilakukan oleh Revina et al. (2011) dan Ben-Haim et al. (1985) menunjukkan bahwa aktivitas memvisualisasikan rumah kubus dari tampak kiri, tampak kanan, tampak depan, tampak belakang dan tampak atas mampu meningkatkan kemampuan visualisasi siswa.

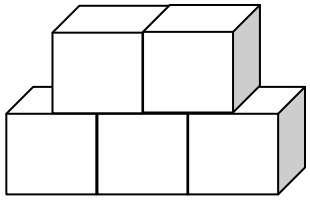
D. Metode Pembelajaran

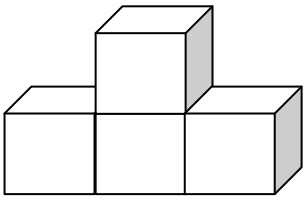
Kerja kelompok dan diskusi

E. Pendekatan Pembelajaran

Pendidikan Matematika Realistik Indonesia (PMRI)

F. Kegiatan Pembelajaran

Kegiatan	Uraian	Waktu (menit)
Kegiatan Awal	**Apersepsi:** Pengulangan materi yang telah diajarkan sebelumnya dan mengaitkan materi sebelumnya dengan materi yang akan dipelajari **Motivasi:** 1. Guru menyampaikan aktivitas pembelajaran pada hari ini: bahwa siswa akan mengeksplorasi susunan batu bata 2. Guru menyampaikan tujuan pembelajaran	5
Kegiatan Inti	**Eksplorasi** 1.Guru menyampaikan konteks dan pemasalahan yang akan dikerjakan oleh siswa Pada aktifitas ini, siswa akan menyusun kubus-kubus menjadi bentuk tertentu pada arena berpetak yang disediakan. Kemudian siswa diminta untuk menggambarkan tampak samping (tampak depan, tampak belakang, tampak kiri, dan tampak kanan) serta tampak atas dari susunan kubus yang mereka buat. 2. Guru memfasilitasis peserta didik melakukan pengamatan atau observasi terhadap rumah kubus. • Dalam menyelesaikan permasalahan-permasalahan yang ada di lembar kerja siswa, siswa dapat membuat susunan kubus yang serupa dengan gambar dengan menggunakan kubus-kubus kayu yang tersedia. • Untuk mempermudah siswa dalam menggambar, siswa dapat menyusun kubus pada arena berpetak yang disediakan. • Tanda panah pada gambar menandakan arah depan • Berbeda dengan susunan balok-balok pada aktifitas sebelumnya yang disusun seperti gambar berikut ini, 	10 - 15

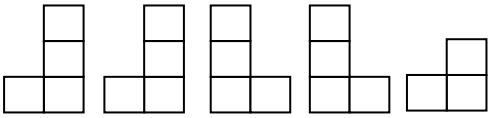
	pada aktifitas ini, kubus-kubus harus disusun seperti gambar di bawah ini 	
	Elaborasi 1. Siswa menyelesaikan permasalahan 1 dan 2 yang diberikan pada Lembar Kerja Siswa 2. Diskusi Diskusi dapat dimulai dengan memilih salah satu kelompok untuk mempresentasikan salah satu dari hasil kerja mereka. Guru meminta kelompok lain untuk menguji kebenaran gambar ataupun argument yang digunakan oleh kelompok presenter. Jika siswa memberikan jawaban yang tidak tepat, guru bisa mengajak siswa bersama-sama menyusun rumah kubus seperti yang dibuat oleh kelompok presenter. Kemudian siswa diminta untuk menggambarkan tampak samping dan tampak atasnya. Sangatlah penting bagi guru untuk menekankan bahwa sering kali ditemukan tampak kiri dan tampak kanan seolah terlihat sama, tetapi jika diperhatikan dengan seksama posisi benda di sebelah kanan dan sebelah kiri akan beralih fungsi. 3. Siswa menyelesaikan permasalahan 1 dan 2 yang diberikan pada Lembar Kerja Siswa	35 – 40
	Konfirmasi 1. Guru memberikan umpan balik positif dan penguatan dalam bentuk lisan. 2. Guru memberikan motivasi kepada peserta didik yang kurang atau belum berpartisipasi aktif 3. Guru membantu menyelesaikan masalah dengan memberikan jawaban yang benar 4. Melakukan refleksi terhadap pengalaman belajar yang telah dilakukan	5
Kegiatan akhir	Guru menyimpulkan hal-hal yang telah dipelajari Guru menyampaikan rencana pembelajaran berikutnya	5

