SUPPORTING 7th GRADE STUDENTS' UNDERSTANDING OF THE AREA MEASUREMENT OF QUADRILATERALS AND TRIANGLES THROUGH REALLOTMENT ACTIVITIES

A THESIS

Submitted in Partial Fulfillment Requirements for the Degree of
Master of Science (M.Sc.)
In
International Master Program on Mathematics Education (IMPoME)
Graduate School Sriwijaya University
(In collaboration between Sriwijaya University and Utrecht University)

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FACULTY OF TEACHER TRAINING AND EDUCATION
SRIWIJAYA UNIVERSITY
JUNE 2014

APPROVAL PAGE

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Date of Approval : June 2014

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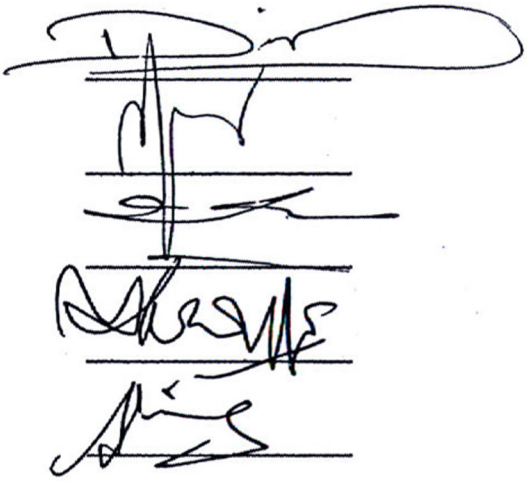

ABSTRACT

In Indonesia, the teaching and learning of are measurement is mostly dominated with memorizing and applying formulas or algorithms. It has been studied that this way of teaching will not support students' understanding of concepts of area measurement. Students will depend on their memorization abilities of the formulas to solve area measurement problems. Thus, we need instructional activities which emphasize the concepts rather than just memorizing formulas. The researchers designed nstructional activities carried out in six meetings with PMRI (Pendidikan Matematika Realistik Indonesia) approach. In this study, design research was used to investigate how relallotment activities could support students' understanding of area measurement. This study is aimed at contributing to a local instructional theory of area measurement. Twenty nine grade 7 students and one teacher of SMP Pusri participated in this study. The analysis of students' work and video of the learning process showed that comparing activity could enables students to develop their understanding of the concept of conservation of area. This concept could support students the meaning of an area and area measurement when integrated with other concepts. Understanding this concept helps students to measure areas of quadrilaterals and triangles by reshaping and derive area formulas.

Keywords: Area measurement, conservation of area, Pendidikan Matematika Realistik Indonesia (PMRI), Design research.

ABSTRAK

Di Indonesia, pembelajaran pengukuran luas sering didominasi dengan penghafalan and penerapan rumus-rumus atau algoritma. Sudah dilakukan penelitian bahwa cara pembelajaran sepeti itu tidak dapat mendukung pemahaman siswa tentang konsep-konsep pengukuran luas. Siswa hanya bergantung pada kemampuan ingatan mereka tentang rumus-rumus untuk menyelesain permasalahan pengukuran luas. Oleh karena itu, kita memerlukan aktifitas belajar yang menekankan pada pemahaman konsep daripada sekedar menghafal rumus. Peneliti merancang aktifitas belajar yang disampaikan dalam enam pertemuan dengan pendekatan Pendidikan Realistik Matematika Indonesia (PMRI). Dalam studi ini, desin research digunakan untik mengetahui bagaimana aktifitas reallotment dapat mendukung pemahaman siswa tentang pengukuran luas. Studi ini bertujuan untuk berkonstribusi terhadap teori instruksi lokal tentang pengukuran luas. Dua puluh sembilan siswa kelas 7 adan seorang guru berpartisipasi dalam penelitian ini. Hasil analisa dari pekerjaan siswa adan video saat pembelajaran menunjukkan bahwa membandingkan luas dapat memacu siswa mengembangkan pemahamannya tentang konsep konservasi luas. Konsep ini dapat membantu siswa memahami pengertian luas dan pengukuran luas saat diintegrasikan dengan konsep-konsep yang lain. Dengan memahami konsep konservasi luas dapat membantu siswa mengukur luas segi empat dan segitiga dengan mengubah bentuknya dan dapat menurunkan rumus-rumus luas.

Kata kunci: Pengukuran luas, konservasi luas, Pendidikan Matematika Realistik Indonesia (PMRI), design research.

SUMMARY

Area measurement has various applications in human life such as determining the area of a land, and finding the number of tiles needed to cover a floor. Area measurement is also related to other materials such as the multiplication of fractions, enlargement and similarity (Cavanagh, 2007). In integral calculus, to find an area under a curve can be estimated by the sum of areas of rectangles under the curve. A good understanding of the concept of area is important in learning integral calculus (Cavanagh, 2007). Since area measurement is very important, the Indonesian curriculum puts this topic in all levels of education, especially in the elementary and secondary levels. Some studies that have been conducted about this topic show that students in all levels experience difficulties in dealing with area concepts (Cavanagh, 2007).

Within a design research, we developed a learning trajectory of area measurement to support students' understanding of area measurement. We also designed a hypothetical learning trajectory (HLT) consisting of conjectures how students would react on the problem and how teacher could give support to students. We carried out the instructional activities and tested out the HLT to twenty nine 7^{th} grade students of SMP Pusri Palembang in two cycles. Six students participated in the preliminary teaching experiment with the researcher as a teacher. This preliminary teaching was aimed at revising the HLT to be used in the second cycle. Twenty three students participated in the teaching experiment in cycle 2 with their home class teacher. Before the teaching began, students took a 30-minutes pre-test to know their prior knowledge of area measurement. After the end of the last meeting, students also took a post-test to know what students have learned from the designed activities.

Based on the findings in this study, it can be concluded that students could develop more conceptual understanding of area measurement by comparing areas involving reallotment activities. By comparing areas within contextual problems, students could understand the meaning of area and also the concept of conservation of area. In addition, students could differentiate between area and

perimeter through this activity. When students worked on reallotment activities, students develop their strategy of reshaping. As students understand the concept of conservation of area, students could apply it when estimating area using squares units of measurement. Students combined the non-fully squares to make fully squares in order to measure an area of a figure. More importantly, students also applied this strategy in solving quadrilaterals and triangles problems. Students reshaped the quadrilaterals and triangles into a rectangle to measure their areas. Students understand when they reshape the quadrilaterals and triangles into a rectangle, their areas remains invariant. Hence, by relating the quadrilaterals and the formed-rectangle, students could derive the area formulas. Students could derive are formula of triangle by seeing the triangles as half of the parallelogram and of a rectangle. Area formula of trapezoid can be derived well when students use the area formula of triangles.

RINGKASAN

Pengukuran luas mempunyai banyak aplikasi dalam kehidupan manusia seperti penentuan luas suatu tanah, dan menentukan jumlah ubin untuk menutupi suatu lantai. Pengukuran luas juga berhubungan dengan materi lain seperti perkalian pecahan, perbesaran dan kesamaan (Cavanagh, 2007). Pada kalkulus integral, untuk mencari luas daerah di bawah kurva juga dapat diestimasi dengan jumlahan luas-luas dari persegi empat yang berada di bawah kurva tersebut. Pemahaman yang baik tentang konsep-konsep luas sangat penting saat siswa belajar kalkulus integral (Cavanagh, 2007). Karena pengukuran luas sangatlah penting, makakurikulum di Indonesia memasukkan topik ini pada semua level pendidikan, khususnya di level sekolah dasar dan menengah pertama. Beberapa penelitian telah dilakukan mengenai topic pengukuran luas menunjukkan bahwa siswa di semua level masih mengalami kesulitan tentang konsep-konsep luas.

Dengan design research, peneliti menngembangkan lintasan belajar tentang pengukuran luas untuk mendukung pemahaman siswa tentang pengukuran luas. Peneliti juga mendesain suatu hipotesis lintasan belajar (HLT) yang berisi prediksi-prediksi bagaimana siswa akan bereaksi terhadap soal-soal yang diberikan dan bagaimana guru dapat mendukung siswa. Peneliti menjalankan instruksi aktifitas dan menguji HLT terhadap dua puluh sembilan siswa kelas 7 di SMP PUSRI Palembang dalam dua siklus. Enam siswa berpartisipasi di pembelajaran permulaan bersama dengan peneliti sebagai pengajarnya. Tujuan dari pembelajaran permulaan ini adalah untuk memperbaiki HLT yang akan digunakan pada siklus kedua. Dua puluh tiga siswa berpartisipasi dalam pembelajaran di siklus 2 bersama guru kelas mereka. Sebelum pembelajaran berlangsung, siswa mengerjakan soal pre-test selama 30 menit untuk mengetahui pengetahuan yang sudah dimiliki siswa tentang pengukuran luas. Setelah pertemuan terakhir, siswa mengerjakan soal post-test untuk mengetahui apa yang sudah siswa pelajari selama mengikuti aktifitas yang telah didesain.

Berdasarkan temuan-temuan pada penelitian ini, dapat disimpulkan bahwa siswa dapat mengembangkan pemahaman konsep-konsep tentang pengukuran luas melalui pembandingan luas yang melibatkan aktifitas reallotment. Dengan membandingkan luas pada soal kontektual, siswa dapat memahami pengertian luas dan konsep konservasi luas. Siswa juga dapat membedakan Antara luas dan keliling dengan aktifitas tersebut. Pada saat siswa mengerjakan akltifitas reallotment, siswa mengembangkan strategi mengubah bentuk. Setelah siswa memahami konsep konservasi luas, siswa dapat menerapkannya saat mengestimasi luas menggunakan kotak satuan luas. Siswa menggabungkan kota-kotak yang tidak penuh untuk menjadikannya penuh untuk mengukur luas suatu bangun. Yang lebih penting adalah, siswa dapat menggunakan strategi ini untuk meyelesaikan soal-soal yang berkaitan dengan segi empat dan segitiga. Siswa mengubah bentuk menjadi persegi panjang untuk mengukur luasnya. Siswa memahami bahwa disaat mereka mengubah bentuk segi empat dan segitiga menjadi persegi panjang, luas bangun tersebut tetap. Oleh karena itu, dengan menghubungkan segi empat dan persegi panjang, siswa dapat mendapatkan rumus luas bangun tersebut. Siswa dapat mendapatkan rumus segitiga dengan melihat luas segitiga sebagai setengah dari jajar genjang ataupun persegi panjang. Rumus luas trapezium dapat diperoleh dengan baik ketika siswa menggunakan rumus luas segitiga.

“Every student can learn, just not on the same day, or the same way.”

- George Evans

“I never teach my pupils; I only attempt to provide the conditions in which they can learn.”

- Albert Einstein

I specially dedicated this thesis to:

My mother (Sumiyatun) who has always blessed me with unconditional love, uncountable prayers, encouragement, and support throughout my entire life. Dedications go to my beloved aunt (Salamah), beloved sisters (Isroni Astuti and Ani Sri Rahayu) and my beloved brothers (Isnan Arifin, Isa Anshori, and Fajar Nurochman) for their love, prayers, and support.

PREFACE

All praises to The Almighty Allah SWT and Alhamdulillah for His blessing so that I could finish this thesis. I did not stand alone when I was facing hard and difficult time during my study. I am very thankful to people who have supported and encouraged me on my journey to pursuit a successful study. First, I would like to express my gratitude to my Dutch supervisors: Monica Wijers and Dolly van Eerde who gave me support in designing activities and completing the methodological aspect of this study. My gratitude also goes to my Indonesian supervisors: Dr. Darmawijoyo and Dr. Ratu Ilma Indra Putri, M.Si. for their insightful discussion and support in finishing this thesis. My appreciation also goes to Maarten Dolk, the coordinator of IMPoME in Utrecht, for his advice and discussion during my study in the Freudenthal Institute for Science and Mathematics Education (FIsme), Utrecht University, the Netherlands. Also, thank you very much for all staffs and lecturers in the FIsme, Utrecht University who inspired me and motivated me to work harder. I, moreover, thank to Mark Uwland for helping me with the English support. Thank you all for your hospitality.

I would never have a chance to study in the Netherlands without support from PMRI team, Nuffic - NESO and Dikti. Thank you to the director of Diktendik, Mr. Supriyadi Rustad. Thank you to Prof. R.K. Sembiring, Mba Martha, all PMRI, NESO, and Dikti staffs, for awarding me and arranging the scholarship. Thanks also goes to Dr. Hartono and Dr. Sugiman who gave me a recommendation to the PMRI team to be selected as one of IMPoME 2012 scholarship awardees. Thanks to Mr. Ariyadi Widjaya for the supports and advises.

I also thanks to Prof. Dr. Hilda Zulkifli, M.Si., DEA., as the director of Graduate School Sriwijaya University, Sofendi, M.A., Ph.D.as the dean of Faculty of Teacher Training and Education, and Prof. Dr. Zulkardi, M.I.Komp., M.Sc., as the head of Mathematics Education Department in Graduate School Sriwijaya university, all lecturers and staffs, among them: Dr. Ratu Ilma Indra Putri, M.Si., Dr. Yusuf Hartono, M.Sc., Dr. Somakim, M.Pd., Mba Tesi, who gave me a lot of support during my study in Palembang. I would like to extend my gratitude Fauziyah, S.Pd. – a great mathematics teacher, and Dra. Trisna Sundari - the principal of SMP PUSRI Palembang for their support and hospitality during the hard time in conducting the study.

I wish to thank to all my friends in IMPoME 12 with whom I have worked and played alongside for the past two years. I would never forget all your kindness and

our joyfulness together. Last but by no mean least, I also thank to my friends in IMPoME 11 and IMPoME 13 for their warmth and friendship.

I consciously understand that this thesis is far away from perfect. Thus, any insightful critics and constructive ideas will be gladly accepted.

Palembang, June 2014

Wahid Yunianto

CURRICULUM VITAE

Wahid Yunianto born in Jakarta, 2 June 1988, is a student of International Master Programme on Mathematics Education of Sriwijaya University – Utrecht University 2012. He is the first son of Katena and Sumiyatun. He spent his childhood and gained his education in Klaten, Central Java (TK Pertiwi Kemudo I, SDN Kemudo II, SMPN I Prambanan, SMAN I Jogonalan). He got his undergraduate degree at Yogyakarta State University in 2011.

He was awarded a scholarship in 2012 to continue his master degree called International Master Programme on Mathematics Education (IMPoME) focusing on Realistic Mathematics Education. He got an English training from Dikti for 1.5 months at Sriwijaya University. Finally, in January 2013, he took some parts of his study at Utrecht University, the Netherlands. He completed his study for two years. The writer actively participated and joined students' organizations during his study. He joined Student Activity of Foreign Languages (2007-2009). He also joined Students Activity of Radio Broadcasting (2009-2011).He also did part time jobs as radio announcer and mathematics tutor. He also actively involved in PPI Utrecht during his study at Utrecht University in 2013.

The writer lives in Prambanan, Central Java and can be reached through HP: 085643763865 or email wahid_yunianto@yahoo.co.id. After completing his study, he plans to continue his study and do research on mathematics education.

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CHAPTER I

INTRODUCTION

1.1. Background

Students learn about area measurement from elementary school until university. Area measurement has various applications in human life such as determining the area of a land, and finding the number of tiles needed to cover a floor. Area measurement is also related to other materials such as the multiplication of fractions, enlargement and similarity (Cavanagh, 2007). In integral calculus, to find an area under a curve can be estimated by the sum of areas of rectangles under the curve. A good understanding of the concepts of area is important in learning integral calculus (Cavanagh, 2008). Since area measurement is very important, the Indonesian curriculum puts this topic in all levels of education, especially in the elementary and secondary levels.

Some studies that have been conducted about area measurement topic show that students in all levels experience difficulties in dealing with area concepts (Cavanagh, 2007). Cavanagh (2008) shows that many students confused between area and perimeter, confused about the height of a shape and do not understand the basis of the formula for the area of a triangle. In Indonesia, the emphasis in teaching and learning mathematics is on algorithm and the use of formulas (Fauzan, Slettenhaar & Plomp, 2002). In addition to this, learning by memorizing formulas and applying them will not support students' understanding of the concept of area. In line with this, Zacharos & Chassapis (2012) argue that the lack of understanding of the mathematical concepts is due to the use of traditional teaching methods overstressing formulas and algorithms without giving attention to students' comprehension of the concepts. Related to area measurement, Martin & Strutchens (2000) (cited in Kamii and Kysh, 2006) state that the concept of area is often difficult for students to understand, and that this is perhaps due to their initial experiences in which it is tied to a formula (such as area as length × width) rather than more conceptual activities. Zacharos (2006)

states that research in the field of mathematical education often reveal poor understanding of the processes used for area measurement of plane figures.

A recent study by Zacharos & Chassapis (2012) in grade 6 of a Greek elementary school shows statistically that the experimental group used more successful strategies than the control group. Students in the experimental group learned the Euclidean method area of comparison and the principles of overlapping. Meanwhile, the students in control group only learned about the formulas and used regular text books provided by the school. It was found that students in the experimental group learned more strategies than those in the control one. However, we still do not know how and why these teaching interventions work. Based on the learning activities in the experimental group, it is still too easy for students to compare two regular shapes that have been partitioned into two equal parts. Students will easily notice that the figures have the same area since only the orientation of the figures is different. It seems that these activities do not give students more opportunities to further explore the concept of area, overlapping. In addition, it is also important to know the concept of conservation of area, in which reshaping the area of a shape does not change its area. Zacharos & Chassapis (2012) suggest that it is still needed to find teaching interventions that focus on the comprehension of concept of area in order to lead the transition from overlapping practices to formulas.

In Indonesia, some studies related to area measurement have been conducted (see Fauzan, 2002; Yuberta, 2011; Febrian, 2013; Fiangga, 2013; Funny, 2013; Putrawangsa, 2013). In addition, these studies were conducted in elementary school. Fauzan (2002) recommends that the development of the local instructional theory should begin with teaching and learning of mathematical topic from the lower grades and gradually to the higher grades. Fiangga (2013) and Funny (2013) did research on area measurement focusing on the concept of conservation of area before students learn about area formulas. Funny (2013) suggests to further study on the effect of learning of conservation of area when students are learning or after they learn area measurement. Meanwhile, Febrian (2013) and Putrawangsa (2013) did research on area measurement that focused on

unit of measurement but did not focus on the area formulas. Yuberta (2011) suggests to further study on how students achieve the area formulas. In addition, Putrawangsa (2013) also suggests to further study on students' understanding of the standard unit of measurements, such as centimeter square and meter square. It seems that the previous studies only focus only on specific concept of area measurement, unit of measurement alone or conservation of area alone. In Indonesia, no studies have been conducted in secondary level in which students have learned a formula to measure areas in elementary schools. Dickson (1989) (as cited in Cavanagh, 2007) in his study, shows that over one third of students aged 9 to 13 who have been taught the formula A= length x width used this formula exclusively even when it was inappropriate to do so. Therefore, giving only a formula will not work well to help students understand area measurement.

Based on the aforementioned discussion, there is still a need to investigate secondary school students' understanding of area measurement. Therefore, this study will investigate the students' understanding of area measurement by focusing on the concept of conservation of area integrated with unit measurement to support students to understand area formulas to measure area of quadrilaterals and triangles in secondary school. This study will use "reallotment" which is the act of reallocation or redistribution of something by cutting and pasting. In area measurement, it reshapes a figure into another one without changing its area. In other words, the area of a figure remains the same when it is reshaped into other shapes. In addition, different shapes would possibly have the same area. The concept of unit of measurement through the tiling activity will support students to understand the area formula of rectangle. From the activity of reshaping the other quadrilaterals and triangles into a rectangle, students will understand how the area formulas of quadrilaterals and triangles can be derived from the area formula of rectangle. Reshaping into a rectangle will help students to derive the other area formulas of quadrilaterals.

1.2. Research Aim and Questions

This study is aimed at contributing a local instructional theory to support students' understanding of area measurement through reallotment activities. Hence, research questions in this research are:

1. *How can reallotment activities support students' understanding of the concept of area measurement?*
2. *How can reallotment activities support students to measure areas of quadrilaterals and triangles?*

CHAPTER II
THEORECTICAL BACKGROUND

2.1. Area measurement

Area measurement is a part of geometry. There is more to area measurement than multiplying the length and width. Fowler (1987) states that due to the arithmetization on all areas in mathematics including geometry the area of a rectangle is seen as the product of the length of its base and height. He states that up to 2nd century B.C., Euclidean geometry seems to have been completely different and not arithmetized. Zacharos & Chasapis (2012) argue that geometry was related to the comparisons of quantities such as length, area, capacity, etc. In addition, they state that measurement procedures are based on similar physical characteristics of the quantities being compared or measured such as in comparing an area, using surface. More importantly in Euclidean geometry, in dealing with area measurement, if we want to show that two figures have equal areas we can divide one of the figures into parts and then fit those parts in certain ways to produce the second figure (Bunt, Jones & Bedient, 1988). In the criteria for equality of triangles this strategy is called ‘overlapping’ or ‘epithesis’ and this strategy can be used extensively to determine the equality of areas as well (Zacharos, 2006). In addition, dividing or parting and rearranging to produce a new figure involve knowledge of the concept of conservation of area. It means that breaking up the first figure into parts and rearranging from those parts to produce the second figure will not change the area of the original figure.

The concept of conservation of area is a fundamental and preliminary aspect in students’ understanding of the concept of area measurement (Piaget, Inhelder & Szeminska, 1981; Hirstein, Lamb & Osborne, 1978; Maher & Beattys, 1986 as cited in Kordaki, 2003). It is an important concept that students need to master in learning area measurement. Therefore, students need to understand this concept. Students might have experienced reshaping a figure without knowing that they apply the concept of conservation of area. Kordaki (2003) states that

students can master the concept of conservation of area through the *cut, move* and *paste* activities that is rearranging the parts of a figure to produce a new one with an equivalent area. In addition, it is necessary to let students do those activities in order to understand the concept of conservation as prerequisite knowledge to understand the concept of area measurement (Hirstein et al., 1978; Douady & Perrin, 1986 as cited in Kordaki, 2003).