G. Media/Sumber Pembelajaran

- balok kayu berukuran 3 x 3 x 3 cm
- lembar kerja siswa

H. Penilaian

1. Bentuk Tes : Tugas Terstruktur
2. Bentuk Soal : Lihat lampiran (LKS)
3. Rubrik penilaian:

No Soal	Jawaban	Skor
1	 TD Tka TB Tki TA	30
2	Jawaban dapat bervariasi	35
3	Jawaban dapat bervariasi	35

Palembang, Maret 2013

Wali Kelas IIIa, Peneliti

Fatmawati, S. Pd Dwi Afrini Risma

NIP. NIM. 20112812009

Mengetahui,

Kepala SDN 117 Palembang

Toman Siregar, S.Pd

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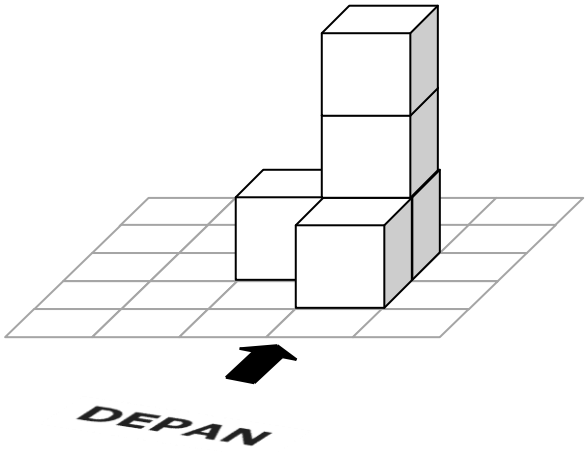
AKTIVITAS 4

Konteks

Kita akan berburu harta karun. Untuk menemukan harta karun kalian harus menemukan petunjuk di kompleks rumah yang terbuat dari kubus-kubus. Salah satu pemilik ‘rumah kubus’, Pak Rusman, memiliki petunjuk penting. Pak Rusman akan memberikan petunjuk jika mereka melakukan tiga tugas. Tugas pertama adalah kalian seharusnya menggambarkan tampak samping dan tampak atas rumahnya. Pak Rusman juga ingin membangun dua rumah kubus lainnya. Jadi, tugas dari pak Rusman adalah kalian harus membangun dan menggambarkan tampak samping dan tampak atas dari 3 rumah kubus

Perhatikan gambar susunan kubus berikut ini.



Buatlah rumah kubus yang sama pada kotak-kotak yang disediakan, amatilah bangun tersebut. Bagaimanakah gambar rumah kubus tersebut jika dilihat dari depan, sebelah kiri, belakang, dan sebelah kanan?