The procedure to measure an area involves the surface to be measured or compared. Therefore, area is closely related to surface. Baruto & Nason (1996) define area as an amount of region (surface) enclosed within a boundary and this amount of region can be quantified. In everyday words, the area of a figure or object is the amount of 'stuff' needed to cover the figure (Konya and Tarcsi, 2010). Moreover, there is a need to find the 'stuff' in order to make it easier to determine the area of a shape. Cavanagh (2007, 2008) states that area measurement is based on partitioning a region into equally size units that cover it without any gaps or overlaps. Here, the 'stuff' needed to measure an area is a unit of measurement.

Reynolds & Wheatley (1996) state that to determine an area of a region can be done by comparing that region to another region like a square unit. They argue that in comparing regions that assigns numbers, there are four assumptions. The four assumptions are (1) a suitable two-dimensional region is chosen as unit, (2) congruent regions have equal areas, (3) regions do not overlap, and (4) the area of the union of two regions is the sum of their areas. Therefore, learning and teaching of area measurement can be taught though tiling activity (Reynold & Wheatley, 1996). In line with this statement, tiling activity can be used to teach students that area is a measure of covering (Konya & Tarcsi, 2010). Tiling activities use the idea of covering a region without any gaps or overlaps within certain tiles as units of measurement. Stephan & Clements (2003) argue that there are at least four foundational concepts that are involved in learning of area measurement: (1) partitioning, (2) unit iteration, (3) conservation, (4) structuring array. In this study, the researcher integrates all four foundational concepts in the instructional activities

2.2. Students' understanding and misunderstanding of the concept of area

Huang & Witx (2011) reveal that students with a good understanding of the concept of area and the area formula exhibited competency in identifying geometric shapes, using formulas to determine areas, and self-correcting mistakes. Meanwhile students with a good understanding of multiplication that underlies the area formula, but who lacked understanding of the concept of area, showed some ability to use area formulas. Huang & Witx (2011) also state that the students who were unable to interpret the property of multiplication underlying the area formula irrespective of their conceptions of area exhibited the common weaknesses in identifying geometric shapes and in differentiating between area and perimeter. It is clear students need to have a good understanding of the concept of area before they learn the area formulas.

Studies on mathematics education have often shown that students have a poor understanding of area measurement related to the processes used when they measure plane figures (Zacharos, 2006). In addition, Zacharos (2006) states that the way of teaching and learning of area measurement is responsible for difficulties and poor understanding of area measurement. Zacharos & Chassapis (2012) state that problems related to the understanding of mathematical concepts are due to a traditional approach in the teaching and learning of mathematics by overstressing the familiarization with algorithms and underestimating the importance of the comprehension of the concepts. Mostly, Indonesian teachers teach area measurement by using a traditional approach. What students understand about area measurement in a traditional teaching is applying formulas.

In a traditional teaching approach, mostly teachers only give the procedural algorithms or formulas to determine areas of geometrical shapes. Students tend to memorize the formulas such as the area of a rectangle is base x height (A= b x h). Cavanagh (2007) states the teaching and learning of area measurement will not be successful if it focuses too much on formulas instead of conceptual understanding. Therefore, what students learn in a traditional mathematics classroom is only memorizing a formula and applying it without having knowledge of the concept of area measurement and how and why the

formulas work. As a result of this teaching approach (misconceptions), students do not understand the concept of area and face several difficulties in learning area measurement or in learning how to measure areas.

Some studies have revealed that students at all levels experience difficulties dealing with area concepts (Cavanagh, 2007). Students think that an irregular figure does not have an area with the justification that the shape is strange and also it has too many sides (see Cavanagh, 2007). Hirstein, Lamb & Osbone (1978) (as cited in Cavanagh, 2007) reported in their study that elementary school students counted all regions equally regardless of their geometrical shape when using a grid. In their study, only less than half of the seventh graders were able to do the task of determining the area of a shaded part consisting of full squares and triangles (half square) in the grid. They treated the triangles as if these were the same units as the squares (Kamii & Kysh, 2006).

Students also got confused between area and perimeter and wrongly used the slant height instead of the perpendicular height as the altitude (Cavanagh, 2007). For instance, students measured an area using the formula of perimeter or vice versa. Students also added the base plus the height instead of multiplying base with height to find the area of a rectangle (see Zacharos & Chassapis, 2012). Özerem (2012) reports that seventh year secondary school students have a number of misconceptions and a lack of knowledge related to geometry subjects, such as using the wrong formula due to the lack of understanding of the concept of area and the memorization of formulas.

To sum up, students' difficulties are due to the traditional teaching that stress too much on the procedural algorithms and formulas instead of conceptual understanding. Therefore, innovations in teaching and learning of area measurement are needed to support students‟ understanding of area measurement.

2.3. Promoting the learning of area measurement

To deal with students' difficulties in learning area measurement, teachers should support students to understand the concept of area. There are four foundational concepts involved in learning to measure area: partitioning, unit iteration, conservation and structuring an array (Stephan & Clements, 2003).

Therefore, students need to understand these concepts in order to have a good understanding of area measurement. Zacharos & Chasappis (2012) in their experimental study reveal that students who learn the conceptual characteristic of area measurement exhibit more successful strategies than the control group who just learn formulas.

In the study by Zacharos & Chasappis (2012), students in the experiment group have the opportunities to learn about the Euclidean method for comparison and the principles of overlapping. However, it is not clear whether the teacher explains these concepts or students find the concept by themselves. Instead of explaining the concepts to students, we should let students experiment by themselves and to give a role to a teacher as facilitator. Cavanagh (2007) states that students in grade 7 still need to have hands-on activities since it helps students to overcome their misconceptions such as the difference between area and perimeter and the confusion of slant-perpendicular height. Mathematics teachers should include classroom activities that let students investigate and develop the concept of area in a meaningful way. The teacher can provide mathematical contexts that can develop students' understanding. Problems embedded in a context could encourage the students to develop the concept of area measurement (Harris & Putri, 2011). Cavanagh (2008) suggests that the teachers should consider designing instructions to include appropriate activities and allow sufficient time for students to develop a conceptual understanding of array structures before proceeding to use numerical calculations and area formulas. He also states that "taking time to develop the area formulas more slowly allows students the chance to develop a sound conceptual understanding as a solid basis for further work in area measurement". Activities such as superimposition, decomposition, re-composition as well as the concept of congruence are essential for students for the conceptualization of the formulas for area measurement (Huang and Witz, 2011). They also state that the more students use geometric operations and numerical calculations for measuring areas, the more understanding of the formulas for area measurement and how they work they attain.

In this study, the design instructional activities mainly focus on the concept of conservation of area integrated with unit of measurements. Students will explore the concept of conservation of area by comparing and reshaping. In comparing, students need to overlap one region into another one and do cut and paste strategy in order to see which region is larger. Related to the conservation concept, students will reshape also some geometrical figures into a rectangle. Reshaping activity will help students to understand more about concept of conservation of area, perimeter and area, and the areas formula of quadrilaterals and triangles. The next activity is comparing tiled floors that embed the unit of measurement. We can see a tiled floor as a region partitioned using two-dimensional unit. In tiling floors, people use different size and type of tiles. Normally, the floor is tiled using a square tile. Since there are different size of square tiles, students will compare the two floors with different size of tiles. Then students will see that the floor can be partitioned into different sub regions. In addition, comparing two floors with different size of tiles will also lead students to grasp the need of the same unit of measurement.

After students explore the tiled floors, they will tile floor by themselves. This is called the unit iteration. Students will cover floors with unit of measurement, a square unit. In covering a rectangular floor, students will cover fully the floor's surface. They will count the number of the tiles to compare. In counting the tiles, students may use multiplication strategy. It is the idea of the area formula of rectangle. Students will also cover non-rectangular (a parallelogram floor) floor that allows students to cut and paste the tile in order to cover the floor. The concept of conservation of area is again used in combining the tile or square units. In dealing with rectangular floors, some students may only tiles the edges of the floor instead of covering fully the floor's surface with the tiles. Students explore in structuring array by only cover the edges of the floor. Therefore, students will learn how the area formula of rectangle, base x height, works. Hence, students understand the area formula of rectangle. In the end of the lesson, students will reshape other quadrilaterals and triangles into a rectangle and derive the area formulas of parallelogram, triangle, trapezoid, rhombus and kite.

2.4. Area and Perimeter in the Indonesian Curriculum

Indonesia now is starting to implement a new curriculum called the curriculum of 2013. One of the problems related to mathematics education in Indonesia is the curriculum (Zulkardi, 2002; Fauzan, 2002). In mathematics education, Fauzan (2002) states that the specific instructional objectives from Grade 1 till Grade 6 are dominated by remembering facts and concepts verbally, studying procedural algorithms, and applying formulas. In addition, he also states that in learning the topics of areas and perimeters, the objectives are dominated by remembering and applying the formulas. Now, in the Indonesian curriculum of 2013, area measurement is introduced in the third grade and continuously given up to seventh grade. The following tables are the standard (main) competences and basic competences in the curriculum of 2006 related to area measurement (Badan Standar Nasional Pendidikan, 2006a,b). Mostly, the teaching and learning of measurement is stressed on applying formula without conceptual understanding in curriculum of 2006.

Table 2.1. Standard and basic competences for third grade in semester 2

Standard of Competence	Basic Competence
Measuring the perimeter and area of squares and rectangles and apply it to solve related problems	Measuring the perimeter of squares and rectangles Measuring the area of squares and rectangles Solve related problems involving perimeter, area of squares and rectangles.

Table 2.2. Standard and basic competences for fourth grade in semester 1

Standard of Competence	Basic Competence
Using the concept of perimeter and area of simple plan figures to solve problem	Determining perimeter and area of parallelogram and triangle Solving related problems involving perimeter, area of parallelogram and triangles.

Table 2.3. Standard and basic competences for fifth grade in semester 1

Standard of Competence	Basic Competence
Determining the area of simple plane figures and applying it to solve problems	Finding the area of trapezoids and kites Solving related problems involving area of plane figures

Table 2.4. Standard and basic competences for sixth grade in semester 1

Standard of Competence	Basic Competence
Determining the area of simple polygons, circles and volume of prism	Determining the area of polygons that are from the combination of simple plane Determining the area of circles Determining the volume of prism and cylinder

Table 2.5. Standard and basic competences for seventh grade in semester 1

Standard of Competence	Basic Competence
Understanding the concept of quadrilaterals and triangles to determine their size	Identifying the properties of triangles based on their sides and angles Identifying the properties of rectangles, squares, trapezoid, parallelograms, rhombuses and kites Determining the area of triangles and quadrilaterals and applying it to solve related problems Drawing triangles, altitude, line bisector, weighted line

From all basic competences above in the curriculum of 2006, it is clear that in teaching and learning of area measurement, it focuses on the calculating or measuring of areas without giving a chance to learn the basic concept of area. Of course, after experiencing the teaching and learning of mathematics with this curriculum, students still have a shallow understanding of area measurement since it focuses too much on formulas and applications afterward. Therefore, students

who learned through curriculum of 2006, now they may have difficulties learning area measurement in grade 7, especially in measuring area of quadrilaterals and triangles.

In the curriculum of 2013, elementary school students learn mathematics that is integrated with other subjects within themes. Therefore, there is no mathematics subject but thematic learning that involves many subjects under chosen themes. In the curriculum of 2013, the standard of competence for the seventh grade is different from the curriculum of 2006. In the main standard of competence, students need to understand the knowledge (factual, conceptual, and procedural) based on the curiosity, technology, art, culture related to phenomenon and reality (Kemendiknas, 2013). However, there are no basic competences that focus on the concept of area (see table 2.6). Even in the syllabus provided by the ministry of education, students only discuss to find the perimeter and area formulas. In addition, it is proven from the new teacher handbook released by the ministry of education that in the seventh grade, there are no activities in which students experience the concept of area (see figure 2.1).

Table 2.6. Standard and basic competences for seventh grade in semester 2

Standard of Competence	**Basic Competence**
Understanding knowledge (factual, conceptual, and procedural) based on the curiosity of knowledge, technology, art, culture related to phenomenon and reality.	Understanding the characteristics of plane figures and use them to determine the perimeter. Estimating and measuring area of irregular plane figures by applying geometrical principles.

It is obvious that in curriculum 2013, the teacher should put attention on students' understanding of the concepts of area measurement. However, it seems that the teacher handbook still lack of mathematical problems focusing on the concepts.

Here is an example of problem that students need to solve when learning area measurement in mathematics handbook curriculum of 2013.

Indah a flower garden with various types of flowers planted there. The flower garden is divided into some blocks. Block I is planted with white flowers within an area of 625 m^2. Block II is a rectangular block planted with red flowers. Its length is 50 m and its area is 1/5 of area of block I.
a. Determine the length of block I
b. Determine the width of block II
c. Determine how many hectares the total area of Indah's flower garden.

Gambar 4.1 Kebun Bunga

Figure 2.1. An area measurement problem in seventh grade

It is clear that the problem in figure 2.1 is dominated by measuring area and perimeter of a shape with given lengths of its sides or vice versa.

In summary, it is good that the curriculum of 2013 pays attention to the conceptual understanding in the standard of competence. However, with the adaptation of the new curriculum and within the teacher handbook that still focuses on formulas, there is a need to support students and teachers in teaching and learning about area measurement. RME advises in teaching and learning to start with a context and to let students mathematize their surroundings using models with guidance of the teacher. Therefore, it will help students understand the conceptual understanding of (RME).

2.5. The use of RME in developing students' understanding the concept of area measurement

RME studies in Indonesia show that the RME approach has the potential to address some fundamental problems in Indonesian primary schools (Fauzan, 2002). Pendidikan Matematika Realistik Indonesia is an adapted RME approach. In addition, the results indicate that the Learning Environment with an RME approach could have an impact in changing the pupils' beliefs, or in increasing the

positive attitude of pupils in the secondary schools toward mathematics (Zulkardi, 2002). The teaching and learning of area measurement using an RME approach has been studied by several researchers (see Fauzan, 2002; Yuberta; 2011; Febrian, 2013; Fiangga, 2013; Funny, 2013; Putrawangsa, 2013). They mostly focus on elementary students or on the beginning of teaching of area measurement. There is no research of secondary school students on understanding of the concept of area measurement by using an RME approach.

As the promising approach in teaching and learning area measurement, there are tenets that are used in the lessons that this study will design. Treffers (1987) (cited in Bakker, 2004) defines five basic tenets in RME, namely phenomenological exploration or the use of context, using models and symbols for progressive mathematization, using pupils' own constructions and productions, interactivity and intertwinement. We will describe the use of those tenets in the lesson designs of this study.

1. Phenomenological exploration or the use of context

The students experience a meaningful way of learning mathematics (area measurement) through contexts that are embedded in the concepts intended to be achieved. In this study, the students do activities with realistic contexts such as comparing leaves, rice fields and tiling floors. We conjecture the contexts can promote the students' understanding of the concept of area such as overlapping, conservation area, and unit measurements. We include the context that leads students to reshape figures into a rectangle. We conjecture that this context can evoke students‟ understanding of the idea of the conservation of area. It is also hoped that students will use this understanding to reshape quadrilaterals into a rectangle without having difficulties in determining the height of those figures. It will also help students to differentiate between area and perimeter. The comparing tile floors will lead to the unit of measurements. Comparing tiled floor and covering floors with tiles are contexts that are rich of concepts, such as partitioning, unit iteration, structuring array, and conservation.

2. Using models and symbols for progressive mathematization

Models are important to bridge the mathematization from informal to

formal mathematics. In this study, the students will extensively use several models of irregular shapes such as leaves, rice fields, tiles and paper grid. Initially students really cut and pasted and reshaped the figures to just reshape by making steps or arrows. Students could reshape a figure without really cutting them. In this way, we conjecture to support students' development of thinking from a concrete to a more formal level. We also expect that in the end pupils can use a grid to figure out the area of plane and find the area formulas of quadrilaterals and triangles.

3. Using pupils' own constructions and productions

Students will use their own strategies when solving problems. In this level students will actively construct and produce their understanding of several important ideas like overlapping, cut and paste, reshaping and constructing unit measurements during the lessons. The roles of the teacher are to support and facilitate by asking questions and providing help if needed.

4. Interactivity

Interactivity is an important part of learning. Students need to communicate well with other students, and even with the teacher about their argumentation, reasoning, and justification, so that they can defend it during the class discussion. Also, other students can actively ask questions so that they learn from each other by sharing their ideas and strategies. The teacher should not tell the students if their strategies are correct or not, but the teacher should orchestrate the discussion and lead to the right track. It also helps students to become independent of the teacher. In this study, the teacher orchestrates class discussions to support students' argumentations.

5. Intertwinement

Learning of area measurement does not stand alone but is related to other topics such as the commutative and distributive laws in multiplication. One of the difficulties in learning mathematics is that students cannot see the relations between each topic they learn. They learn each topic in mathematics as separate topics. Therefore, intertwinement is important so that students see the relation between area and the concepts of addition, multiplication and estimation.

CHAPTER III
METHODOLOGY

Students need to learn mathematics in meaningful ways and have better understanding of the mathematical concepts instead of mimicking and memorizing formulas and procedures given by the teachers. Some studies show that students need to learn the conceptual mathematics instead of mimicking and memorizing formulae. Teaching and learning innovations of area measurement prove that students who have learned mathematics in meaningful ways have a better understanding than students who have learned formulas. However, we do not know how and why these innovations work. In addition, educational research like this lacks practical relevance. Therefore, we need to know well how and why teaching and learning innovations of area measurement work well in order to support students' understanding.

3.1. Research approach

Theoretically, the aim of this study is to contribute to the local instructional theory that supports students' understanding of the concept of area measurement, especially in quadrilaterals and triangles by exploring the idea of reallotment. Practically, the aim of this research is to investigate how innovative the reallotment activities could be used to support students' reasoning and reach the mathematical goals of the concept of area measurement.

These two aims imply that there is a need for both the design of instructional means and research about how these activities support students' learning of the concept of area measurement. In a design research, Collins, Joseph & Bielaczyc (2004) and van den Akker (1999) (cited in Van den Akker, Gravemeijer, McKenney & Nieveen, 2006) state that, "by carefully studying progressive approximations of ideal interventions in their target settings, researchers and practitioners construct increasingly workable and effective interventions, with improved articulation of principles that underpin their impact" Therefore, a design research is chosen as the methodology in this study since it

provides a methodology to understand and to improve the educational practices through an iterative process (van den Akker, et. al., 2006). In this study, we want to know how reallotment activities can support students' understanding of area measurement determine. By using a design research approach, we develop a sequence of lessons and a hypothetical learning trajectory and improve them through cycles in order to reach the end goal.

There are three phases of a design research, namely, preparing for the experiment, design experiment, and the retrospective analysis (Gravemeijer & Cobb, 2006).

3.1.1. Preparing for the Experiment

This phase is also called the preliminary phase, the goal of which is to formulate a local instructional theory (Gravemeijer & Cobb, 2006). As this local instructional theory in this phase is not fixed, the researchers can elaborate and refine it during the experiment). In this phase, it is important to prepare learning activities through literature review. From the literature, we can find information related to students' difficulties dealing with area measurement and what activities have been proven to work well in supporting students' understanding of area measurement. This information can be used to make a sequence of learning activities and formulate conjectures about what students may do (students' thinking and strategies). These conjectures are part of a Hypothetical Learning Trajectory (HLT). The HLT contains three components, namely, the learning goals, the instructional activities and the hypothesis of students' thinking (Simon, 1995). The hypothesis is the conjectures of what students will do to solve the problems and students' and the teacher's reactions during the lessons. This HLT will be carried out and tested during the design experiment and can still be adjusted.

3.1.2. Design Experiment

Gravemeijer & Cobb (2006) state that the design experiment is aimed at testing and improving the conjectured local instructional theory developed in the preliminary phase. It is also aimed at developing and understanding how it works. As the initial HLT and the activities are designed in the preliminary phase, the

researcher will conduct a teaching experiment to get an insight into how the designed lessons or instructional activities work. In the teaching experiment, data are collected to answer the research questions. In doing the teaching experiment, the instructional activities are carried out in two cycles. In the first cycle, a preliminary teaching is conducted within a small group of students consisting of 5-6 students. The researcher acts as a teacher in this cycle and the teacher can observe how the researcher conducts the lessons. This approach benefits the teacher because she will obtain ideas about how she may conduct the lessons in the teaching experiment (cycle 2). By doing a preliminary teaching, the researcher can adjust and refine the instructional activities, which may result in a better design for the next cycle. It resulted in a revised HLT for the next cycle.

After the designed activities have been refined, the second cycle will be conducted. In this cycle, the teaching and learning take place in a real classroom environment, with a whole class of students. There is no difference in the mathematical content of the teaching experiment in both cycles. However, the designed activities in the second cycles has been refined and improved. The researcher and the teacher discuss about the activities to adjust and make agreements on how the lessons will be delivered before conducting the teaching experiment. After each lesson, the researcher and the teacher reflect on the whole learning process concerning the strong points and weak points of the lesson.

3.1.3. Retrospective Analysis

During and after the teaching experiment, the researcher does retrospective analysis. One of the primary purposes is to contribute to the development of a local instruction theory (Akker et al, 2006). In retrospective analysis, the role of the hypothetical learning trajectory is a guideline and points of references in analyzing the entire data set collected during the teaching experiment. Moreover, the actual teaching and learning is compared to the HLT. In the analysis, the researcher describes what supports the conjectures and what does not support or contradicts them. In the end, the conclusion of this analysis will be used to answer the research questions.