Gambarlah rumah kubus tersebut

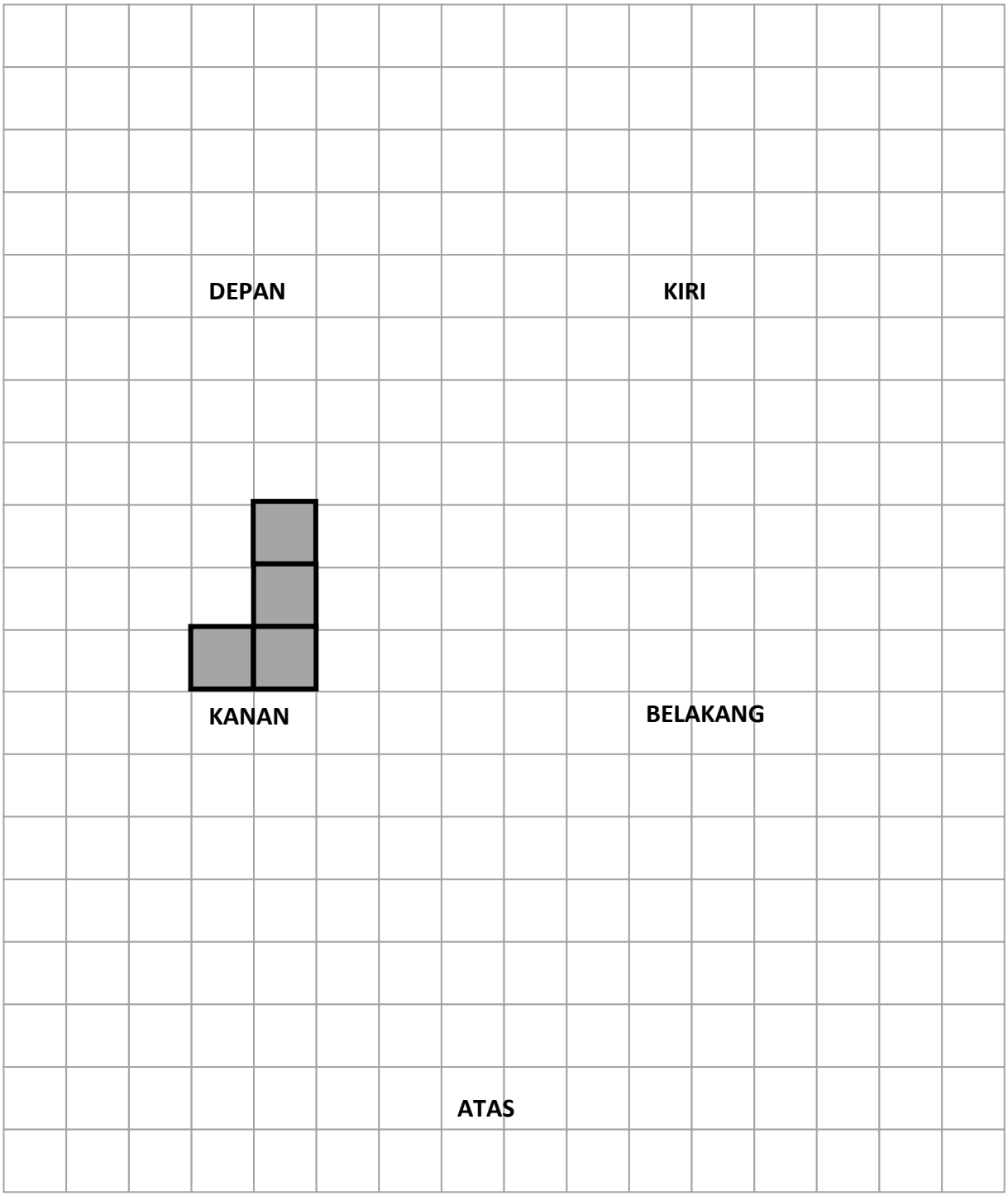
- Tampak depan
- Tampak kiri
- Tampak kanan
- Tampak belakang
- Tampak atas