3.2. Data Collection

3.2.1. Preparation Phase

This study will be conducted with Indonesian students in the seventh grade (12-13 year-old). In this phase, data are collected to get the information of the students, the teacher and the classroom setting. The data are collected through a classroom observation and an interview with the teacher.

Classroom observation

By conducting classroom observations, we will learn about the usual teaching and learning and it will provide us with insight into the questions that may be asked to the students and the teacher in the interview. In order to collect the data, the researcher utilizes video recording and make fields notes during the observation. The observation focuses on the students' and teacher's activities, the interaction between the teacher and students, the interactions among students, and also the classroom norm and socio-mathematical norms. It also focuses the teaching and learning process, to see what materials or media and contexts used by the teacher to support students in learning the mathematical topic.

Interview with the teacher

It is important to know the teacher's point of view of his / her beliefs about the teaching and learning of mathematics. Therefore we conduct an interview with the teacher (see the interview scheme in appendix A). The teacher usually knows students' habits in learning area measurement very well. It also helps to know how the teacher usually teaches this topic and to know the social norms in the classroom. The interview is used also to clarify the data from the observation. The data is collected by audio recording and notes.

3.2.2. Teaching Experiment (Iterative Cycle)

Preliminary teaching experiment (cycle 1)

The aim of preliminary teaching is to know students' thinking and reasoning to improve HLT. A small group of students consisting of 5-6 students will participate in this preliminary teaching. In this cycle, the researcher takes a role as a teacher. Meanwhile, the teacher will observe how the teaching and learning process with the focus group goes. The data is collected through

classroom observations by video recording and students' written work during the lessons. The mini interviews and discussion with students will be recorded in order to know students' thinking during the teaching and learning process.

Teaching experiment (cycle 2)

The new improved (revised) HLT from the first cycle is used in this second cycle. This teaching experiment takes place in a real situation, a natural classroom setting. This cycle will be carried on in one class of seventh grade students in Indonesia. The researcher also chooses some students to be the focus group. These students belong to average level students. The decision about the students' level of understanding is based on the result of the pre-test and the interview with the teacher. The students in the focus group should be heterogeneous but have more or less the same abilities. This focus group will help the researcher to collect the data and analyze it in order to answer the research questions. In addition, the researcher will analyze the data from other students if it is considered important and interesting. The data collected through video recording, students' written work, and field notes. In addition, short discussions with the focus group and whole class discussions are also recorded in order to obtain data about students' thinking and reasoning.

3.2.3. Pre-test and Post-test

Before conducting the teaching experiments, the researcher conducts a pre-test (appendix B). Pre-tests are conducted twice, that is in the preliminary teaching experiment (cycle 1) and in the teaching experiment (cycle 2). In the pre-test, we collect students' written work to gather information students' prior knowledge about what students already know about area measurement. In the end of the whole lessons, the researcher conducts a post-test (Appendix D) with all students in both the preliminary teaching experiment and the teaching experiment. The problems in the post-test were designed differently with the pre-test but have the same level difficulties. The post-test is used to know what students have learned after the teaching and learning. In other words, the post-test can be used to assess the development of students after they involved in the designed instructional activities.

3.2.4. Validity and Reliability

There are two kinds of validity, namely internal and external validity. As we know, internal validity refers to the quality of the data collections and the soundness of the reasoning that has led to the conclusions (Bakker & van Eerde, 2012). As we want to measure the students' understanding, we collect the data that can measure it though video registration, interviews, and students' work. It is a way of improving the internal validity. The data triangulation between the results of video registrations, interviews and students' written work will improve the internal validity.

As reliability is concerned with the independency of the researchers, we collected the data with video recordings to prevent the influence of the researchers. Selected fragment from the video recording will be a powerful data to make inferences and argumentation since it is based on the reality or factual data. In addition, since the teaching experiment is conducted in real classroom setting, it will contribute the ecological validity.

3.3. Data Analysis

3.3.1. Pre-test

From the pre-test, the students' work will be assessed quantitatively and qualitatively. The number of correct and good answers and their strategies in solving the problems will give insight into students' prior knowledge of area measurement.

3.3.2. Preliminary Teaching Experiment (Cycle 1)

The initial HLT is compared to the data from the actual teaching and learning. Data collected in this phase are video and students' work. Not all data from the video registration will be analyzed but only relevant and important fragments related to the students' learning process. The important and relevant fragments are parts that support students' understanding and do not support students' understanding while working with the instructional activities. These fragments contain the conversation among students and between the teacher and the students and the discussions of the mathematical concepts and students'

understanding. These fragments will be transcribed. The field notes will also support the video data. We try to give interpretations of the fragments with the help of the HLT as a guide. Data from students' work are analyzed to know students' thinking. The data from the students' work is triangulated with the data from the video recording. The reflection in this data analysis will be used to improve the HLT for the next cycle

3.3.3. Teaching Experiment (Cycle 2)

As we did on the preliminary teaching experiment, we do a retrospective analysis by comparing the actual learning process to the revised HLT. We choose relevant and important segments from the video registration, including the conversation among students, between the teacher and students and the discussions. These fragments will be transcribed and we will interpret those fragments with the help of the revised HLT. These data are triangulated with the data from the students' written work, video, and the field notes. Data analysis in this phase can be used to improve the HLT as the final HLT. The final HLT will contribute to the local instructional theory in the domain of area measurement. The result of this analysis will be used to answer the research question and make conclusions.

3.3.4. Post-test

Data gathered from the post-test at the end of the teaching experiment will be analyzed to determine how far students develop their understanding of area measurement. The data from post-test is also compared with the data from pre-test. In this case, we can see whether students make improvement in their strategies, argumentation, and reasoning. The result of this analysis will be used to support other result in order to draw conclusions.

3.3.5. Validity and Reliability

Regarding to the internal validity in data analysis, the researcher continuously tests and improve the HLT based on the collected data. The detail descriptions in analyzing the data, the teaching experiment, the reasoning and assertions to draw conclusion will improve the external validity of data analysis. These descriptions will be useful for other researchers or teachers to adjust the

setting to their own settings. In analyzing data, we discussed the fragments with colleagues to avoid subjectivity of the researchers. This contributes to the internal reliability of this study. Regarding the external reliability, we provide information about how the research is carried out, how the data is collected and how we analyzed data to draw conclusions. It let outsiders be able to track and follow what the researchers have done in this study. It will give an opportunity for other researchers to conduct or replicate the same study.

CHAPTER IV
HYPOTHETICAL LEARNING TRAJECTORY

In this study, as a part of a design research, the researcher designs a hypothetical learning trajectory (HLT) in teaching and learning of area measurement. Simon & Tzur (2004) describe that an HLT consists of three components, namely, the learning goals, the mathematical activities and the predictions of students' thinking. Simon (1995) states the learning goals define the directions that will be achieved within the mathematical activities. Meanwhile, the mathematical activities are designed in certain sequence aimed at promoting students' understanding. The last component is the predictions or conjectures of students' thinking when they work on the mathematical activities. In making the predictions of the students' thinking, the teacher should envision how students will react, engage, and argue from the given mathematical tasks (Simon, 1995). However, Gravemeijer (2004) states that it is not easy for teachers to design an HLT and they need our support to design it. Therefore, the researcher has to investigate whether the thinking of the students actually as conjectured and revise or adjust the learning trajectory based on the findings. As explained that an HLT is a mean to plan students' learning of particular mathematical concept. In this study, the mathematical concept is area measurement. Indeed, as Simon (1995) states that the learning trajectory is always hypothetical and we will not know precisely in the actual teaching and learning. It means that the teacher can never be sure of what student will react, think, and do until they are really working on the mathematical tasks that we designed (Fosnot & Dolk, 2001).

As stated before, this study is aimed at contributing to a local instructional theory for understanding area measurement in the secondary school level. To achieve this aim, the instructional activities are designed to support students to understand area measurement by exploring the concept of conservation of area integrated with unit of measurement. Hence, in this chapter, we elaborate an initial HLT that is revised and refined during the study. The HLT contains of six

lessons in three weeks period. In each lesson, we describe the starting point, the learning goal, and the description of the activity and conjectures of students thinking. The instructional activities for learning of area measurement embedded in the initial HLT are described as follows.

4.1. Comparing Leaves

A. The starting points

Area measurement has been taught in elementary school in Indonesia. However, the teachers mostly only give the area formulas to find the area of geometrical figures such as a square, rectangle, rhombus, parallelogram and triangles. They seem to see that the area is only applying formulas by multiplying the length of sides of the geometrical figures. However, they do not have an understanding how the area formulas work. In fact, some students have some experience with the term "area" related to daily words they have heard. For instance, they often heard that the area of his yard is larger. They often see the advertisement of a land is based on the price of one square meter unit. In fact, in daily life, students have experienced in comparing things, for instance when they choose the clothes to buy, they often put one cloth into another cloth, or when they are given two options to choose one of two pieces of cookies, they will compare them first and choose the bigger pieces. The starting points describe the relevant knowledge and skills to support them in accessing and understanding the new topic, comparing irregular figures. The starting points for the first lesson are as follow

- Students have a limited understanding of area formulas of geometrical figures
- Students have experiences in comparing things in daily life by overlapping
- Students have heard that the area of something (land) is related to square meter units

This knowledge is important because students need to develop their reasoning why one thing is larger by comparing and why cut and paste will

preserve its original area, why the irregular figures still have areas and why they need unit of measurement to estimate the area.

B. The learning goal

- The students are able to grasp the idea that the irregular figures still have area
- The students are able compare areas of two irregular figures.
  - The students are able to grasp the concept of area that is region inside of the boundary.
  - The students are able to do overlapping to compare two figures
  - The students are able to do cut and paste
  - The students understand that cut and paste of a figure will preserve its area
- The students grasp the idea of unit of measurements

C. The description of the activity and conjectures of students thinking

Task 1(Group)

To begin with, the teacher brings the context of photosynthesis. As this context can refresh students to the material they have learned in science class. The teacher will show a picture of a tree and sun and students what they know about photosynthesis process and what play important roles in this process. The students are expected to answer that the leaf and the sun play important roles. The students are asked whether the different leaves will produce the same amount of food or not? They are expected that it depends on the size of the leave. The teacher distributes the worksheet 1 to each group. Each group consists of four or five students. The teacher asks whether students understand the problem or not. Furthermore, in order to know which leaf will have more sunlight, they should compare the area. It is aimed to refresh students' understanding of area. We expect that students will come up with overlapping one leaf into another leaf to compare. By doing this activity students will not easily compare the area of the leaves since the shape of the leaves are different. We expect that students will come up with the idea of cutting and pasting to see whether one leaf can fit another one.

In order to help student to do overlapping, the teacher can pose a question, if you have the leaves on your hands, what you will do with them? They will they need to cut the leaves from the worksheet. Therefore the teacher provides the cutting tool like scissors. The teacher then lets students to work on the worksheet. While students work on the worksheet, the teacher may walk around in case students need help and to make note what strategies used in the group. This will allow the teacher to decide which group that will present in the class discussion. It is better to choose the groups with different strategies or different level of thinking. It is possible that students do the same activity like cut and paste, but some students may throw away some parts of the cut and do not aware of it. Others might carefully take care of each piece of the cut in order to keep the area of the leaf that they cut. Therefore, students will have a fruitful discussion.

The students will answer that leaf A will have more sunlight but the leaves have almost the same size. It is possible that students will only use their superficial judgment (perceptional judgment) by just looking at two leaves and say that leaf B is larger because it looks bigger or wider. Students will overlap and trace the leaves and cut some parts of the leaves and put it in the non-overlapping parts. The following shows the conjecture how students overlap the leaves (see figure 4.1).

Figure 4.1. Overlapping the leaves

The students are not expected to come up with a perfect answer or solution. But, it is expected that students informally use the idea of overlapping and doing cut and paste to compare the leaves. It is a good start since students refresh their knowledge of area and experience what the ancient mathematician

did in the past related to area. In Euclidean geometry, before the aritmathization of geometry, two objects are said to be equal in area if one object can fit another one by overlapping it or parting it and rearranging to make the other object.

Task 2 (Individually)

Students will work individually in this task. After students finish with worksheet 1, in order to relate the context, the teacher relates that plants produce food not only for itself but also produce food for human. The teacher asks students about plants that produce food for human and where they can find those plants. The students are expected to reply "paddy" as their answer. The teacher asks students about rice field they know. The teacher then shows the types of rice fields exist in Indonesia. The teacher distributes the worksheet 2 to each student. The problem is to compare two irregular rice fields. The rice fields have no plants yet. Students need to determine which rice field that will produce more paddies. To check whether students understand the problem or not, the teacher may pose a question like *"Could you tell me what the problem is?"*. If students have understood the problem on the worksheet, the teacher lets students work on the worksheet individually. Meanwhile students work on the worksheet, the teacher may walk around to observe and make some notes of strategies used by students. The teacher observes whether students need help or guidance or not. However, the teacher will let students work with their strategies in order to get the variation of students' solution.

Here, the teacher will see whether students will use the strategies experienced in the worksheet 1 or not. Therefore, the predictions of students' thinking will be similar in comparing leaves that students will overlap the rice fields and cut it to fit one rice fields. After students finish the worksheet 2, the teacher will tell that they will discuss their work later in the end of the session.

Task 3 (Individually)

Students will work individually in this session. The teacher begins the third session by relating the second context of rice fields. The teacher tells that what you can see in two weeks after the seeding period in the rice fields. The students are expected to answer that the paddies are growing up. The teacher

shows the slide of the rice field presented before. The teacher asks whether students now can compare which rice field will produce more rice. Each student will get the worksheet 3. The teacher asks students what they understand of the problem. The teacher may ask: *"Tell me what you know about the problem?"* or "*What is the difference from the previous rice fields?"*. Moreover, the teacher lets students work on the worksheet 3 individually. The teacher will walk around and observe if students need help so that the teacher can give hints or clues to help. The teacher will make some notes of students' strategies and consider the students that will present in the classroom discussion.

In this session, students may have different strategies in solving the problem. Students may count one by one the dots in each rice field and compared them. Student will make rectangles to count the dots efficiently by using multiplication strategy as shown below:

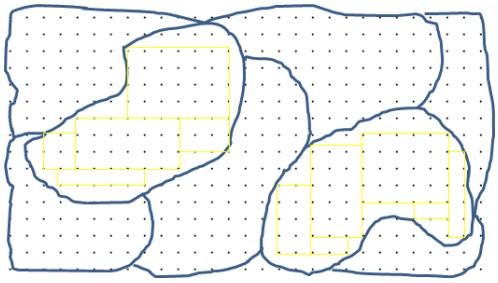


Figure 4.2. Making rectangles in the rice field

Some students may use the similar strategy but they make a rectangle that contain the rice field and use multiplicative strategy to find how many dots in the rectangle. After that, students will subtract the dots with the dots outside the rice field.

The role of the teacher is to give some questions to help students. If students count one by one the dots, the teachers may ask students whether they have another strategy to find the number of dots in a faster way like *"Do you have a faster way to count the dots?"*. If student make rectangles and use multiplication strategy to count the dots, the teacher may ask *"What do you do in counting the dots?," How does it work?".*

It is also possible that students combine overlapping and counting strategies and count only the dots in the non-overlapping parts as shown below:

Figure 4.3. Overlapping the rice fields

If students only count the dots in the non-overlapping area, the teacher may ask *"Why do you only count the dots only in the non-overlapping area?"*. The teacher may make notes how students cut the rice field and how they compare them. If students overlap in a certain position, the teacher may ask "*If you do it in a different position, will it be the same result?"*If students have finished the worksheet 3, the teacher tells students that they will have a discussion.

In the discussion, the teacher will not give the correct answers but just lead the discussion in the right track. The teacher may ask students who do not present the question:

"Do you know what they have just explained?" or "Could you tell me what they explain your, words?", Do you agree with what they say?, Do you have another solution or strategy?

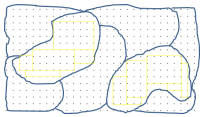
After the discussion, the teacher and the students will conclude together what they leaned today. There are some points of that should be in the conclusion. The main conclusions are:

- The leaves and the rice fields have irregular shapes but still have areas and we can compare their areas.
- The area is region inside the boundary.
- When we cut and paste the leaves or the rice fields, it will not change its original area, or the area remains the same.
- The dots may help also to compare the areas

Table 4.1. The overview of the activity and the hypothesis of the learning process in lesson 1

Activity	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
Comparing leaves	Students are able to compare two leaves with their own strategies. Students grasp the idea that an irregular shape has an area. Students understand that area is region inside the boundary.	The students will try to compare the leaves by: • Use their superficial judgment by just looking at two leaves and say one leaf is larger than another because it looks bigger or wider or the leaves are almost the same • Trace one leaf and place it over another one to see the non- overlapping areas • Overlap one leaf to another one and cut parts of non-overlapping area and paste them to non- overlapping area of another leaf. 	After the teacher distributes the worksheet 1 to each group then ask students whether they understand the problem on the worksheet or not.*"Could you tell me what the problem is?"* If students answer based on the superficial judgment or use their perception, the teacher may ask students how they can be confident about their argument by asking: *"How do you know it?" "How do you prove it?"" How do you convince others?"* If students have difficulties, then the teacher asks students if they

Activity	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
			have the leaves on their hands, what they will do. *"What will you do if you have those leaves in your hands?"* Ask students what they can do from the leaves on the worksheet. If students reply that they need something to cut, then provide the materials. Otherwise, just provide the materials.
Comparing rice fields	Students are able to compare two irregular figures by overlapping, cutting and pasting. Students grasp the concept of conservation of area	The students will use the same strategies like in comparing leaves. • Use their superficial judgment by just looking at two rice fields and say one rice field is larger than another one because it looks longer or almost the same. • Trace one rice field and place it over another	The teacher may ask students about plants that produce food for human to the rice field. *Tell me plants that produce food for human!* The teacher asks students what they know about the shape of rice fields. *What do you know about the shape of rice fields?*

Activity	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
		one to see the non- overlapping areas • Overlap one rice field to another one and cut parts of non-overlapping area and paste them to non- overlapping area of another rice field.	The teacher asks students whether the area of the rice fields changes or not when they cut and paste the rice fields.*What happens to the leaf after you cut and paste?*
Comparing dotted rice fields	Students are able to compare two with their own strategies. Students understand that area is region inside the boundary. They will grasp the idea of unit measurement but not too much focused on this meeting.	Students may count one by one the dots in each rice field and compared them. Student will make rectangles to count the dots efficiently as shown below:  or they will make a bigger rectangle covering the rice field and use the multiplication strategy to count the dots and then subtracting the result with the outsider dots.  Students combine tracing and counting strategies and count only the dots in the non-overlapping parts.	If students count the dots one by one, ask them to count the dots in a faster way. *Do you another faster way to count the dots?* If students have difficulties, ask them to do cut and overlap. *Can you cut and overlap the rice fields?*

4.2. Rice Field Transaction Deal I

A. The starting points

Students has experienced in comparing irregular figures such as leaves and rice fields in lesson 1. The students are able to do cut and paste to compare two things. Students have grasped the concept of conservation of area. These starting points are very useful to introduce the new activity within the similar context, comparing rice fields which have more regular shape. In the reallotment activity (cut and paste), students understand that when the cut some parts and combine or rearrange again by pasting, they unconsciously know that the area of their combination or arrangement is the sum of the parts and the cut-leaf. This activity will preserve the area of the original figure. Therefore, in task 2, they will compare and combine two rice fields. In this lesson, students are expected to use their previous knowledge of comparing, overlapping, cutting-pasting and combining.

B. The learning goal

- The students are able to do overlapping to compare two shapes
- The students are able to understand the concept of conservation of area.
  - The students are able to do cut and paste
  - The students are able to understand that when they cut and paste (reallot) the rice field and make into another shape preserve its original area
- The students understand that the area of the combined rice field is the sum of areas of the parts
  - Students are able to combine two rice parts of rice field into one rice field
  - Students are able to compare the rice field with the combined rice field.

C. The description of the activity and conjectures of students thinking

Task 1 (Group)

The students are given a chance to deepen their strategy in comparing area of two figures. In this lesson, students will compare two figures which have more

regular shape like a rectangle. To connect the context in this lesson, the teacher relates the previous context about rice fields. Therefore students will not feel that they always learn new things in different meetings. The teacher now begins with asking students the about rice fields they know. In the previous lesson, the teacher has shown some rice fields. It is expected that students still remember it. The students are expected to answer by replying that they know a rectangular rice field. The teacher then asks whether any student who has a house near a rice field. The teacher may ask them whether they have heard about a rice field are sold to build a factory? Then each group gets the worksheet 4.

The first task is to determine whether the transaction of the rice field is fair. There is a factory that is built near a farmer rice field. The factory owner wants to buy the farmer rice field but the farmer does not want to sell it instead of getting a new rice field. Therefore the factory owner offers a rice field to exchange the farmer's rice field. The problem is to help the farmer to decide whether this transaction is fair or not for him. In order to solve the problem, students need to understand what the fairness means. If it is called fair when the farmer gets the rice field with the same area, then students need to know whether the new rice field has the same area as the farmer' rice field or not. In order to do so, students will compare the area of those rice fields by comparing, overlapping, cutting and pasting. Moreover, students will use their previous knowledge of comparing by overlapping, cutting and pasting.

Since there are three options of answer, students will choose one of them. The first choice is that students will accept the offer because the rice field look longer therefore they will get more lands. Other students also will choose the second option that they will not accept the offer because the new rice field is shorter. These two answers are based on students' perception or they just superficially judge based on the visual condition. The teacher may help by giving hints such as referring to the comparing the leaves and rice fields in the previous meeting. The teacher also provides the materials (scissor and glue) to help student solve the problem.

Some students may choose the third answer that they will see whether the new rice field will fit the farmer's rice field or not. They will overlap, cut and paste to see whether the new rice field will fit the farmer rice field or vice versa like in figure 4.4 below.

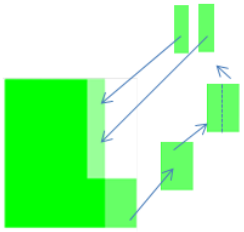


Figure 4.4. Overlapping, cutting and pasting

After students finish the worksheet 4, the teachers will tell that they will discuss their work later.

Task 2 (Individually)

The second task is still related to the transaction deal of the rice field. This problem is developed from the previous problem. In this problem, the factory owner offers two rice fields to exchange. Therefore, the farmer should decide whether this transaction is fair or not to make a deal. The students should help the farmer to solve this problem. After students get the worksheet 5, student will work on it and choose one of the three options of answer.

Students will choose the first option that they will accept the offer because the farmer will have two rice fields and it is larger. Some students will also choose the second option that they will not accept the offer because the farmer's rice field is longer. These two answers are based on superficial judgment that they only see from the visual condition.

Some students may choose the third option that students need to know whether they can fit those rice fields to the farmer's rice field or not. The students will combine the new rice fields and compare it to the farmer rice field by overlapping, cutting and pasting. The following figure shows the strategy used to compare the rice fields.

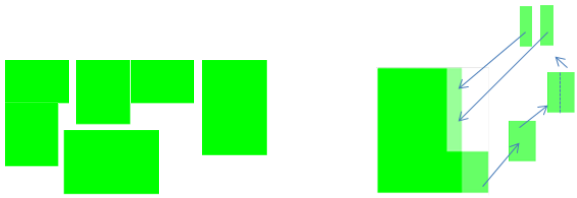


Figure 4.5. Combining, overlapping, cutting and pasting

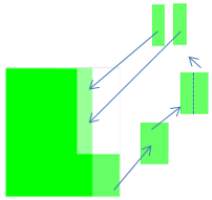
The teacher will orchestrate a class discussion of students' work on worksheet 4 and 5. The teacher will not give the correct answer but just lead the discussion in the right track. The teacher may ask students who do not present the questions:

"Do you know what they have just explained?""Could you tell me what they explain in your words?" "Do you agree? Why and why not?" "Do you have another solution or strategy?"

After the discussion, the teacher and the students will conclude together what they learned today. The main conclusions are:

- The area of two figures is equal if we can fit one figure exactly to the second figure.
- If we cut and paste, the area remains the same, it is called conservation of area.
- If we combine two figures, the area of the combined figure is the sum of the area of the two figures.

Table 4.2. The overview of the activity and the hypothesis of the learning process in lesson 2

Activity 2	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
Comparing regular rice fields.	Students are able to do overlapping to compare two shapes. Students are able to compare two regular shapes by doing cut and paste (reshaping) in order to fit another shape. Students understand the concept of conservation of area	Students will choose first two options based on their perceptional judgment (visual). Students will cut the rice fields from the worksheet and do overlap one rice field to another one. They cut parts of non- overlapping area of one rice field and paste them on non-overlapping parts of one of the rice field and paste them on the non-overlapping area of another rice field to fit the second rice field. 	The teacher provides the materials like scissors and glue to give the students a clue what to do with the materials. If students do not get what to do, the teacher may refer to the strategy cut and paste in lesson 1 that students used. *Do you still remember what you did in previous meeting? Can you do it to solve this problem?* If students choose the third answer, ask them*: "If it fits the farmer's rice field, is it fair"* *"What will you do to fit the rice field* Ask students whether after they cut and paste (reallot) the rice field the rice are area will remain the same or not.

Activity 2	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
			"What do you think of the size of the rice field after you cut and paste?", "Does it change its area, why?" *"Can you find the area of the farmer's rice field?"* After students finish worksheet 4, tell students that they will discuss their work later.
Comparing a regular rice field with two parts of rice fields.	Students are able to combine two rice parts of rice field into one rice field. Here, students understand that the area of the combined rice field is the sum of areas of the parts. Students are able to compare the rice field with the combined rice field using cut n paste strategy.	Students will combine two rice fields first and get one rice field. Students then will compare the rice field with the combined rice field by overlapping them and doing cut and paste as used before. 	The teacher may ask whether they can combine the two rice fields or not. *Can you combine the rice fields in to one rice field?* The teacher also asks the area of the combined rice field with the area before combined (area of two rice fields). *What do you think of the area of combined rice field with the two parts?* The teacher may ask students whether the area of the rice field remains the same after cut and paste. *Do you think the area of the rice field is different after you cut and paste? Why?*

4.3. Rice Field Transaction Deal II

A. The starting points

Students have learned about comparing two figures by overlapping, cutting and pasting. They have understood that by cutting and pasting will not change the area of its original figure. This starting point is relevant to let students explore more about reallotment activity. In this lesson they will learn that the reallotment activity will preserve the area but not the perimeter. Therefore students will see the different also between the area and perimeter. Students will deepen their understanding of area and perimeter. Relate to the reallotment activity, students will also reshape quadrilaterals into a rectangle .

B. The learning goal

- The students are able to do overlapping to compare two shapes
- The students are able to understand the concept of conservation of area.
  - The students are able to do cut and paste
  - The students are able to understand that when they cut and paste (reallot) the rice field and make into another shape preserve its original area but not the perimeter.
- The students understand the difference between the perimeter and area
- The students are able to reshape figures into a rectangle.

C. The description of the activity and conjectures of students thinking

Task 1(Group)

In this task, students will learn more about reallotment activity. The problem in this task is designed to lead student explore more about reallotment activity to deepen their understanding of area and perimeter. The context is still about a rice field transaction. Students will determine which rice field that will be fair to exchange the farmer rice field. There are six options offered by the factory owner, some rice fields have the same area and some have the same perimeter. Students should determine which rice field fits the best to fairly exchange the farmer's rice field. They should also determine which rice field that has the shorter path if the walk around. This activity will let students get the understanding of perimeter. Students will get the sense that walk around the edges

of the rice field is perimeter. In the case that the farmer rice field and the option have the same area, it will be different in perimeter. Therefore, the reallotment activity will preserve the area but not the perimeter. There are some options that have the same perimeter as the farmer's rice field. There are also some rice fields that have the same area with the farmer's rice field in different shape. There are also rectangular rice field with the same area as the farmer's rice field. Rectangular rice fields are more familiar in Indonesia and easy to find. Students will determine and choose from the options. The teacher provides materials like strings, pins, scissors and glue and distributes the worksheet 6.

Students will answer or choose one rice field that looks bigger, longer, or wider. They just use their perceptional justification. However, since students have experienced about the fairness of the transaction deal in previous lesson, they will use the comparing strategy by overlapping, cutting and pasting.

Students can use the materials to help them solve the problem. Students will use the string and pin to measure the perimeter. They will compare the length of the string of each rice field to the length of the string if the farmer's rice field. In other words, students will compare the perimeter of the rice fields. They will decide that the rice field that fits best the farmer's rice field is the rice field with the same perimeter.

Students will also compare the area by overlapping, cutting and pasting. They will determine the fairness by looking for the rice field that has the same area as the farmer's rice field. Students have been familiar with this strategy since in lesson 1 and 2 they did the same way. After students find the rice field that has the same area, they will compare the path when they walk around by using the string and the pin. They will compare the lengths of the string of the rice fields.

Task 2(Individually)

Reshaping is based on the reallotment activity that students will make a new shape from a given figure. In this task, students will reshape the geometrical figures like a parallelogram, a trapezoid, a kite and a rhombus. They should reshape those figures into a rectangle. It is possible that students would randomly cut and paste the figures. They will use trial and error strategy. However, some

students may notice how to reshape the figures into a rectangle. The following figure shows how students reshape a trapezoid and a rhombus into a rectangle.

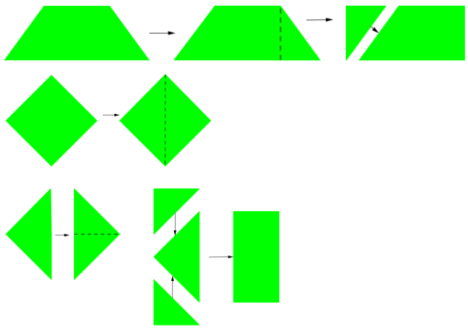


Figure 4.6. Reshaping into a rectangle

The teacher may ask what changes students notice after reshaping. They are expected to answer that the shape changes, the area remain the same and the perimeter changes. Students will determine the perimeter after the reshaping by using the string and the pin. Students will compare the length of the string before and after reshaping. If students have finished the worksheet 7, the teacher tells students that they will have a discussion.

In the discussion, the teacher will not give the correct answers but just lead the discussion in the right track. The teacher may ask students who do not present the question:

"Do you know what they have just explained?" or "Could you tell me what they explain your, words?", Do you agree with what they say?, Do you have another solution or strategy?

After the discussion, the teacher and the students will conclude together what they leaned today. There are some points of that should be in the conclusion. The main conclusions are:

- Reallotment activity by reshaping or cutting and pasting will preserve the area but not the perimeter.
- Reshaping into a rectangle will be useful to find the area.
- The area is region inside within the boundary.
- The perimeter is the boundary of the figure.

Table 4.3. The overview of the activity and the hypothesis of the learning process in lesson 3

Activity Lesson 3	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
Determining the rice field to make a fair deal. Grasp the idea of perimeter. Comparing the perimeter before and after the reshaping	Students are able to choose which rice field to fairly exchange the farmer's rice field by comparing the area. Students are able to differentiate between area and perimeter. Students understand that reshaping will preserve the area not the perimeter. Students are able to differentiate between area and perimeter.	Some students may choose one of the options and maybe more than one. Students only judge superficially based on their visual. They will say that it is fair because the farmer will get a longer rice field or it is not fair because the shape is different. Students will choose rice field which has the same perimeter as the farmer's rice field by using the string. Students will choose the rectangular rice fields because it is regular and common. Students will choose the rice field which has the	Ask students to convince their arguments *"Tell me the reason why you think so?"* *"Can you convince others?"* *"Maybe the materials can help you"* If students choose the rice field with the same perimeter, just let them to do so and this group will present in the classroom discussion. If students cut and paste the farmer's rice field to fit the optional rice field, ask students *"Why do you do that", What is your goal by doing that?* If students choose only the

Activity Lesson 3	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
		same area by reshaping the farmer's rice field. Students will compare the lengths of sting to measure the perimeter of each rice field. Students will use the string to measure the perimeter before and after reshaping and compare them	rectangular rice fields, ask: *Why do you choose them? Do they have the same area?* After students finish worksheet 6, tell students that they will discuss their work later. The teacher may ask students what is the difference between area and perimeter.
Reshaping quadrilaterals into a rectangular.	Students are able to do cut and paste to reshape figures into a rectangle.	Students may do trial and error. As students are able to do reshaping in previous activity, this geometrical figures are easier to reshape. 	Ask students how they reshape it. *What did you do first? Did you do trial and error? Or do you have your way to reshape them?* Ask also: *If you reshape, what will remain the same and what will not?* *What do you know about area and perimeter?* *If you reshape, do you think it will help you to find the area after reshaping? Why?*

4.4. Tiles and Floors

A. The starting points

Students are able to compare two figures by overlapping, cutting and pasting. Students understand the concept of conservation of area. Students are also able to count the dots in the first lesson by using multiplication strategy in rectangle. These starting points are relevant to introduce the context of comparing tiled floors.

B. The learning goals

- The students are able to compare two floors with different size of tiles as their unit of measurements.
- The students are able to grasp the need of unit of measurement
  - The students are able to compare two floors with the same unit of measurement.
  - The students are able to cover the floor with the same unit measurement
- The students understand the area formula of rectangle
- The students are able to determine areas of rectangles from given length of its sides.

C. The description of the activity and conjectures of students thinking

Task 1 (Group)

In this task, students will deal with comparing two tiled floors. The floors have different size of tiles. Students need to determine which floor is larger. The students will not overlap and cut anymore instead of comparing based on the tiles. The students are given a chance to deepen their strategy in comparing area of two figures integrated with unit of measurement. Students are expected to count the tiles by using multiplication strategy. The teacher begins with asking about the floors that they ever see, and how they look like. The teacher asks student whether they can determine which floor is larger without any measurement tools.

Student will solve the problem by counting the number of tiles and compare them. Students will just compare the number of tiles and determine that floor A is larger since it has more tiles. Some students may compare first the tiles

on both floors. They will take on tile on each floor and compare. They will see that one tile in floor B is four times as one tile in floor A. Then the will multiply the number of tile in floor B by four and compare this number to the number of tiles in floor A (see figure 4.7). In counting the number of tiles, students may count them one by one. Other students may use multiplication strategy to count the number of tiles in each floor.

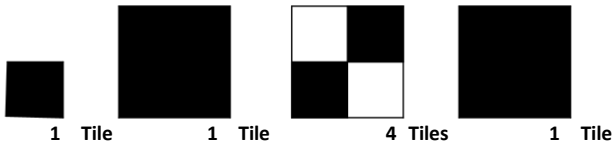


Figure 4.7. Comparing tiles

In the next problem, students will explore to cover some floor using tiles. Since the students have seen tiled floors, the teacher asks them whether they can cover the floor using a given tile or not. There are three floors that they can cover. The task is to determine which floor is larger. The rectangular floors are easier to tile but the parallelogram floor is harder to tile. Students need to cut some tiles to cover the floor. In comparing the areas of the floors, they will compare the number of the tiles. In determining the number of the tiles in each floor, they will count one by one or multiplication strategy. Some students will just put or draw some tiles on the sides of the floor, not all the floor. Then they will use multiplication strategy to find the number of the tiles on that floor. However, in the floor with parallelogram shape, the will cover all the floor using the tiles. They will adjust the tiles by cutting them. The following picture shows the conjectures of how students tile the floor.

Figure 4.8. Tiling floors

Task 2 (Individually)

The next problem is that students need to find the areas of two floors from a given dimension of a tile (25 cm x 25 cm). Students are expected to determine the area of the floors using multiplication strategy. In order to so, they need to know how many tiles in the edges of the floors.

Students will put or draw some tile on the edges of the floors and multiply them. After getting the number of the tiles they will multiply it by 625 since each tile has the area 625 cm^2. Other students may draw the tiles on the edges of the floor and then find the length of the edges of the floor by adding 25 or the number of the tiles that fit the edges is multiplied by 25. After that students will multiply the lengths of the edges and get the area of the floors.

In the next problem, students will determine the area of rectangles from given lengths of its sides. Since the have been familiar with the multiplication strategy, they will multiply the length of the sides of the rectangles. Student will get sense the area formula of rectangle is *length x width* or *base x height*. The students understand where the formula comes from and how it works. After students finish the worksheet 9, the teacher will orchestrate a classroom discussion.

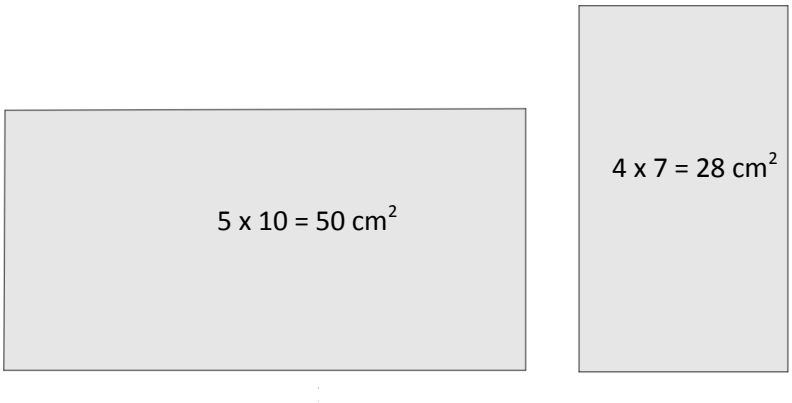


Figure 4.9. Using multiplication strategy

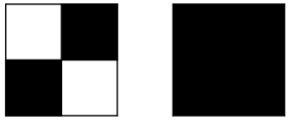
In the discussion, the teacher will not give the correct answers but just lead the discussion in the right track. The teacher may ask students who do not present the question:

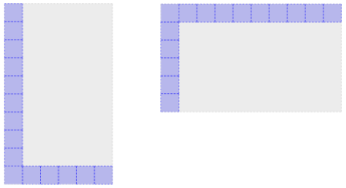
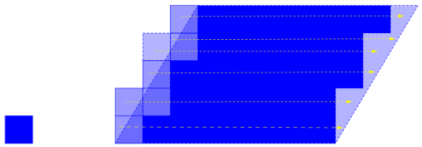
"Do you know what they have just explained?" or "Could you tell me what they explain your, words?", Do you agree with what they say?, Do you have another solution or strategy?

After the discussion, the teacher and the students will conclude together what they leaned today. There are some points of that should be in the conclusion. The main conclusions are:

- We can compare area of two figures by using the same unit of measurement.
- The area formula of rectangle is *length x width* or *base x height*
- We can find the area of a rectangle by multiplying its length of base and height.

Table 4.4. The overview of the activity and the hypothesis of the learning process in lesson 4

Activity Lesson 4	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
Comparing tiled floors	Students are able to compare two floors with different tiles as their unit measurements. Students understand the need of the same square unit to compare area.	Students will count the number of tiles on each floor either one by one or using multiplication strategy. Students will compare the number of tiles from the floors and says that floor A is bigger since it has more tiles or some students will say that floor B is bigger since it has a bigger tile. Students will take one tile of each floor and compare them.  Students may realize that the tile on floor B is for time as big as the tile on floor A. 	Do not provide materials like scissors or tools to cut. Let students use their strategies to compare the floors. If they found that the floors has the same size. Ask: *What did you do see them having the same area?* If students count the tiles *How do you find the number of tiles in each floor?* Make a discussion if there is an answer that they judge the floor based on the number of tiles.

Activity Lesson 4	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
Tiling / structuring array	Students are able to compare floors by the number of square units cover them. Students are able to use their cut and paste strategy to tile the parallelogram floor.	Students will easily tile rectangle floors by putting some tiles on the edges of the floors and use multiplication strategy to count the tiles as follows:  Or they continue to tile fully the floor by using a ruler and count the tiles.Students will tile with possible position of full tile unit and cut the remaining parts then paste then to  the untilled parts. Students may reshape the floor into a rectangle and then tile it. Students may do trial and error.	The teacher prepares the material such as straightedges if students need them. The teacher will not provide the tools to cut. The teacher needs to ask students: *What do you do to cover the floors?* When students have difficulties in covering the parallelogram floor, suggest: *You may modify the tiles.*

Activity Lesson 4	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
Determining area of rectangular floors	Students are able to use multiplication strategy. Students understand how the formula *length x width* or *base x height works.*	Students will tile all the surface of the floor and count one by one the tiles. After students get the number of the tiles (60 tiles), they will multiply it by 625 cm^2 since each tile has an area of 625 cm^2. Therefore, the area of the floor is 37500 cm^2. Students will only tile the edges of the floors and multiply the number of tiles on the vertical edge with the number of tiles in horizontal edge. After students get the number of the tiles, they will multiply it by 625 cm^2 since each tile has an area of 625 cm^2. Students will only tile the edges of the first floor and measure the length of the vertical and the horizontal edges. They will get the length of the	Ask: *What do you do to cover the floors?* Or suggest: *You may use pencil to draw your tiles.* If students only draw or tile only some parts on the edges of the floor, ask: *Can you determine the number of the tiles by tiling some parts? Why?* When students cover all the floors by tiles, ask them how they count the number of the tiles? *How do you count the number of the tiles?* If they count one by one, ask do you have a faster way to count them? *What is the area of the floors?*

Activity Lesson 4	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
		horizontal and vertical edges are 250 cm and 150 respectively. Therefore, they will find the area of the floor is 37500 cm^2. On the second floor, the lengths of the horizontal and vertical edges are 150 cm and 250 cm. Its area is equal to the first floor.	*How many centimeter squares?* Remind students of the standard measurement units. *Is the unit is centimeter or centimeter squares?* *If the edges of the floor are called base and height, what can you conclude?* Tell students that they will discuss their work after.
Determining area of rectangles by applying area formula	Students are able to apply area formula for rectangles.	Students will multiply the length of the base and height of each rectangle to get its area.	The teacher may ask how this way works. *How does it work?* *Can you conclude what the area formula of rectangles is?*

4.5. Tiled floor and grid paper

A. The starting point

Students have been able to measure the area of tiled floor using the multiplication strategy. Students understand how the formula to find the area of rectangular shape. This starting point is relevant to students to determine the area of a floor that not all tiles can be seen. Therefore, students will use the multiplication strategy by finding the number of tiles in the edges of the floor. Using the tiled floor can be useful in the following task to estimate the area of irregular figures. Student will grasp to use the tiles as the unit of measurement to estimate irregular figures. Moreover, students will explore the unit of measurement using grid paper to estimate and compare two irregular figures

B. The learning goal

- The students are able to determine the area of a floor using the multiplication strategy and apply area of formula to find the area of a floor.
- The students are able to grasp the need of a square as unit of measurement
  - The students are able to estimate the area of an irregular figures
  - Students are able to estimate and compare the area of two irregular figures
  - Students can make paper grid by themselves to estimate the area of an irregular figure.
  - Students understand that the smaller unit of measurement, the more accurate its estimation.

C. Description of the activity and conjectures of students thinking

Task 1 (Group)

After students explore the unit of measurements, covering floor and structuring array and understand the area formula of rectangle, student will explore the use of unit of measurement to measure areas of irregular figures. Here the teacher relates to the tiled floor of a living room with furniture to let students deepen the use of multiplication strategy in measuring area. The task is that students need to find the area of a living room’s floor. The living room is set up

with furniture. The students need to determine the area of the floor from a given picture of the floor from above. Therefore, students cannot count all the tiles easily since the tiles are covered by the furniture.