Nama Kelompok: _____

Gambarlah rumah kubus yang kamu buat apabila

- Tampak depan
- Tampak kiri
- Tampak kanan
- Tampak belakang
- Tampak atas

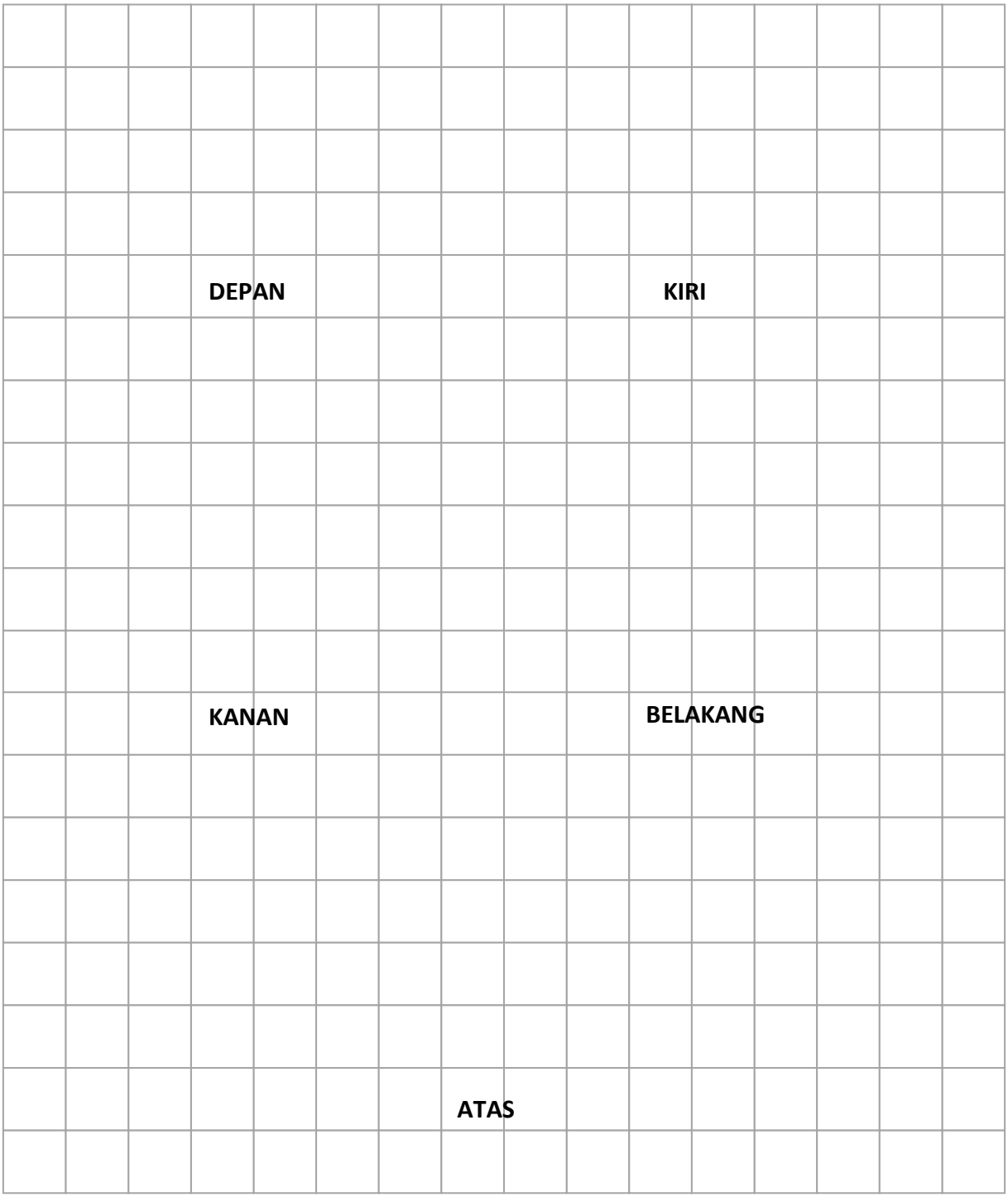
Sebagai contoh, lihatlah gambar tampak kanan dari rumah kubus di bawah ini.



Nama Kelompok:_____

Buatlah rumah kubus yang terdiri dari 5 kubus kecil.
Gambarlah rumah kubus tersebut

- Tampak depan
- Tampak kiri
- Tampak kanan
- Tampak belakang
- Tampak atas



Nama Kelompok :_____ **Nama:_____**

Buatlah rumah kubus yang terdiri dari 4 kubus kecil.
Gambarlah rumah kubus tersebut

- Tampak depan
- Tampak kiri
- Tampak kanan
- Tampak belakang
- Tampak atas

DEPAN **KIRI**

KANAN **BELAKANG**

ATAS

RENCANA PELAKSANAAN PEMBELAJARAN

Nama Sekolah	:	SD Negeri 117 Palembang
Mata Pelajaran	:	Matematika
Kelas/Semester	:	III/2
Pertemuan	:	5 (kelima)
Alokasi waktu	:	2 x 35 menit
Standar Kompetensi	:	Memahami unsur dan sifat-sifat bangun datar sederhana

A. Tujuan Pembelajaran

1. Menyusun kubus dari gambar tampak samping dan tampak atas yang diberikan
2. mengidentifikasi susunan rumah kubus dari gambar tampak samping dan tampak atas yang diberikan
3. Menyelesaikan permasalahan dengan menggunakan kemampuan spasial yang telah dikembangkan.

B. Indikator

1. Menyusun kubus dari gambar tampak samping dan tampak atas yang diberikan
2. mengidentifikasi susunan rumah kubus dari gambar tampak samping dan tampak atas yang diberikan

C. Materi Pembelajaran

Materi ini merupakan materi tersulit dari kelima materi yang ada. Dibutuhkan kemambuan ‘membaca’, mengintrepretasi gambar yang baik untuk menyelsaikan permasalahan yang akan disajikan. Aktifitas ini tidak hanya membantu mengasah kemampuan visualisasi spasial siswa tetapi juga kemampuan spasial siswa secara keseluruhan.