The students may draw lines to make the tiles visible (see figure 4.8). Then students will count one by one the tiles and multiply it with 400 since each tile is 20 cm x 20 cm. Therefore, students get the area is 11 x 14 x 400cm^2 or 61,600 cm^2.

Some students will multiply only the tiles on the edges of the floor and then multiply them. It is always possible that they will measure the length of the edges of the floor and then multiply them, 220 cm x 280 cm or 61,600 cm^2.

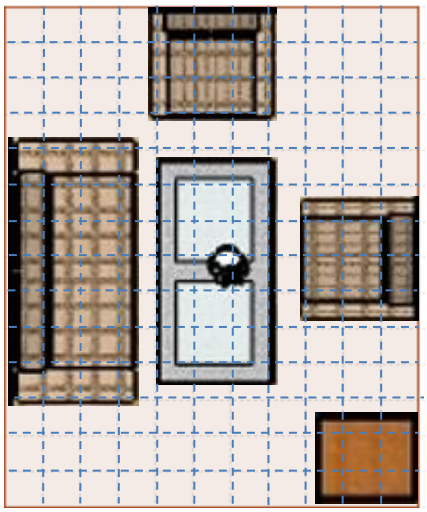


Figure 4.10. Making lines to see the tiles

The following problem is to estimate the area of a carpet on the living room. Students will use the tiles to estimate the area. However, the carpet is not easy to estimate since there are some tiles that are not fully covered by the carpet.

Students will only count the number of full tiles. Some students will not only count the full tiles but also the tiles covered by the carpet. They will estimate the non-full tiles and add them to the full tiles. Some student may also reshape or just move the part of the carpet to make a full tile (see figure 4.11). After students

get the number of the tiles, they will multiply it by 625 since one tile has an area of 625 cm^2.

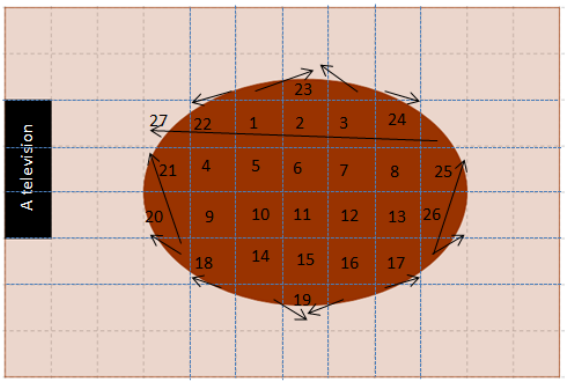


Figure 4.11. Estimating area of a carpet

Task 2 (Individually)

In this task, students will come back to the problems in the first lesson. They will compare the irregular rice fields and the leaves. Students are not provided with cutting tools to cut the rice fields and the leaves.

Students will solve the rice field problem by connecting the dots and make a grid paper from it.

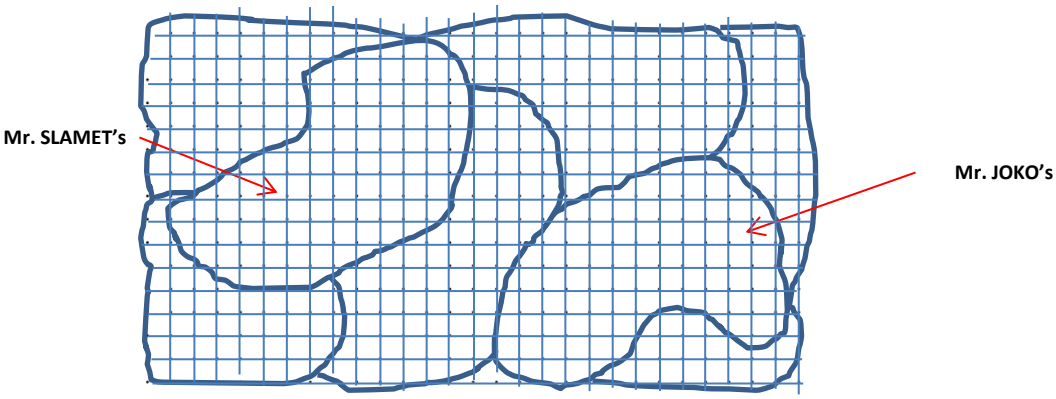


Figure 4.12. Making grid from the dotted rice fields

Student will count the number of full square units and compare them. Some students will not only count the full square units but also non-full square units belong to the rice fields. Students will combine the non-full square units by moving it to make a full square unit. They will connect the non-full square units by drawing connecting lines. Students may also shaded or cross out the parts that have been combined into a full square unit. Some students may use estimation of the non-full square units, such as, one third, one fourth, or half. After they find the estimations, the will compare them to decide which one is larger.

In solving the leaves problem, students are given hints to draw a grid paper to on the leaves. There will be a variation of sizes in the grid paper. They will use the size of 2 cm x 2 cm or 1 cm x 1 cm. Therefore, there will be a discussion whether the smaller unit of measurement will estimate better the area of the leaves. They will count the number of the full square units and compare them. The students will also be aware of non-full square units. Students will combine the non-full square units to make full square units. When student use a smaller size of paper, students will count the full squares units and just estimate the parts of the leaves by saying one third, one fourth or half. Then students will add them all and get the estimate of the area of the leaves. The following shows how students estimate the area of the leaves using a grid paper.

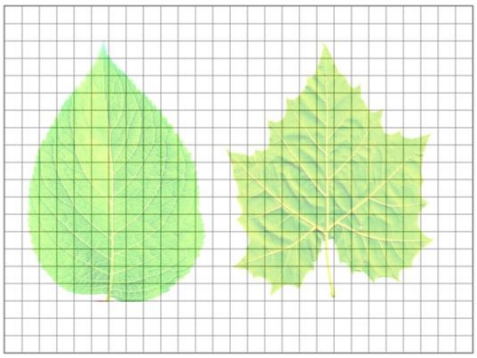


Figure 4.13. Making grid to estimate and compare leaves

After students finish the worksheet 11, the teacher will orchestrate a class discussion. In the discussion, the teacher will not give the correct answers but just

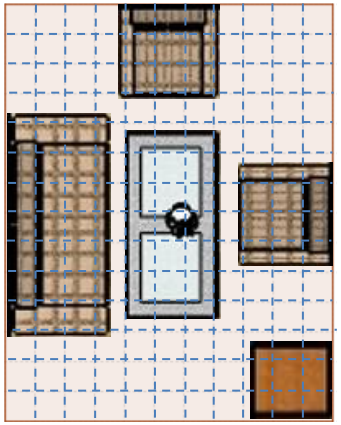
lead the discussion in the right track. The teacher may ask students who do not present the question:

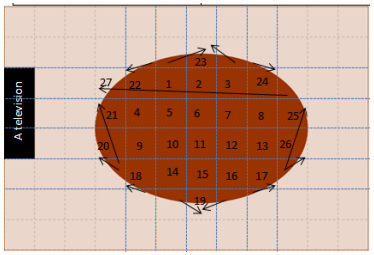
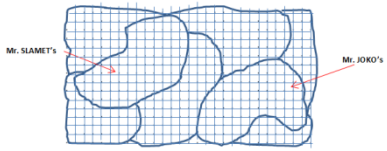
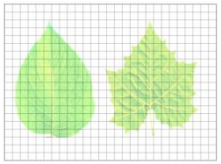
"Do you know what they have just explained?" or "Could you tell me what they explain your, words?", Do you agree with what they say?, Do you have another solution or strategy?

After the discussion, the teacher and the students will conclude together what they leaned today. There are some points of that should be in the conclusion. The main conclusions are:

- We can find the area of a rectangular floor by multiplying the number of tiles in the edges of the floor or multiplying the lengths of its sides.
- We can use a paper grid to estimate an area of a figure.
- The smaller the square units, the better it estimate area of a figure

Table 4.5. The overview of the activity and the hypothesis of the learning process in lesson 5

Activity Lesson 5	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
Estimating an area of a covered floor.	The students are able to determine the area of a floor using the multiplication strategy and apply area of formula to find the area of a floor.	Students draw lines to trace the tile from the visible lines of the tiles. Then they will count the tiles one by one or by using a multiplication strategy. 	The teacher just let students do with the strategies they use. If they have difficulties ask or suggest to use any tool to help *Do you need something for help? A ruler or straightedge maybe useful.* If students try to count one by one, pose a question: *Do you have a faster way to count? Do you still remember what you learned in previous meeting?* If students use multiplication strategy, ask the students how long the length and the width of the floor are? *Can you use the formula that you have in previous meeting?* Always remind students the standard unit of measurement, is it cm or cm^2?

Activity Lesson 5	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
Estimating the area of a carpet	Students are able to estimate the area of a given shape by using a square tile as the unit of measurement. Students are able to combine the cut and paste strategy and the unit measurement to estimate an area of a figure.	Student will use the line on the tiles to make the tile pattern visible. From those tiles, students can estimate the area of the carpet. 	The teacher can ask: *How do you find the area of the carpet from the tiles? How many tiles do you think that are covered by the carpet?* The teacher may remind students of the reallotment activity, *You may reshape (move) it to make it easier to estimate.*
Comparing dotted rice fields and comparing leaves	Students are able to estimate the area of the dotted rice field by using square units. Students grasp the use of grid paper to estimate the area of irregular shape and combine it with the cut-paste strategy.	Students will connect the dots with a straightedge or a ruler. And estimate the square units fit the rice fields.   Students will make their own grid paper and put the leaves on it and count the number of squares and compare them	If the students still count the dots, suggest students to connect the dots with a ruler. Let students to solve the problem, some assistance are needed if students have difficulties counting the square units. *"Do you have another way to count the square units"*.The teacher may remind students of the reallotment activity, *you may reshape it to make you easier to estimate.*

4.6. Building and Glasses

A. The starting points

Students are able to reshape the geometrical figures into a rectangle by cut and paste. Students understand the concept of conservation of area. Students understand the area formula of rectangle. These starting points are relevant to learn the area formulas of other quadrilaterals and triangles. Students will reshape the quadrilaterals and triangles to derive the area formulas of those geometrical figures. Students will also explore how the area formula of triangles comes from.

B. The learning goal

- Students are able to reshape a parallelogram, a trapezoid, a rhombus, a kite and a triangle into a rectangle.
- Students are able to derive the area formulas of quadrilaterals and triangles from the area formula of rectangle.

C. Description of the activity and conjectures of students thinking

Task 1 (Group)

In this task, students will explore the relation between a rectangle and a parallelogram to derive the area formula for a parallelogram. The context is about a building with its side has a parallelogram shape. The teacher will show the picture of the building in screen. Students will deal with a problem related to glasses to cover a side of buildings. There are two buildings in the problem that students need to determine the area of glasses to cover the side of the buildings. The first building has a rectangular shape on its side meanwhile the second building has parallelogram shape on its side.

Students will solve the problem by counting the number of the square unit of glasses in the rectangular building. Students will count one by one or use the multiplication strategy. After students get the number of the square units, students will multiply it with 49 m^2 since each square unit has an area of 49 m^2. Therefore, students will get the area is 1960 m^2.

Some students may also measure the length of the base and the height of the building. Then they will multiply these lengths (35 m x 56 m) to get the area of the glasses.

In dealing with the parallelogram building, students will not easily count the number of square units. They need to reshape this building into another shape for instance a rectangle (see figure 4.14). Students will easily reshape this building since they have experienced the reshaping activity. Students will get the rectangle and then find the area by counting one by one the square units or using multiplication strategy. Student may also to find the length of base and height and multiply those lengths and get the area is 35 m x 56 m or 1960 m^2. Students will compare the area of glasses of the two buildings and find out that the area is equal.

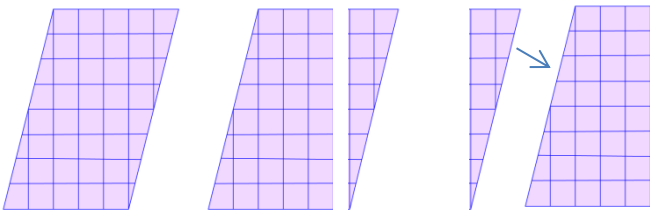


Figure 4.14. Reshaping a parallelogram into a rectangle

In the next problem students will deal with finding the area of parallelograms from given base in the grid paper. Students need to determine the areas of the parallelograms. Students will solve this problem by reshaping the parallelograms into a rectangle and use the multiplication strategy. Some students may directly multiply the length of the base and height since they have noticed that the formula works out this way (see figure 4.15).

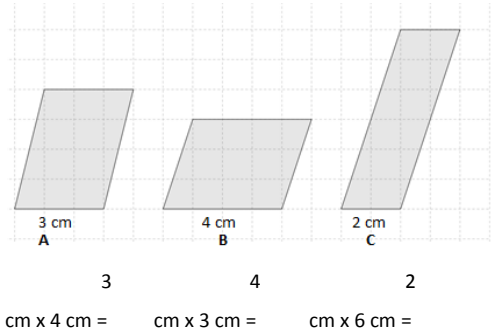


Figure 4.15. Multiplying base and height

In the last problem, students need to find the area of a parallelogram with given the base, the slant height and the perpendicular height.

Students will solve this problem by multiplying the base and the slant height. Some students will also multiply the length of the base with the perpendicular height as follow.

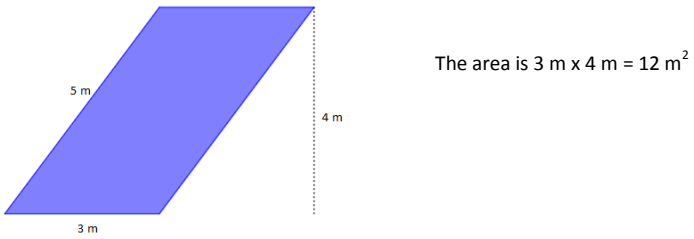


Figure 4.16. Applying area formula base x height

Task 2 (Group)

In this task, students will explore to find the area of for a triangle by reshaping it into rectangle. Students will also see the relationship between a rectangle and a triangle and a parallelogram and a triangle. In the first problem, the context is triangular buildings. The teacher shows the triangular building in the screen. The buildings have a triangular shape if it is seen from one side. The buildings are covered with glasses. Students need to find the area of glasses of a side of the buildings. The students only know the lengths of the base of the buildings.

Students will solve the problem by counting the number of square units in the buildings. Student will find out that each square unit has 4 m x 4 m. The height of the buildings is 32 m. However, student will not easily find the number of square units. From the given hint, students can reshape the building. They will reshape the triangles into a rectangle as follow.

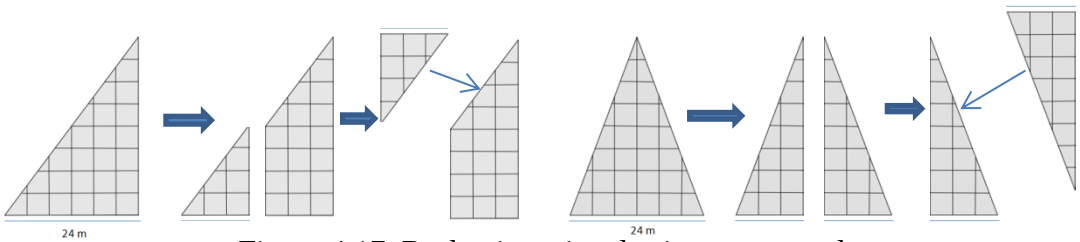


Figure 4.17. Reshaping triangles into a rectangle

In the next problem, students will deal with determining area of shaded regions in a parallelogram and a rectangle in grid paper. The shaded regions are triangles with the lengths of the base. The students should find the area of the triangles.

Students will solve this problem by finding the area of the parallelogram and the rectangle and then divide them by two. The will notice that the area of the shaded regions are half of the parallelogram and the rectangle. To find the area of the parallelogram and the rectangle, students have learned the area formula in the previous task. Therefore, to find the areas of triangles, students will multiply the length of the base and height and divide by two, 5 cm x 5 cm : 2. Students will get the same result for both areas of triangles, 12.5 cm^2.

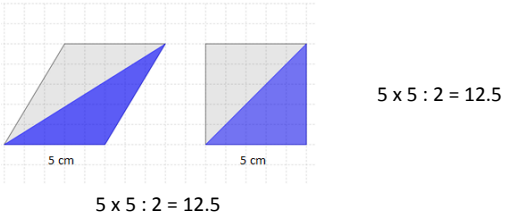


Figure 4.18. Applying the area formula of rectangle and halving it

Task 3 (Group)

In task 3, students will explore other quadrilaterals to derive their formulas by reshaping them into a rectangle. In the first problem, the context is still about a building with a trapezoid side. The trapezoid is on grid paper and the length of its base is given, 22 m. Students need to determine the area of glasses to cover this side of the building.

Students will solve the problem by reshaping this trapezoid into a rectangle since they use the hint on the worksheet (figure 4.19). Students will get a rectangle with the lengths of its base and height is 22 m and 20 m respectively. Students will use the multiplication strategy or apply the area formula of rectangle. Students will get the area of glasses to cover the side of the building is 440 m^2.

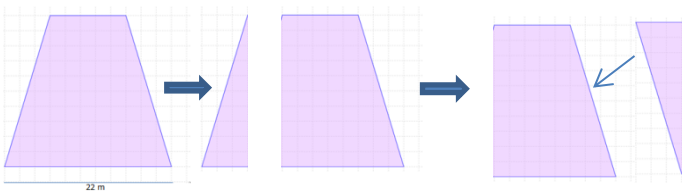


Figure 4.19. Reshaping a trapezoid into a rectangle

The next problem, students will deal with the other quadrilaterals such as kite and rhombus. Students should determine the area of the kite and the rhombus from given lengths of its diagonals. In order to find the areas of the kite and the rhombus, students will use the hint on the worksheet.

Students will solve the problem by reshaping the kite and the rhombus into a rectangle (see figure 4.20). They will find the rectangle and get the lengths of the base and the height

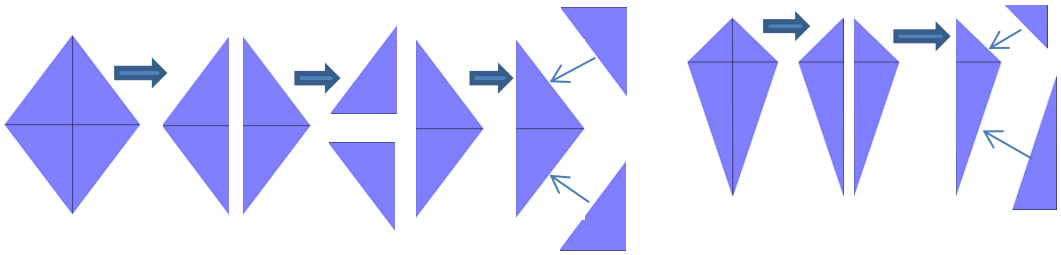


Figure 4.20. Reshaping a rhombus and a kite into a rectangle

After they get the lengths of the base and the height, they will multiply them and get the answer. Students should derive the relation between the length of the diagonals and the lengths of the base and height of the rectangles. The teacher may ask, how the area formula ½ *x length of diagonal 1 x length of diagonal 2* works to find the area of a kite and a rhombus.

After students finish the worksheet 14, the teacher will orchestrate a class discussion. In the discussion, the teacher will not give the correct answers but just

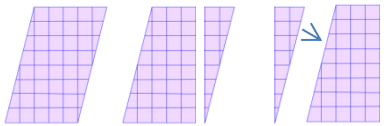
lead the discussion in the right track. The teacher may ask students who do not present the question:

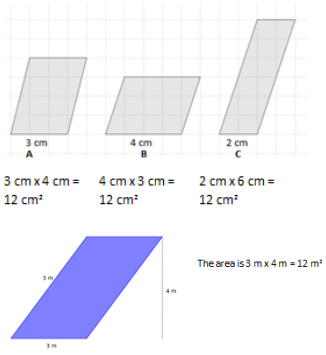
"Do you know what they have just explained?" or "Could you tell me what they explain your, words?", Do you agree with what they say?, Do you have another solution or strategy?