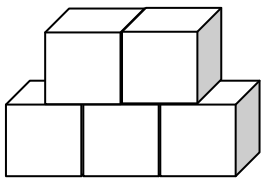
D. Metode Pembelajaran

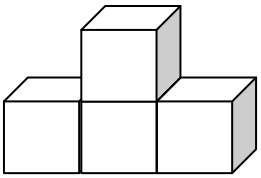
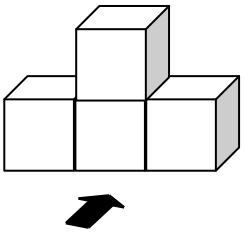
Kerja kelompok dan diskusi

E. Pendekatan Pembelajaran

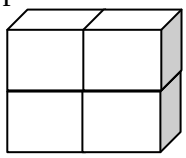
Pendidikan Matematika Realistik Indonesia (PMRI)

F. Kegiatan Pembelajaran

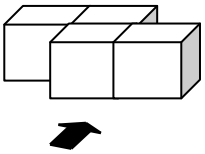
Kegiatan	Uraian	Waktu (menit)
Kegiatan Awal	**Apersepsi:** Pengulangan materi yang telah diajarkan sebelumnya dan mengaitkan materi sebelumnya dengan materi yang akan dipelajari **Motivasi:** 1. Guru menyampaikan aktivitas pembelajaran pada hari ini: bahwa siswa akan menyusun kubus-kubus kayu sesuai dengan susunan yg diinginkan dari gambar tampak samping dan tampak atas yg diberikan. 2. Guru menyampaikan tujuan pembelajaran	2 - 3
Kegiatan Inti	**Eksplorasi** 1.Guru menyampaikan konteks dan pemasalahan yang akan dikerjakan oleh siswa Pada aktifitas ini, siswa akan menyusun kubus-kubus menjadi bentuk tertentu pada arena berpetak yang disediakan. Kemudian siswa diminta untuk menggambarkan tampak samping (tampak depan, tampak belakang, tampak kiri, dan tampak kanan) serta tampak atas dari susunan kubus yang mereka buat. 2. Guru memfasilitasis peserta didik melakukan pengamatan dan dalam menyusn rumah kubus • Dalam menyelesaikan permasalahan-permasalahan yang ada di lembar kerja siswa, siswa dapat membuat susunan kubus yang serupa dengan gambar dengan menggunakan kubus-kubus kayu yang tersedia. • Untuk mempermudah siswa dalam menggambar, siswa dapat menyusun kubus pada arena berpetak yang disediakan. • Tanda panah pada gambar menandakan arah depan • Berbeda dengan susunan balok-balok pada aktifitas sebelumnya yang disusun seperti gambar berikut ini,  pada aktifitas ini, kubus-kubus harus disusun seperti gambar di bawah ini	3 - 5

		
	Elaborasi 1. Siswa menyelesaikan permasalahan yang diberikan pada Lembar Kerja Siswa dan Diskusi Berbeda dengan aktifitas-aktifitas sebelumnya, pada aktifitas ini soal pertama akan dibahas bersama-sama. Sementara soal kedua dan soal ketiga akan dikerjakan sebagai latihan untuk masing-masing kelompok. Berikut ini dijabarkan tahapan-tahapan mekanisme diskusi dan kerja siswa: • Siswa diberikan satu gambar tampak depan dari susunan kubus, kemudian mereka harus menyusun kubus-kubus sesuai dengan gambar tersebut. Diharapkan siswa akan menyusun kubus-kubus seperti pada gambar berikut ini.  • Selanjutnya guru memilih dua atau tiga kelompok untuk menunjukkan bentuk susunan mereka. Siswa diminta untuk menyebutkan jumlah kubus yang mereka gunakan. • Guru mengajak siswa untuk mengamati tampak depan, kiri, dan atas dari susunan kubus. Apakah susunan tersebut sudah sesuai dengan gambar yang ditunjukkan oleh LKS. • Kemudian guru menanyakan kepada siswa apakah satu gambar saja cukup untuk menjawab teka-teki tersebut? Dari berbagai jawaban yang diberikan, dapatkah mereka menentukan jawaban mana yang paling benar? Mengapa? • Berikutnya siswa diberikan satu gambar tampak kiri dari susunan kubus. Sama seperti sebelumnya, siswa diminta untuk menyusun kubus-kubus berdasarkan gambar yang diberikan. Tahapan mekanisme diskusi selanjutnya sama seperti di atas. Di akhir diskusi, guru bertanya kepada siswa apakah jumlah	40 – 45

kemungkinan jawabannya bertambah banyak atau bertambah sedikit ketika mereka diberikan gambar kedua? Mengapa demikian?



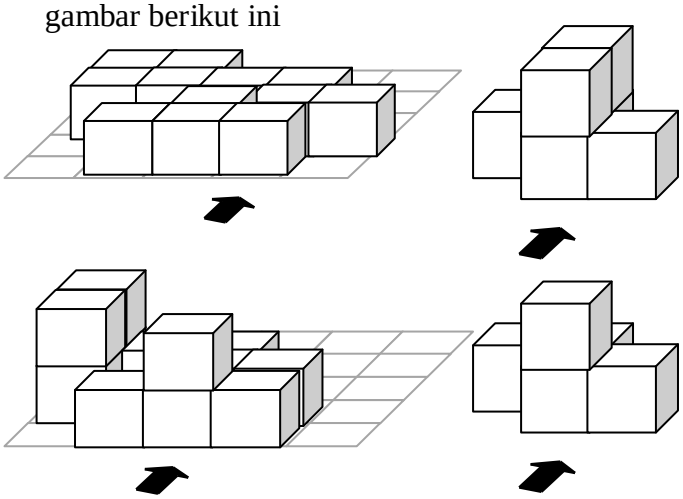
- Diskusi dilanjutkan dengan memberikan siswa gambar tampak atas dari susunan kubus. Siswa diminta untuk menyusun kubus dari gambar tampak atas seperti pada gambar berikut in.



- Guru menginstruksikan kepada siswa untuk meyusun kubus-kubus tersebut sehingga memiliki tampak atas, tampak kiri, dan tampak depan seperti yang telah mereka buat.

  Konjektur pemikiran siswa:

  Siswa akan menyusun kubus-kubus seperti pada gambar berikut ini



- Guru menunjukkan gambar jawaban susunan kubus yang benar, dan menjelaskan kepada siswa bagaimana cara membangun susunan kubus dari tiga gambar yang diberikan. Guru harus memastikan bahwa siswa memahami masalah yang telah mereka kerjakan.

2. Dua soal berikutnya adalah latihan untuk siswa.
3. Setelah semua kelompok selesai mengerjakan latihannya, jika masih ada waktu, siswa diizinkan untuk melihat hasil kerja kelompok lain.

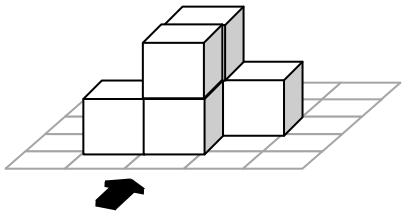
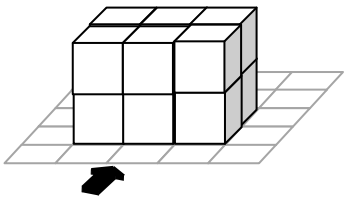
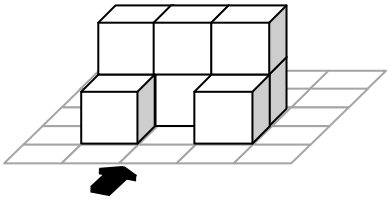
	Konfirmasi 1. Guru memberikan umpan balik positif dan penguatan dalam bentuk lisan. 2. Guru memberikan motivasi kepada peserta didik yang kurang atau belum berpartisipasi aktif 3. Guru membantu menyelesaikan masalah dengan memberikan jawaban yang benar 4. Melakukan refleksi terhadap pengalaman belajar yang telah dilakukan	5
Kegiatan akhir	1. Guru menyimpulkan hal-hal yang telah dipelajari pada pertemuan ini 2. Guru menyimpulkan hal-hal yang telah dipelajari selama 5 pertemuan	2 – 3

G. Media/Sumber Pembelajaran

- balok kayu berukuran 3 x 3 x 3 cm
- lembar kerja siswa

H. Penilaian

3. Bentuk Tes : Tugas Terstruktur
4. Bentuk Soal : (lihat LKS)
5. Rubrik Penilaian :

No Soal	Jawaban	Skor
1		35
2		30
3		35

Palembang, Maret 2013

Wali Kelas IIIa,

Fatmawati, S. Pd

NIP.

Peneliti

Dwi Afrini Risma

NIM. 20112812009

Mengetahui,

Kepala SDN 117 Palembang

Toman Siregar, S.Pd

NIP.