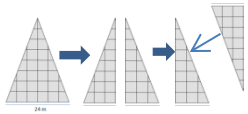
After the discussion, the teacher and the students will conclude together what they leaned today. There are some points of that should be in the conclusion. The main conclusions are:

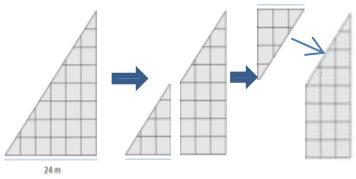
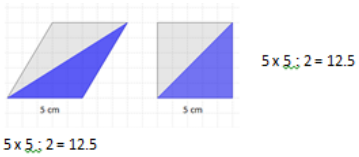
- The area formula of parallelogram can be derived from a rectangle, the area formula of parallelogram is *base x height*.
- The area formula of triangle can be derived from a rectangle; the area formula of triangle is *½ x base x height*.
- The area formula of trapezoid can be derived from a rectangle, the area formula of parallelogram is *½ x (sum of the length of parallel sides x height).*
- The area formula of rhombus and kite can be derived from a rectangle, the area formula of rhombus and kite is *½ x (length of diagonal 1 x length of diagonal 2)*

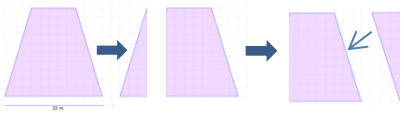
Table 4.6. The overview of the activity and the hypothesis of the learning process in lesson 6

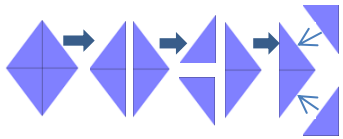
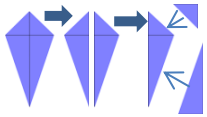
Activity Lesson 6	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
Comparing area of sides of two buildings with rectangular and parallelogram shape	Students are able to determine the area of a parallelogram by reshaping and derive the area formula from a rectangle.	Students will count the full square units and combine the not fully square units with other not fully square units in order to get full square units. Then students will count the square unit one by one or using multiplication strategy. Students may reshape the figures into a rectangle and count the square units one by one or using multiplication strategy. 	The teacher will show a building with a parallelogram shape and ask : *What is the height of this building? Can you determine how many glasses to cover that side of building?* The teacher distributes the worksheet 12 to each group. If students if students count one by one, ask: *"Do you have a faster way to count the square units?* *Do you still remember the formula to find an area of a rectangle?* If students have difficulties in counting the number of square units in the parallelogram, suggest student to reshape into another figure. *Maybe, you can reshape it into*

Activity Lesson 6	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
			another figure. After students find that the rectangle and the parallelogram have the same area. Ask: *If they have the same base, height, do you think they have the same area? Can you use the area formula for rectangle?*
Determining areas of parallelograms	Students are able to use the formula of rectangle to find the areas of parallelograms.	Students will reshape the parallelograms into a rectangle and apply the area formula of rectangle. Students will use directly the area formula of rectangle to find the areas of parallelograms.  	After some minutes and students have finished the 1st problem, the teacher then asks to work on the next problem. The teacher may suggest, *Maybe, you can try to use the formula and prove it by reshaping.* If students reshape the parallelogram into a rectangle and use multiplication strategy or area formula for rectangle, the teacher asks: *Can you say that the area formula of a parallelogram is same with the*

Activity Lesson 6	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
			formula of rectangle? So, what is the general area formula of parallelogram? If students only use the formula, the teacher may ask: *How can you use the area formula of a rectangle? Why does it work? Can you tell me the relation between the rectangle and the parallelogram? Can you generalize the area formula of parallelogram?*
Determining areas of triangles	Students are able to derive the area formula of triangle	Students may count one by one the square units Students may reshape the triangles into a rectangle and apply area formula of rectangle 	The teacher asks students where they can find a triangular shape. The teacher reminds students about a unique building, in previous problem, a parallelogram building. The teacher shows a picture of building with triangular shape. The students are asked whether they can find the area of glasses to cover the side of the building. *Could you find*

Activity Lesson 6	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
			*the area of glasses to cover the building* If students if students count one by one and have difficulties, ask: *"Maybe, you can use the hints on your worksheet"* After student reshape the triangle into a rectangle, and still count one by one the square units, ask: *Do you have a faster way to count them? Do you still remember the area formula of rectangle?* *What is the formula now?*
Determining the areas of shaded areas.	Students understand that the area formula of triangle is half of the are formula of rectangle (*1/2 x base x height*)	The students will count one by one the square units. The students will use the formula of parallelogram and rectangle and divide by two. 	If students count one by one the square unit, suggest them: *What do you think the area of the shaded part? What is the relationship with the parallelogram and the rectangle?* If students use the formula of parallelogram and rectangle, ask *So,*

Activity Lesson 6	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
			what do you think the area of a triangle?
Determining areas of trapezoid	Students are able to use the formula of rectangle to find the areas of trapezoid.	Students may count one by one the square units Students will reshape the trapezoid and use the area formula of rectangle 	The teacher shows a picture of building with trapezoid shape. The students are asked whether they can find the area of glasses to cover the side of the building. If students if students count one by one and have difficulties, ask: *"Maybe, you can use the hints on your worksheet"* After student reshape the triangle into a rectangle, and still count one by one the square units, ask: *Do you have a faster way to count them? Do you still remember the area formula of rectangle?What is the formula now?* See the base of your trapezoid and the base of the rectangle *What can you conclude?*

Activity Lesson 6	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
			If students have difficulties, suggest students to use the hint on the worksheet.If students reshape the trapezoid and use the area formula of a rectangle, ask: *How do you find the area? If you use any formula, what is the formula?* Ask also the height of the trapezoid, *what is the height of the trapezoid?*
Finding the area of a kite and a rhombus	Students are able to derive the formula of kite and rhombus by reshaping into a rectangle	Students will reshape the kite and the rhombus into a rectangle and use the area formula of rectangle.  	The teacher may suggest students to use the hint on the worksheet. After students have reshaped the kite and rhombus into a rectangle, ask them to use the area formula of rectangle. The teacher should ask: *What is the relation between the lengths of the base and height of the rectangle with the lengths of the diagonals?* *Can you conclude what the area formula of kite and rhombus is?*

4.7. Improvement of HLT

To sum up, the revised HLT contains the improvement of the instructional activities and conjectures of students' strategy after doing preliminary teaching.

Meeting 1

In meeting 1, the activities of comparing leaves and comparing rice fields would be carried out simultaneously to save the time. Cutting the leaves and rice fields from the worksheet took much time. Therefore, in one group, some students would solve the leaves problem and some would solve the rice field problem. Students would overlap the leaves and the rice fields if they are provided with cutting tools. Students may just overlap without cutting the leaves of the rice fields. Students may just imagine cutting and pasting the leaves or the rice fields. If students do not come to overlap, ask them to imagine if they hold the leaves in their hands. If students ask whether it is allowed or not to cut the leaves, just let students cut the leaves. If students really do not know what to do, the teacher just asks students to cut the leaves from the worksheet.

Meeting 2

In this meeting, students had difficulties in cutting neatly the rice fields. Therefore, the rice field that should fit the farmer rice field became unfit due to the cuts. The teacher should ask students to cut the rice fields neatly in order to get the correct answer. Otherwise, some spaces on the overlapping rice fields could be seen and the rice fields cannot fit perfectly. Since activities in this meeting are similar with activities in meeting 3, these activities will be omitted to make the meetings more efficient.

Meeting 3

Students used one string to compare the perimeter was not conjectured in initial HLT. Therefore, the revised HLT has one strategy in comparing the perimeter using one string. It took some time for students to decide the options they will choose. Therefore, the teacher should ask students to efficiently use their time in cutting the options and the farmer rice fields. In the cycle 2, each student will get one worksheet to enable them work faster. Therefore, they can use time

efficiently. If students measure the rice fields, ask them to carefully measure them to avoid errors.

Meeting 4

Since students tiled the floors by drawing the tiles using rulers, they still do not carefully measure the length of each tile. Therefore, students did not get precise tiles. In the cycle 2, it is better to just use the tile to let students tile the floor without using rulers. In cycle 2, this activity will be revised by adding the tile's dimension, for instance 25 cm x 25 cm. In dealing with parallelogram floor, it was not conjectured that students would reshape the floor. Some students will use tiles to find the height and the base of the parallelogram. Therefore, the revised HLT includes these strategies to solve parallelogram floor. Students are able to measure area of rectangles from a given length and width. In cycle 2, determining area of rectangle with given size would be omitted.

Meeting 5

Since the activities in this meeting are too many, the researcher omitted one activity, estimating area of a carpet. The hints were deleted and replaced them into guided questions in the teacher guides. The teacher should pose questions to let student think of what will they do, how, and why.

Meeting 6

The activities are split out into two meetings, in meeting 5 and 6. It is due to the activities in meeting 6 were too many to be delivered in one meeting. One activity in the parallelogram problem was deleted. The parallelogram problem and triangles problem would be carried out in meeting 5. Meanwhile, the trapezoid, rhombus and kite would be carried out in meeting 6. The trapezoid problem was modified to let students derive the area formula. Firstly, the teacher refreshes students' knowledge of distributive law of multiplication. The trapezoids were divided into two triangles so that students would sum the area of two triangles in each trapezoid. Students have learned the area of triangle in the meeting 5. Therefore, students would sum the area formula of triangles to get the area formula of trapezoid. The rhombus and kite problem were also modified. The diagonals were removed to let students think of their own strategy to reshape.

CHAPTER V
RETROSPECTIVE ANALYSIS

We have described in the previous chapter the hypothetical learning trajectory (HLT) in the learning of area measurement that we have designed. In this present chapter, we provide the retrospective analysis of the data collected from both in the first and second cycle. In the first cycle, firstly, the analysis of the first cycle are described by providing the analysis of the pre-test and students interview, the comparison of the initial HLT to the actual learning in the first cycle, and analysis of the post-test. In the second cycle, the researchers did the analysis of classroom observation, of the pre-test, comparison the revised HLT with the actual learning, and analysis the post-test.

5.1. Retrospective Analysis of Preliminary Teaching (Cycle 1)

During the preliminary teaching, the researchers tested out the instructional activities and types of instruction in the initial HLT to a small group of students. Six students from secondary school PUSRI Palembang participated in six meetings and they were divided into two groups; three student in each group. Group 1 consisted of three male students called as boys' group. Group 2 consisted of three female students called girls' group. Before conducting the preliminary teaching, these students did a pre-test lasting for 30 minutes. Two weeks after the last meeting, students took a post-test.

5.1.1. Pre-test cycle 1

This test is aimed at knowing students' prior knowledge. It is important to know both what students have known or understood and what they do not know about area measurement. These information will help the researchers to adjust the instructions and mathematical activities in the cycle 1 to support students' understanding of area measurement. One day after the pre-test, students were interviewed in order to know what they did to solve the problems in the test. Therefore, students' explanations revealed their ways of thinking. The interview was recorded and each student took about ten to fifteen minutes. During the

investigation through the pre-test, the researcher found some important points related to students' understanding of area measurement. The following are the important points that will be used to adjust the initial HLT.

a. Students' understanding of a figure's orientation

In this small group, all students could compare two figures with different orientations. They rotated the first figure in order to get the same position as the second figure. They easily recognized that those figures have an equal area since the shape is just the same. One student clearly explained the name of each figure (diamond and square) and said that they have the same size but have different position. She could explain the lengths of the respective sides are equal.

b. Justification based on lengths of the sides.

Two students were not able to compare a parallelogram and a rectangle with an equal length of the base and the height. They mistakenly judged on the parallelism property. One student said that since the sides are parallel, their areas are equal. For instance, since the opposite sides have the same lengths, they judged that the area is equal. In addition, there is one student who judged the equality of area based on the equalities of the lengths of the sides. Interestingly, he said that since the height of the parallelogram is arbitrary, its area is smaller than the rectangle's. In the case of the triangle, students also compared the areas of triangles by judging the lengths of the sides. The longer the sides, the larger area it has.

c. The knowledge of area formulas

In case of comparing a parallelogram and a rectangle, one student was able to compare the area by the area formula. He knows the area formula of a parallelogram and a rectangle is the same; base x height. Therefore, since the parallelogram and the rectangle have the same lengths of their bases and heights, their areas are equal by using the area formula. In case of comparing triangles, he measured the lengths of the base and height of each triangle. Then he compared the areas by applying the formula. He already knew the area formula of a triangle; ½ (*base* x *height*). However, he measured the bases

and the heights of the triangles using a ruler and made errors measuring. Therefore, area of the first triangle is larger than the second one.

Related to other area formulas, most of students have already known the area formula of a triangle, rectangle, parallelogram, rhombus, kite and trapezoid. However, they sometimes created their own formulas due to the given numbers. They tend to use all information (given numbers) to fit the formula or to find the area. In addition, they did not know where the formulas are derived and why the formulas work. They said that they learned the formulas are like those from their teachers and books. They tended to remember the area formulas. Therefore, if they forget the formulas, they will have difficulties finding the areas of quadrilaterals.

d. The ability to do overlapping

Students did not come up with the idea of comparing two figures by overlapping. It is obvious when they dealt with the leaves problem. Students had to compare two leaves to decide which one gets more sunlight. They tended to judge by using their visual perceptions. If the leaf looks bigger, or wider, it means that it is larger.

e. The ability to do partition of a figure

In dealing with finding an area of an irregular figure, students were able to make partitions to find the area. The area of each partition is added to get the area of the figure. Interestingly, students partitioned the irregular figure into some squares and added each area of the square. However, when they are asked the perimeter, they multiplied the perimeter of each square with the number of squares. In addition, after making partitions to find the area, one student used perimeter formula of a rectangle (*2 length + 2 width)* to find the perimeter of the irregular figure. In general, students were able to make partitions of a figure.

f. The ability to do reshaping

Two students came up with the idea of reshaping. They reshaped the parallelogram into a rectangle and the irregular figure into a rectangle. One

student was asked whether when she reshaped a figure the area will change or not. She confidently answered that the area will not change.

g. The understanding of standard unit measurements

From the students' work and the interview, students do not understand why the standard unit measurement is in square such as cm^2, and m^2. Students use single power in the unit measurement; cm, m. They think that the figure is not a space figure and think that the cm^2 and m^2 are used for space figures. In addition, since students used the wrong formulas or made their own formulas to find areas, it leads to the wrong standard unit measurement. For instance, when the use the wrong area formula of parallelogram (½ *base* x *side* x *height*), they use all given numbers to fit the formula. It resulted in the wrong unit measurement in area; in cubic.

5.1.2. Remarks on Pre-test Cycle 1

Based on the pre-test, students are able to understand that the areas of two figures are equal even though their positions or orientations are different. This understanding will be useful to get students understood the multiplication property; the commutative property. In the meeting 4, students will learn about area formula of a rectangle and explore the commutative property. Comparing two floors with the same area but have different positions (vertical and horizontal) will help students to understand the commutative property. Therefore, students' understanding of figure's orientation is sufficient to learn the mathematical activities designed by the researchers.

Students know the area formulas of quadrilaterals and triangle but they do not understand where the formulas are derived and why the formulas work. Since students only remember and apply the formula or just make their own formulas. They tended to use the given numbers and apply them on the formula whether the formula is correct or not. Therefore, the mathematical activities delay the use of umber until the last three meeting. The numbers will be given in the last two lessons when students have learned the concept of conservation of area. In addition, after students the results, they give the wrong standard unit measurement or forget to give the standard unit measurement. They still are not really aware of

the standard unit measurement. Mostly, they focus on calculations and results. As the standard unit measurement for area is in square, they did some mistakes by giving only cm, m or even cm^3, m^3. Even when they put square on the standard unit measurements, they do not know why it should be in square. Therefore, in can be stressed in meeting 4 when students deal with tiling activities to understand a square unit of measurement.

Students did not come up with the idea of overlapping and reshaping when they compare areas of two figures. Their justifications are based on the lengths of the sides or on visual perceptions. This strategy is good but not sophisticated to prove exactly which one is really larger. Therefore, the activities of overlapping and reshaping are hoped to overcome students' difficulties comparing area of two figures and enrich their strategies in comparing areas. Related to the worksheet, some revisions were done on the numbering of each problem, numbers used, and naming of each figure.

5.1.3. Preliminary Teaching Cycle 1

There were six students involved, namely, Gio, Raudy, Dean, Nabila, Mesi, and Mia in this preliminary teaching. They were divided into two groups. Group 1 consisted of Gio, Raudy, and Dean and Group 2 consisted of Nabila, Mesi, and Mia. They participated in six meetings in order to improve the initial HLT to be used for cycle 2. Feedback and remarks gained from this cycle will be used to improve the HLT. The analysis of the initial HLT is explained as follows:

1. Meeting 1

Activity 1 Comparing leaves

In the first activity students did comparing activities. They compared areas of two irregular shaped (leaves). Numbers were not used in this problem. It can be used to refresh their understanding of the concept of area. Students would not be able to use the area formulas since they did not know the formula to find an area of irregular figure and there is no number used in this problem.

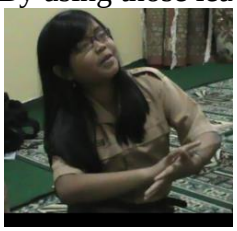
Firstly, the researcher displayed the photosynthesis process and asked students what play important roles in this process. After knowing that the leaves and the sun are important in the photosynthesis, the researcher then asked students

to solve a problem related to a photosynthesis process. Students had to determine which leaf that will get the more sunlight. After delivering the worksheet 1 (comparing leaves), the researcher let students read the problem and asked students about their understanding of the problem. The following fragment shows that students got the point of the problem.

Researcher : What do you know about the problem?
Dean : **Area**
Researcher : Ha? (asking for repetition)
Student : **The leaf that gets more sunlight**
Researcher : Which leaf? How is the leaf's condition?
Dean : **The larger leaf**
Researcher : The leaf that has the larger surface right?
Dean : Nodding

From the transcript, we can see that the student know that the larger the leaf the more sunlight it will get. Before providing the materials (scissors and glue), the researcher posed a question what will they do to solve the problem.

Researcher : Now, solve the problem! If you hold those leaves, what will you do?
Nabila : Find out which one is larger
Researcher : How?
Nabila : by measuring them
Researcher : How?
Nabila : by measuring them
Researcher : Yes, by measuring them, but with what?
Nabila : By using those leaves, which one is larger **(overlapping her hands)**



Researcher : What do you do to the leaves?
Nabila : **Overlap them**

Later on, students worked in groups. Provided with materials such as scissors, students put one leaf to another one to see which leaf is larger. Afterward, Group 1 traced the leaf B on leaf A to cut the non-overlapping area of leaf B. They then

cut the non-overlapping areas of the leaf B and glued it to the non-overlapping area of leaf A (see figure 5.1). Group 1 got the answer that leaf A is larger than leaf B.

Figure 5.1 Student overlapped, cut and pasted the leaves

Another group struggled to make decisions. They knew that when they overlapped one leaf into another one, there are some parts of that surpassed (non-overlapping area). They overlapped many times the leaves until they came up with cutting non-overlapping parts of leaf B and put them on the non-overlapping parts of leaf A. Interestingly, they just imagined they cut and paste the non-overlapping areas of leaf B (see transcript). They did not actually cut the leaves. Therefore, this group decided that the leaves have the same area. The researcher did not conjecture that students would only imagine in cutting and pasting it. However, they have the same idea in comparing the leaves; overlapping, cutting and pasting. The following is the transcript when Group 1 presented their work.

Nabila	: We measure them, and their sizes are equal. why they are equal, because if leaf A is overlapped into leaf B
Researcher	: Yes (agreeing)
Nabila	: We could see their sizes There is more part in leaf A(showing the non-overlapping parts of leaf A) and also in leaf B, it has more part (Showing non-overlapping part of leaf B)


Therefore, **if we see and cut the non-overlapping parts**. It is equal

Researcher : You cut (repeating), you cut the non-overlapping parts and then?

Nabila : If this non-overlapping parts (showing). You cut these, but there is a space(showing)


then the size is equal, if we put them here (showing)

Researcher : Have you tried it?

Nabila : We think, Yes

Researcher : The leaves still are not cut

Nabila : **We just imagined it**

Based on the group's work, it confirms that students solved the problem by doing overlapping, cutting and pasting (see figure 5.2)

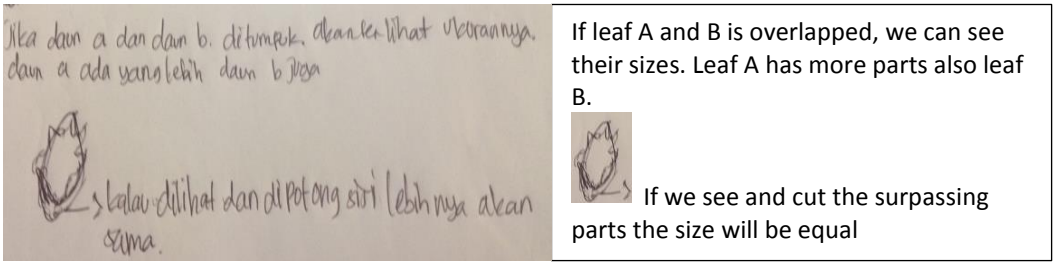


Figure 5.2 Group 2 written work on leaves problem

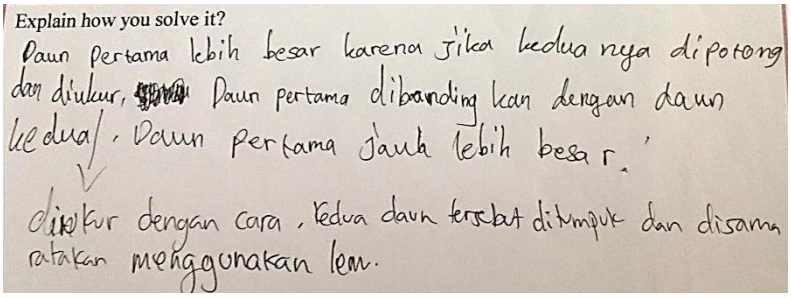
Group 2 drew the overlapped leaves. The arrow show that the cut-parts of leaf B will be pasted in that part (leaf A) just like the Group 1 did.

Group 1 had a different answer and this group argued the solution of the group 2. The Group 1 really cut and glued the leaves and proved that leaf A is larger than leaf B. The following transcript describes how the Group 1 gave their argumentations.

Gio	: **We do not agree with the girl's group** because we think that the second leaf (leaf B) is smaller than the first one (leaf A)
Researcher	: What is the reason?
Gio	: The reason is if those leaves are cut and measured, the first leaf is larger. We measured them by overlapping, cutting and pasting with glue
Researcher	: Show us why it is larger
Gio	: **Because there are spaces in the first leaf**
Researcher	: There are some leftovers, some spaces, right? (Repeating). Then?
Gio	: Therefore, the first leaf is larger

From the transcript above, it can be seen that Group 1 and Group 2 have the same idea of comparing leaves. They overlapped one leaf into another one and cut non-overlapping parts of leaf B and glued (pasted) them to the non-overlapping parts of leaf A. Therefore, the have learned to compare areas of two irregular figures by overlapping, cutting and pasting.

In the Group's 1 work, it is clear that this group really used overlapping, cutting and pasting (figure 5.3). In here, the first leaf and the second leaf refer to leaf A and leaf B respectively.