AKTIVITAS 5

Konteks

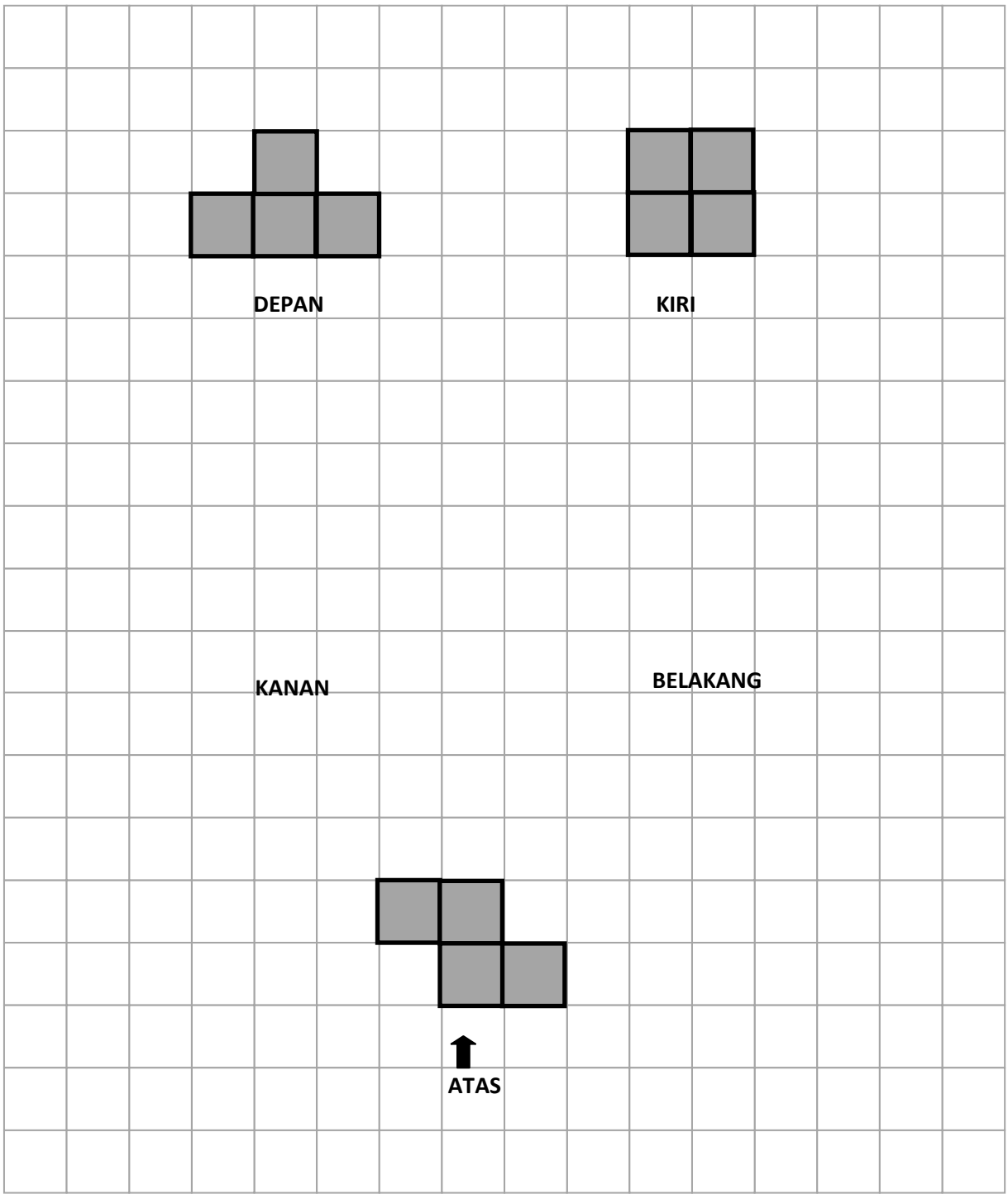
Kamu adalah tiga orang bajak laut yang akan mencari harta karun. Harta karun tersebut terkunci di dalam sebuah bilik rahasia di istana tua. Untuk menemukan bilik rahasia tersebut, kamu membutuhkan 3 benda penting yaitu kompas, peta dan kunci. Kamu membutuhkan peta untuk mencari lokasi istana tua tersebut, kompas tersebut akan digunakan sebagai penunjuk arah ketika sedang membaca peta. Sedangkan kunci akan digunakan untuk membuka peti harta karun. Tiap benda tersimpan pada kamar yang ada di rumah kubus milik Pak Rusman. Untuk membuka kamar tersebut, kalian harus menyelesaikan teka-teki yang diberikan oleh Pak Rusman. Ayo selesaikan teka-tekinya dan temukan harta karun!

Nama Kelompok: _____

Teka-teki 1:

Mari selesaikan puzzle pertama untuk mendapatkan kompas!

Jumlah kotak yang digunakan:_____

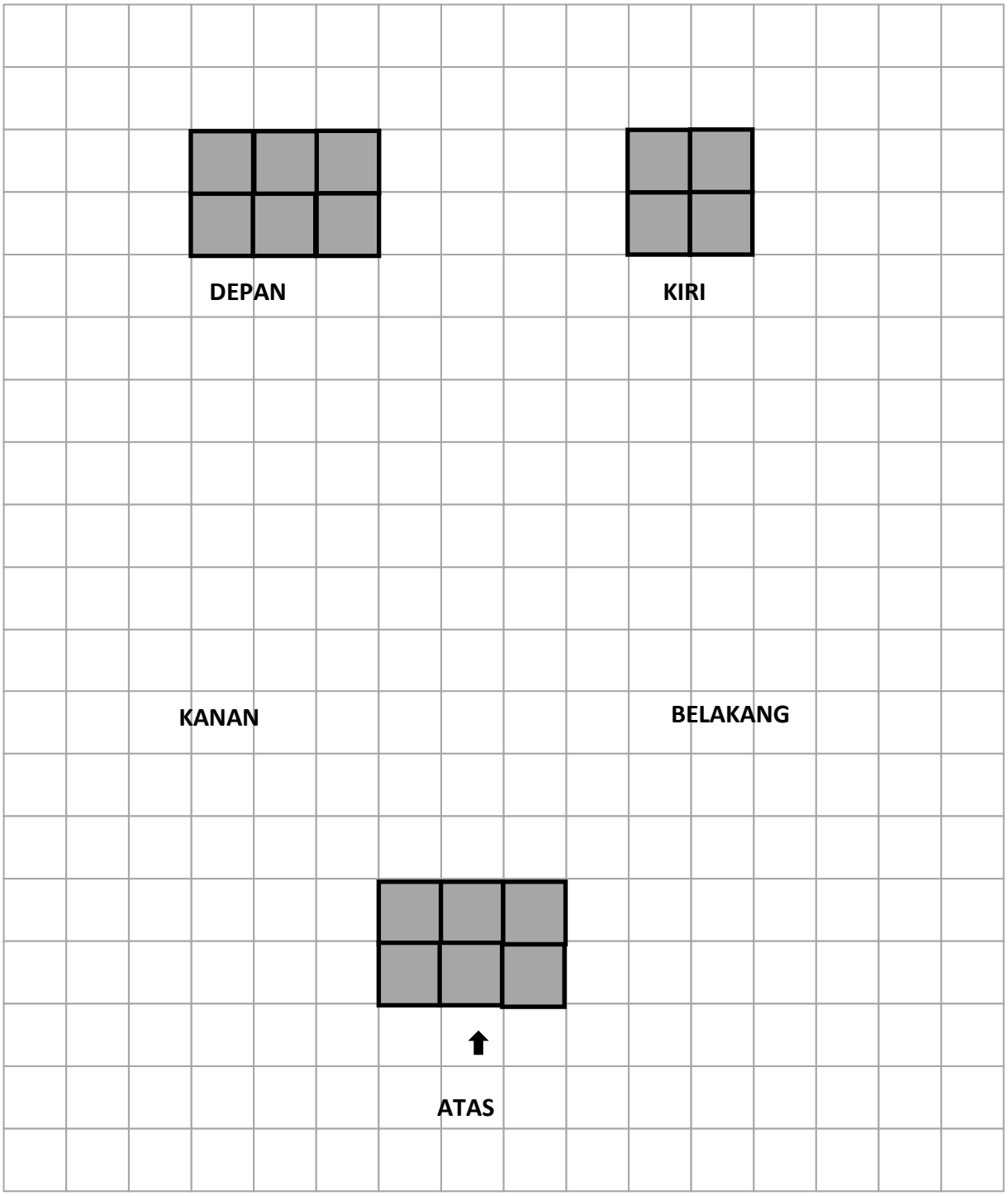


Nama Kelompok: _____

Puzzle 2:

Mari selesaikan puzzle pertama untuk mendapatkan kunci!

Jumlah kotak yang digunakan:_____



Nama Kelompok: _____ Namamu:_____

Puzzle 3:

Mari selesaikan puzzle pertama untuk mendapatkan peta harta karun!

Jumlah kotak yang digunakan:_____