Explain how you solve it?
The first leaf is larger because if both leaves are cut and measured by overlapping both leaves, cutting and pasting with glue. The first leaf is compared to the second leaf. The first leaf is much larger.

Figure 5.3 Group 1 written work on leaves problem

In addition, the researcher asked questions during the presentation related to the area after they cut and paste the leaf.

Researcher	: This parts belong to this leaf (pointing leaf B), is the area of this cut-leaf equal to the uncut-leaf? Does the area change?
Gio	: **No**
Researcher	: It does not change, Why?
Gio	: Because, these cut-parts are not... (having difficulty to say)
Researcher	: Did you throw away some parts?
Gio	: **No, we glued them all**
Researcher	: You glued them all, and united them right? But the shape changed, didn't it?

From this fragment, students from Group 1 know that when they paste all the cuts and did not throw away the cuts, the area will not change. Therefore, students grasped the concept of conservation of area.

The researcher tried to confirm this to Group 2 if they cut and paste the leaf the area will change or not. The following fragment describes how Nabila understands the concept of conservation of area.

Researcher	: So the area changes or not if your group cut and paste the leaf?
Nabila	: We did not cut
Researcher	: Yes, but If you cut and paste, do you think the area changes?
Nabila	: The area changes
Researcher	: **Does it change?**
Nabila	: **Yes**
Researcher	: Why does it change?
Nabila	: This is the area (showing the leaf)
Researcher	: Yes
Nabila	: If the area is 50 cm^2 and we cut 3 cm^2 it will be 47
Researcher	: **But you paste again, does it change the area?**
Nabila	: **No**
Researcher	: No (confirming)

Activity 2 Comparing rice fields

The second activity, student will compare two irregular rice fields. They had to determine which rice field that produces more crops. This activity is aimed at strengthening the overlapping strategy. As students did overlap, cut and paste in comparing leaves, they did the same strategy to decide the larger rice field. Their strategy was predicted in initial HLT. Mia and Gio had different answers. Mia thought that Mr. Joko's rice field is larger than Mr. Slamet's rice field. However, they had the same strategy to solve the problem. The following transcript describes how Gio argued and defended his answer.

Gio	: Mr. Slamet's rice field will produce more crops because if we measure by overlapping, cutting and pasting, Mr. Slamet's rice field is larger
Researcher	: Could you show your work! This part belongs to Mr.? (giving the part)
Gio	: (Showing his work). There is one more part!
Researcher	: Show it!
Gio	: (Showing his work)
Researcher	: Can you see his work? Gio has cut and pasted the rice field and there is...?
Gio	: **Leftover**
Researcher	: **If there is a leftover in Mr. Slamet's, so which one is larger?**
Gio	: **Mr. Slamet's**

From the transcript above, we can see that Gio had the same strategy. He overlapped Mr. Slamet's rice field into Mr. Joko's rice field, cut the non-overlapping parts of Mr. Slamet's and then pasted (glued) the non-overlapping parts of Mr. Joko's. The cuts of non-overlapping parts of Mr. Slamets could cover the non-overlapping parts of Mr. Joko's and remained some parts. Here, Gio knew that if Mr. Slamet's rice field has some leftovers when covering Mr. Joko' rice fileds, Mr. Slamet has a larger rice field.

Again, the researcher posed a question, whether when students cut and paste the rice field, the area will change or not. Students understand the concept of conservation of area. When they cut and paste the rice field the area remains

the same. The following fragment shows that students understand that cut and paste a figure will not change its area.

Researcher : When you cut and pasted the rice field, does the area change?
Mia : No (moving her head)

Therefore, the comparing activities can ignite students reasoning to overlap two figures in order to compare their areas. This also led students to understand that cut and paste a figure will not change its area.

Activity 3 Comparing dotted rice fields

The third activity, students compares two dotted rice fields. As conjectured, most of them counted the dots one by one and compared the number of dots to decide the larger rice field (see figure 5.4).

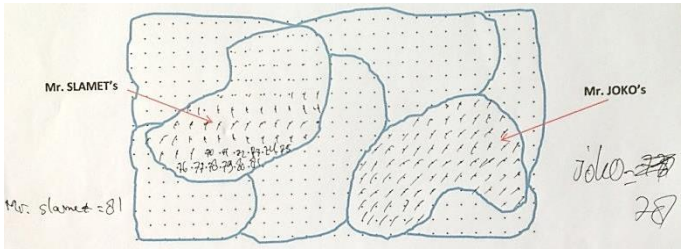
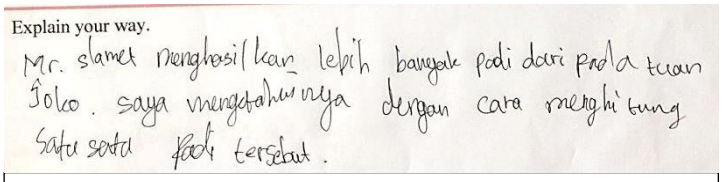


Figure 5.4 Students counted the dots one by one



Explain your way.
Mr. Slamet produces more rice than Mr. Joko. I know it by counting one by one the paddies.

Figure 5.5 Student' explanation in counting the dots

Interestingly, Dean counted one by one on the Mr. Slamet's rice field and used a different strategy when counting the dots on the Mr. Joko's rice fields. He counted by tens by connecting the dots (see figure 5.6). He thought that this strategy is faster to count the dots.

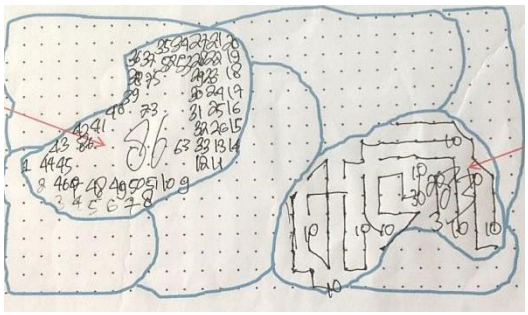


Figure 5.6 Student counted by tens

None student used another strategy that the researcher predicted like making a rectangles or squares on the rice fields. However, they know that using the dots help them to compare areas of two rice fields. In addition, this activity would be strengthened in the meeting 5 when students learn the unit of measurement

The goals of this meeting are achieved. Students grasped the area is inside the leaves. Students understand that cut and paste a figure will not change the area. Students understand that the dots helped them to compare areas.

2. Meeting 2

Before students began the meeting 2, the researcher tried to know what students learned in the meeting 1. In order to know their understanding of the concept of conservation of area, the researcher asked questions as the following:

Researcher	: What did you learn in the previous meeting with scissors and other tools?
Student	: Cutting and gluing
Researcher	: When you cut and glue, what happens then?
Gio	: Fitting (weak)
Researcher	: What?
Gio	: Fitting
Researcher	: Fitting (repeating) then? What happens? The area?
Gio	: **The area is the same but the shape is different**
Researcher	: Please, repeat it again!
Gio	: **The area is the same but the shape is different**
Researcher	: Please repeat what Gio said!
Mia	: **The area is the same but the shape is different**
Researcher	: Ok, we are going to learn this again

From this segment, students still could recall what they learned in the previous meeting. After the researcher delivered the worksheet, the students worked in group.

Activity 1 Transactional deal 1

The problem is about a transactional deal. It is aimed at developing students understanding of overlapping strategy and the concept of conservation of area. Students dealt with a problem of exchanging a farmer's rice field with one rice field offered by an office owner. Students had to determine whether the farmer should accept the offer or not through the fairness of the transaction. It is fair if the area of the farmer' rice field is exchanged with a rice field with the same area. The researcher walked around the class and asked what students were doing

Researcher	: What are you doing Gio?
Gio	: I am cutting…(weak)
Researcher	: Louder please!
Gio	: I am cutting the farmer's old rice field
Researcher	: What will you do after that?
Gio	: **Overlap and fit it**
Researcher	: What is the aim of doing that?
Gio	: **To know the rice field that is larger or smaller**
Researcher	: What is the fairness?
Gio	: **The old rice field is as big as the new one**
Researcher	: You meant, as big as is equal area?
Gio	: He e (nodding)

It is obvious that students used overlapping strategy and then would cut and paste one rice field to fit another one. Students cut the farmer's rice field and the new rice field with scissors. They overlapped the farmer's rice field into the new rice field or vice versa. Students already knew that they should fit the new rice field.

In solving this problem, as conjectured in initial HLT, Group 1 cut the farmer's rice field and the new rice field. They overlapped the rice fields. The new rice field is a rectangle meanwhile the farmer's rice field is L-shaped. They cut the farmer's rice field to fit the new rice field (see figure 5.7).

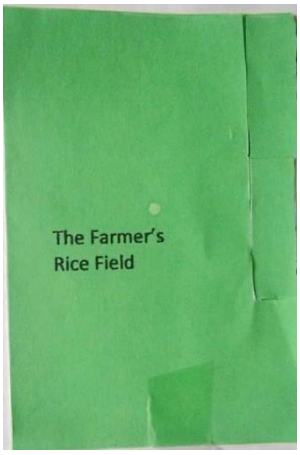


Figure 5.7 Students reshaped the farmer rice field into a rectangle

During the presentation, the researcher asked some questions related to the area when students cut and paste as the following:

Researcher	: When cutting, you cut this part and paste again, does the area change?
Raudy	: No
Dean	: No
Researcher	: Why it does not change?
Raudy	: **Because the cuts are pasted and are not thrown away**
Researcher	: Because the cuts are pasted and are not thrown away. **Does the shape change?**
Raudy	: **Yes**
Researcher	: The farmer rice field is like this, and now?
Raudy	: Becomes a block
Researcher	: Becomes a block (repeating)
Raudy	: Becomes a rectangle
Researcher	: Becomes a rectangle (repeating)

From the transcript, it is obvious that students understand that cut and paste the farmer' rice field will not change its area but its shape. After, Group 1 presented their work, the teacher let Group 2 presented their work. Group 2 presented their answer and had an additional strategy to solve the problem.

Researcher	: Explain to your friends
Mia	: We measured by hands

Researcher	: Measured by hands (repeating), tell us how, can you show how? Can you show to them how to measure
Mia	: (Showing)
Researcher	: See, her hands had marks to measure
Mia	: (showing)
Researcher	: What did you do to measure? Then what?
Mia	: This one and this one is compared
Researcher	: Compared, what do you mean?
Mia	**: We got this long in this one (showing her hand) and also in another one**
Researcher	: That is the side of the rice fields?
Mia	: Nodding
Researcher	: Then what?
Mia	: **The width is this long (showing) and another one is this long, longer**
Researcher	: There is a remaining part
Mia	: **Therefore, the remaining part is cut like this (showing)**
Researcher	: The remaining part is cut

Group 2 measured the lengths and the widths of the rice fields and compared them. Mia measured the length and he width with her hands and made some marks on her hand. Mia knew that the rice fields have an equal length and she compared the widths of the rice fields. She used the width of the new rice field and compared it with the width of the farmer' rice field. Since the width of the farmer' rice field is longer, she decided to cut it and paste it to another side in order to make a figure like the new rice field. This resulted in that the farmer rice field has an equal area with the new rice field (see figure 5.8).

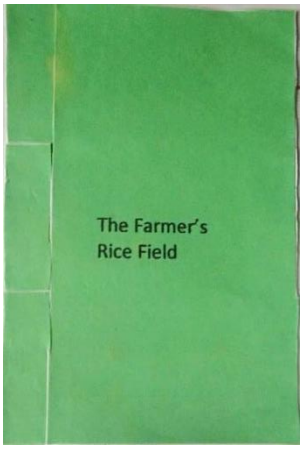


Figure 5.8 Group 2 reshaped the farmer rice field into a rectangle

It can be said that this group measured the sizes of the rice fields and compared them, before they cut the rice field. They know that if two figures have the same size (dimension), they will have an equal area. Therefore, they compared the sizes of the rice fields and decided to cut when they found the longer part and pasted it to get the same size or not.

Activity 2 Transactional deal II

The next problem is still related to a transactional deal. The problem is developed from the first problem. The different is that the rice fields offered by the office owner are two rice fields. Therefore, students had to determine whether the offer is fair or not. Students in Group 1 overlapped the new rice field 1 into the farmer' rice field and fitted them. They overlapped the new rice field 2 into a part of the farmer' rice field which is not overlapped by the new rice field 1. This group then cut and pasted the new rice field 2 to fit the part. They got the new rice field 1 and the new rice field 2 fit the farmer' rice field. In the contrary, Group 2 had a different solution. Students in this group use the same strategy like in the previous problem. However, untidy cuts led them to a wrong solution. They got that the new rice field 1 and the new rice field 2 is larger than the farmer rice field.

Remark on meeting 2

The teacher should ask students to cut the rice fields neatly in order to get the correct answer. Otherwise, some spaces on the overlapping rice fields could be seen and the rice fields cannot fit perfectly. Since activities in this meeting are similar with activities in meeting 3, these activities will be omitted to make the meetings more efficient. Let students to use the provided materials only.

3. Meeting 3

Before students learned the lesson in the meeting 3, the researcher tried to invite their understanding in the previous meeting.

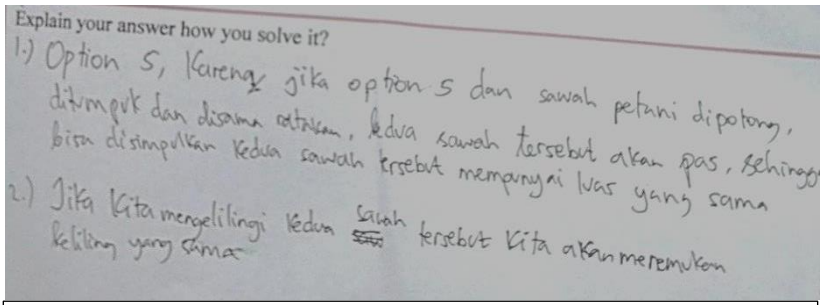
Researcher	: Yesterday, we cut and so on, what happens?
Dean	: **The area remains the same and the shape is different**

Researcher : Do you agree with him?
All students : Yes, we do

From this segment, to some extent some students still remember what they learned the previous meeting. After knowing that students still understand cut and paste will not change area but the shape, then the researcher began the lesson.

Activity 1 Transactional deal III

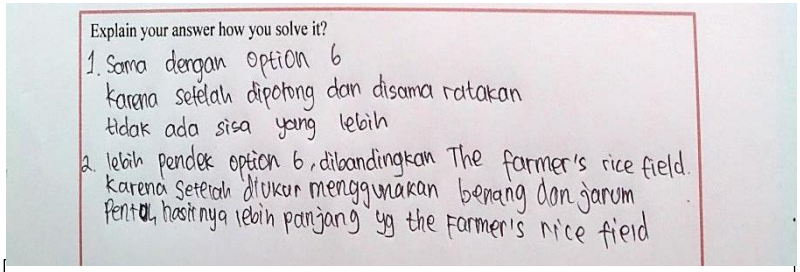
Alike in the meeting 2, students dealt with the transactional deal. This activity is aimed at letting students understand the concept of conservation of area and see the different between area and perimeter. In here, students had to choose which rice field that will be a fair deal. There are six rice fields or options. After they decide a rice field to fairly exchange the farmer' rice field, they had to compare paths if they walk around the farmer' rice field and the chosen rice field. In comparing the paths, students were provided with strings and needles and styrofoam. Styrofoam used as a foundation when students put the needles. At the end, the chose one of them because they thought chosen option could fit if they cut and pasted the option to the farmer rice field. The following figure shows how students solve the problem. Each group had a different solution related to the rice field they chose. Group 1 chose option 5 meanwhile Group 2 chose option 6



Explain your answer how do you solve it?
1. Option 5, because if the option 5 and the farmer rice field were cut, overlapped and fitted, those rice fields would fit. Therefore, we concluded that the two rice fields have an equal area.
2. If we walked around both rice fields, we found that their perimeters are equal.

Figure 5.9. Group 1 chose option 5

Interestingly, in comparing the path, they had a different way. Group one used only one string. Meanwhile Group 2 used two strings.



Explain your answer how you solve it?
1. It is equal to the option 6, because after we cut and fitted it, there is no leftover.
2. Option 6 is shorter than the farmer's rice field because after we measured with strings and needles, it resulted in the path of Mr. Slamet's rice field is longer

Figure 5.10. Group 2 chose option 6

Group 1 concluded that the path has the same length. However, when they presented in front of the class, it was wrong. Gio realized that the string could fit the perimeter of the option 5. However, this string was not enough to trace the edges of the farmer's rice field. In other words, Gio realized that the string he used could not fit the perimeter of the farmer's rice field. They fixed their answer, that the rice field option 5 has different perimeter with the farmer's rice field. Therefore, their conclusion in the worksheet was different with their presentation. We could see that students could directly revise their answer when they realized their mistakes.

Group 2 presented their answer and chose the option 6. They cut the option 6 and tried to fit the farmer's rice field. They overlapped, cut and pasted the option 6 into the farmer's rice field. They got that option 6 can fit the farmer's rice field and it is fair. In solving the perimeter problem, they used two strings. Firstly, they used one string to trace the perimeter of the option 6 and the farmer's rice field. Afterward, they compared the length of the strings. They got that the farmer's rice field has a longer string. Therefore, they concluded that the option 6 has a shorter path than the farmer' rice field path when they walk around those two rice fields.

Activity 2 in this meeting was not conducted because the time was limited. Students had this activity as homework. Students had to reshape quadrilateral into a rectangle. In conclusion, in the meeting 3, students learned that when they reshaped a figure into another shape, the area remains the same but not the perimeter. Students could differentiate between the area and perimeter.

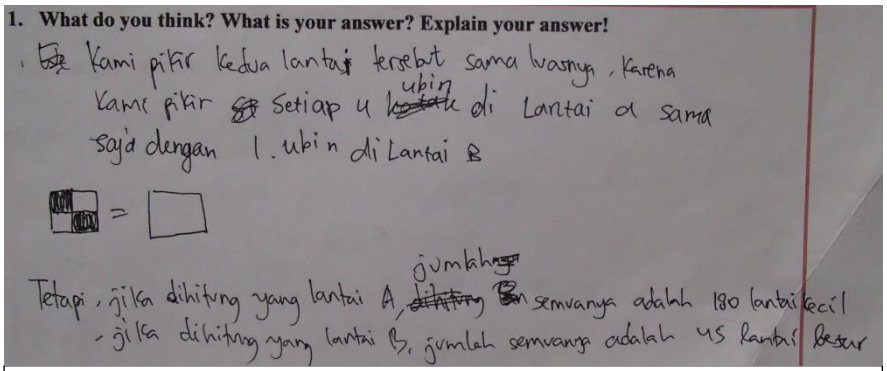
Remark on meeting 3

Students used one string to compare the perimeter was not conjectured in initial HLT. It took some time for students to decide the options they will choose. Therefore, the teacher should ask students to efficiently use their time in cutting the options and the farmer rice fields. In the cycle 2, each student will get one worksheet to enable them work faster. Therefore, they can use time efficiently.

4. Meeting 4

Activity 1 Comparing tile floors and tiling

In this meeting students compared area of two floors with different tiles sizes and tiled floors to determine their areas. In the first activity all group successfully answered the problem. Both group realized that one tile in floor B is equal to four tiles in floor A as the conjectures. They calculated the number of the floor by multiplying the numbers of tiles in the edges (figure 5.11).



We think that the floors have an equal area because we think every 4 tiles of floor A is equal to 1 tile of floor B.

But, if we counted the tiles in floor A, the total is 180 small tiles
If we counted the tiles in floor B, the total is 45 big tiles.

Figure 5.11. Group 1 worked on tiled floors

Another group solved in the same way, they recognized that one tile of floor B is four tiles of floor A

This is also in line with their argumentations in the presentation. Students said that one floor in floor B is equal to four tiles in floor A.

Mia	: The floor A is the same with floor B
Researcher	: The same (repeating), why is it same?
Mia	: **One tile in floor B is equal to four tiles in floor A**
Researcher	: Okay, how many are they?
Mia	: This, if we make it equal
Researcher	: Equal in what?
Mia	: **One tile in floor B is equal to four tiles in floor A**
Researcher	: How many tiles are there?
Mia	: Forty five

From this segment, it is clear that students knew that the tile in floor B is equal to four tiles in floor A. They compared using the same size of tile.

More importantly, students need to know how to find the number of tiles in each floor effectively. None students counted one by one. They knew how to find the number of the tiles on the floor effectively. They multiplied the number of tiles on the edges. However, students had difficulties explaining how this method works. They repeated the same answer because the method works in that way.

Researcher	: How did you get forty five?
Mia	: This is nine (showing tiles on the first row)
Researcher	: Then?
Mia	: This is five (showing tiles on the last column)
Researcher	: Yes, then?
Mia	: Multiply them
Researcher	: Multiply them (repeating) and can you get 45?
Mia	: Yes, I can
Researcher	: Have you checked it?
Mia	: I have
Researcher	: How does it work?
Mia	**: That works in that way**
Researcher	: That works in that way (repeating) Do you have another argument?
Dean	**: That works in that way**

The bold sentences show that students had difficulties in explaining how the method works. Knowing this situation, the researcher helped by scaffolding them.

Researcher	: How many tiles in here (pointing the first row)
Students	: Nine
Researcher	: This (the second row)
Students	: Nine
Researcher	: This (the third row)
Students	: Nine
Researcher	: This (the fourth row)
Students	: Nine
Researcher	: This is nine (the last row)
Students	: Nine
Researcher	: **Why does it work?**
Gio	: **Because there five nines!**
Researcher	: See!

After the researcher posed guided questions, students understand why multiplying only tiles on the edges of a floor could count the total of tiles in the floor. In addition, students also learn the commutative law of multiplication.

Researcher	: How if I do it like this, how many tiles (pointing the first column)
Dean	: **Five, there are five nine times**
Nabila	: It is same
Researcher	: Repeat it again
Dean	: There are nine fives
Researcher	: What did you say?
Nabila	: It is same
Researcher	: Louder please
Nabila	: **It is same in fact five times 9 equals nine times 5**
Researcher	: That is one of properties in multi…?
Students	: **Multiplication**
Researcher	: Multiplication, do you agree?
Students	: Yes

Since the size of the tiles is different, the number of tiles is different in each floor. Therefore, the researcher asked students to explain why it is equal. The following transcript shows how students use the same tile to get an equal number of tiles.

Researcher : This is 180, this is 45, and how can it be equal?
Mia : If we make this(pointing floor A) with the bigger tiles, it has 45, If we make this (pointing floor B) with the smaller tile, it has 180

When students were asked to explain why their strategy works, they could explain it with the help of the researcher.

Students also compared floors by a given tile. As the researcher conjectured, students made tiles only on the edges of the floors. Interestingly, one group reshaped the parallelogram floor in to a rectangle and put a tile and marked the edges. The researcher did not conjecture this. Both groups drew tiles on the edges or put marks on the edges. They used rulers to measure the tile and drew tiles and marks by using the length of the edge of the tile. Some errors made by students. Students moved the rulers to measure each tile on the floors' edges without realizing that they imprecisely measured. Therefore, student did not get a precise measurement and tiles.

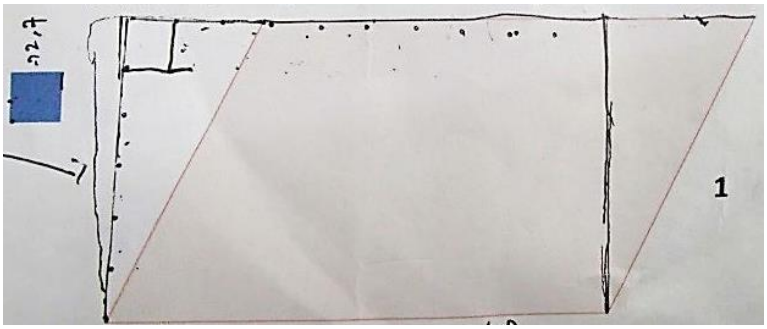


Figure 5.12. Students reshaped the parallelogram floor

Individually, students also worked on the rectangular floors to compare areas. Some students tiled fully on the floors and others just made marks only the edges of the floors. From the given sizes of rectangles, students could find the areas. They multiplied the length and the width of each rectangle to get the area.

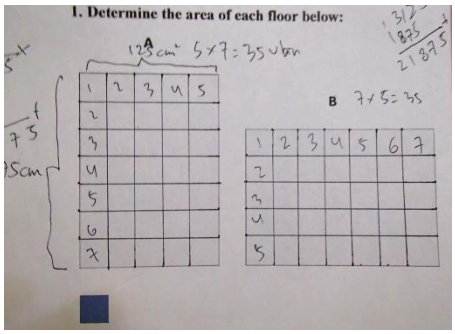


Figure 5.13. Student tiled fully the rectangular floor

Remarks on the meeting 4

Since students tiled the floors by drawing the tiles using rulers, they still do not carefully measure the length of each tile. Therefore, students did not get precise tiles. In the cycle 2, it is better to just use the tile to let students tile the floor without using rulers. In cycle 2, this activity will be revised by adding the tile's dimension, for instance 25 cm x 25 cm. Overall, the mathematical goals in this meeting were achieved. Student can compare the area using the same unit of measurement (tiles). Students could understand the area formula of rectangle by just multiplying the length and the width. Students are able to measure area of rectangles from a given length and width. In cycle 2, determining area of rectangle with given size would be omitted.

5. Meeting 5

Activity 1 Determining area of living room's floor

In this meeting, students dealt with determining area of a rectangular floor, estimating area using square unit, and compare irregular rice filed and leaves in the meeting 1. In determining the area of a rectangular floor, students easily got the answer, by just multiplying the length and width of the floor. As conjectured, students also multiplied the tiles on the edges and then multiplied the result by the area of one tile. Both strategies were used by students (figure 5.14).

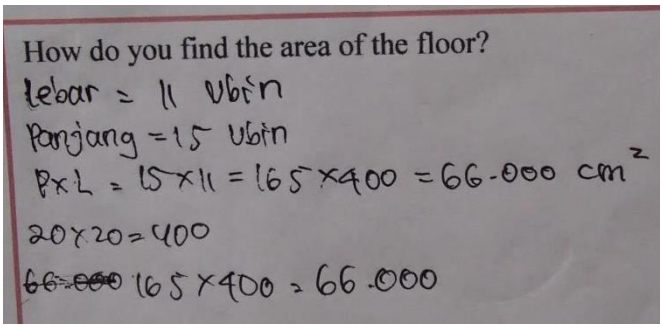


Figure 5.14. Students multiplied the number of tiles

From this figure, it is obvious that students applied the area formula of rectangle to determine the area of the floor. This group made mistake in determining the number of tiles in the length of the floor. It should be fourteen tiles not fifteen tile. Therefore the researcher asked them to recalculate the number of tile in that edge. They realized their mistake and revised it.

Group 1 mistakenly multiplied the number of the tiles on edges with the area of one tile. They should multiply the number of the tiles on the edges with the length of one tile. Therefore, students got a really large floor. The researcher then posed questions related to their answer. Students were asked why the floor is so large like a very large rice field. The researcher also asked the length of the floor is and the length of one tile is. Suddenly, students came up and realized that they should have multiplied it with 20 cm (the length of one tile). Then the researcher let students revised their answer, and compared the answer with the Group 2. At the end, both group had the same answer related to the area of the tiled floor. We can conclude that students have understood how to measure the area of a tiled floor with a given size of tile. They can determine the area by multiplying the number of the tiles on the edges to get the total number of tiles and then multiplying it with the area of one tile. Another strategy used is that students multiply the numbers of tile of one edge with the length of one tile to determine the length and width of the floor. After getting the length and width, they multiply the length and width to get the area of the floor.

Activity 2 Estimating area of a carpet

In estimating area of a carpet, students successfully estimated the area. They already understand that they cannot ignore the non-fully squares. Therefore, students combined the non-fully squares to get fully squares.

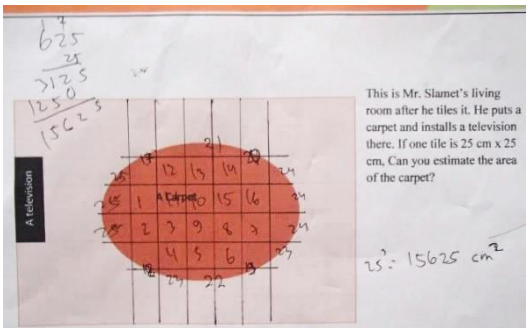


Figure 5.15. Students estimated the area of a carpet

Activity 3 Comparing areas of dotted rice fields and leaves

This activity is aimed to see whether students have developed a new strategy to compare areas. Students are expected to use square unit to compare areas of two irregular figures. In comparing the area of irregular rice fields like in the meeting 1, five students drew squares on the rice fields an compare the number of squares in each rice field. This is in line with the conjectures in initial HLT that some students will still count the dots. One student still counted one by one even the researcher had suggested finding another way. However, students who used the hints drew lines to connect the dots. They finally made squares on the rice fields. In counting the squares students counted all fully squares and combined the non-fully squares to get fully squares (figure 5.16)

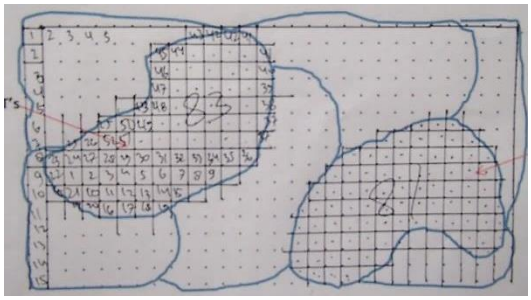


Figure 5.16. Student combined the non-fully squares

From the students work, it can be seen that students put numbers on the squares and also combined the non-fully squares to get fully squares. For instance, students put number 19 twice because this students combined these non-fully number to get one fully square, that is the square number 19. From this point, students could compare areas by using square units. Interestingly, one student made squares on the rice fields. However, this student did not count one by one the squares but he made diagonals on the squares and multiplied the diagonal to get the total numbers of squares. Since the rice fields are not rectangular, this strategy is not appropriate to use. In the discussion, students understood that this strategy could not be applied in irregular figure.

In comparing leaves, students drew grid on the leaves. They used the hints on the worksheet. Firstly, he made marks with 1 cm, but later he made smaller squares about 0.5 cm x 0.5 cm. He used the same strategy to count the number of squares on the carpet and rice fields. He counted the fully squares and then combined the non-fully squares to get fully squares. The number of squares in each leaf was compared and leaf A is larger than leaf B.

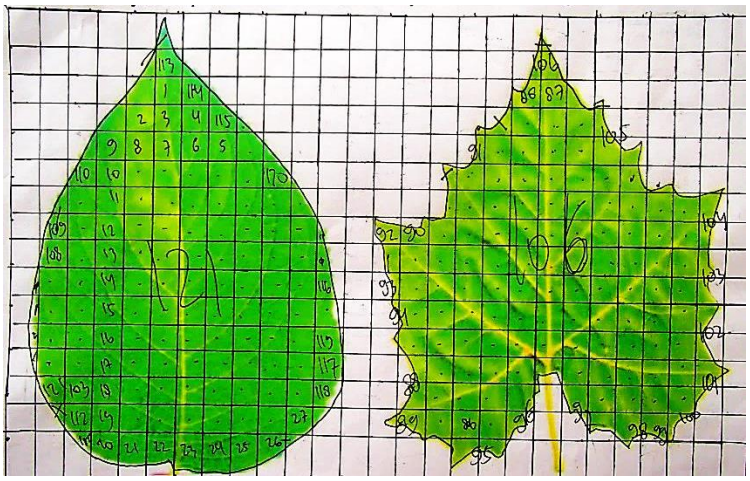


Figure 5.17. Students made squares to measure areas of the leaves

Remark on meeting 5

Since the activities in this meeting are too many, the researcher omitted one activity, estimating area of a carpet. The hints were deleted and replaced them into guided questions in the teacher guides.

6. Meeting 6

Activity 1 Determining area of parallelogram and rectangular building

In the first activity, students had to compare areas of glasses to cover a side of buildings. This activity is aimed to let student derive the area formula of parallelogram. The side first building and the second building are rectangle and trapezoid respectively. Students successfully solved this problem. Students could solve this problem by using two methods used like in the floor problem. Students multiplied the number of glasses on the edges and then multiplied it with the area of one glasses. Students also multiply the number of the glasses on the edges by the length of one glasses to get the length and width. Students also reshaped the parallelogram into a rectangle to find the area (see figure 5.18).

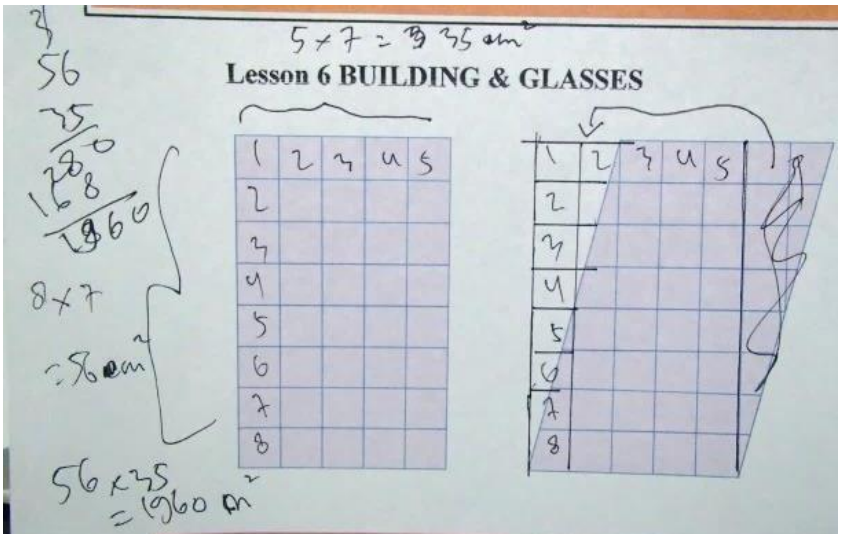


Figure 5.18. Students reshaped the parallelogram building

Student could find the area of parallelogram by reshaping it into a rectangle and concluded the area of rectangle can be used to find the area of parallelogram.

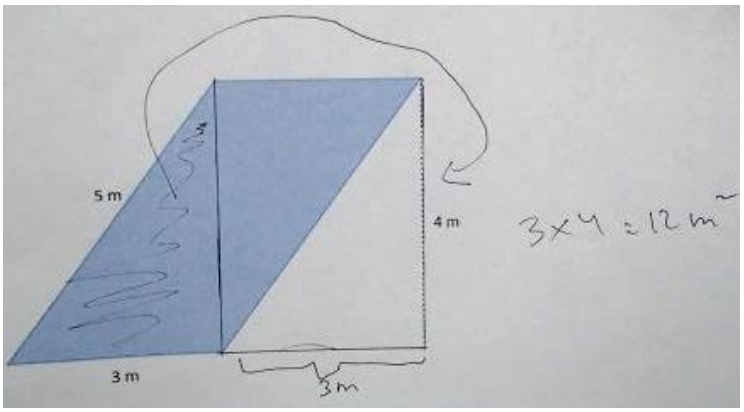


Figure 5.19. Students reshaped the parallelogram into a rectangle

The following segment shows how students could understand why the area formula of parallelogram is derived.

Researcher	: Why is the area of parallelogram base times height?
Dean	: Because, the base? (asking for repeating the question)
Researcher	: Why is the area of parallelogram base times height?
Dean	**: because it is like length times height**
Researcher	: If…?
Dean	**: If it is reshaped into a rectangle**
Researcher	: Do you agree with him?
Students	: Yes
Researcher	: Understood?
Dean	: Nodding
Researcher	: Then, what you did here Gio?
Gio	: Reshaping
Researcher	: If you do reshaping what happens?
Gio	**: the shape changes, the area does not change**

From the segment, we can see that students reshaped the parallelogram into a rectangle and it did not change the area. Therefore, the area formula of rectangle applies also to the parallelogram.

Activity 2 Triangular Building

Students had to determine the area glasses to cover a side of triangular buildings. Students also had to determine areas the shaded triangles inside a parallelogram and a square. This activity is aimed at letting students derived the area of triangle. Students reshaped the buildings to find the areas. Students also

could understand the area formula of triangle can be derived. They reshaped the triangular building into a rectangle and determined the areas.

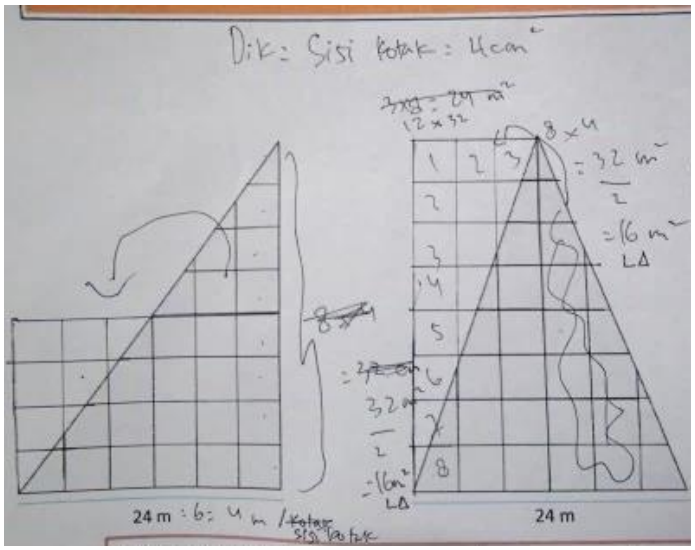


Figure 5.20. Students reshaped the triangular building

In the next problem, students knew the relationship the area of shaded triangle is half the parallelogram. Therefore students could derive the area formula of triangle. The following segment describes how students related the parallelogram to the triangle.

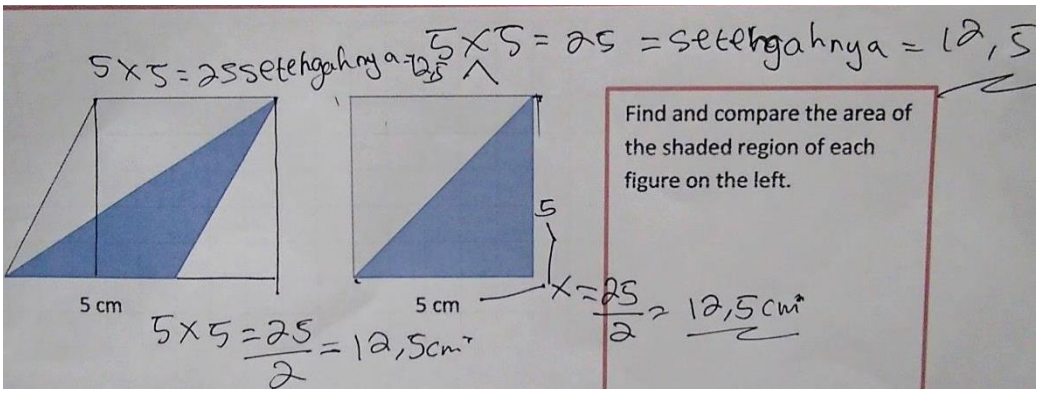


Figure 5.21. Students halved the area of the parallelogram

Students reshaped the parallelogram and measured its area. Students then divided the area of parallelogram by two to get the area of the shaded triangle. It is evidence that students relate the area of the shaded triangle as half the area of parallelogram. Therefore, students could derive the area formula of triangle as in the following segment.

Researcher : Do you know why it is base times height divided by two?
Students : Yes, we know
Researcher : Because of what?
Mesi : **Because of the parallelogram**
Researcher : Because of what?
Mesi : Because a half the parallelogram
Researcher : We know that the area formula of parallelogram is…
Mesi : **Base times height**
Researcher : You understand now, don't you?
Nabila : Yes, I do
Researcher : Do you understand Nabila?
Nabila : Nodding
Researcher : Repeat it again, why the area of the triangle is base times height divided by two
Nabila : **Because a half the parallelogram**
Researcher : What is the area formula of parallelogram?
Nabila : Base times height
Researcher : Why is it base times height?
Nabila : **Because it is just like a rectangle.**

Indeed a lot of efforts (posing guided questions) needed to make students understands. In addition, the shaded area of triangle in the parallelogram could help students to generalize the area formula of triangle.

Activity 3 Trapezoid building

In dealing with the trapezoid building, students successfully find the area of glasses to cover a trapezoid building by reshaping it into a rectangle (see figure 5.22). This activity is aimed at letting students derive the area of trapezoid.

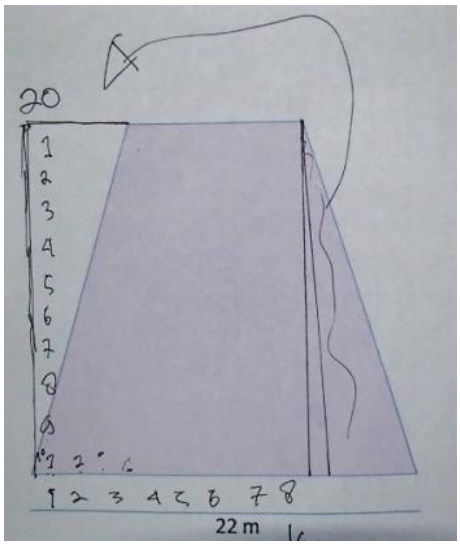


Figure 5.22 Students reshaped the trapezoid building

In dealing with area of trapezoid, most students use the area formula. They still memorized the formula. Students had difficulties explaining the relationship between the formula and the reshaping they did.

This activity seemed to be not successful to derive area formula of trapezoid. However, the reshaping activity for isosceles trapezoid helped students to measure their areas. Therefore, this activity is revised for cycle 2. The trapezoids would be divided into two triangles in order to use the area formula of triangles.

Activity 4 Determining area of rhombus and kite

Students had to determine areas of a rhombus and a kite. This activity is aimed at letting students derive the area formula of rhombus and kite. In dealing with kite and rhombus, students were able to reshape these figures into a rectangle to find the area. Some students have known the formula (1/2 diagonal 1 x diagonal 2). Then the researcher asked students to use to method they know to compare the result of each method. Gio presented his answer and he could understand why the formula can be derived from the area formula of rectangle. He said that the area of rectangle is length x width. He knows that the length is the diagonal 1 and the width is ½ diagonal 2. Other students, Raudy and Mia also could understand how the formulas are derived. To get all students understands to get the formula, the

researcher need a lot of efforts (guided questions). However, they know that if they forget the formula they can reshape the rhombus and the kite.

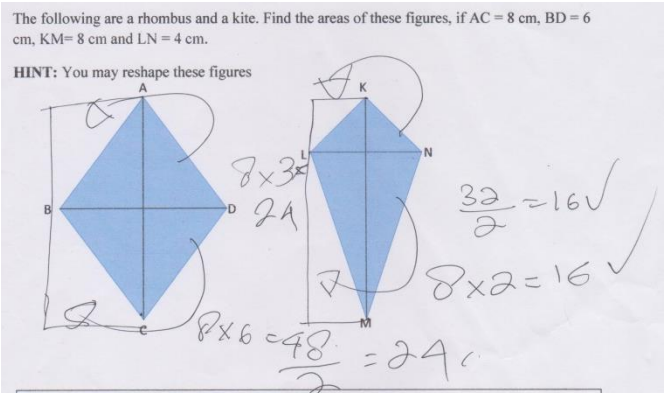


Figure 5.23 Students reshaped the rhombus and the kite

Remark on meeting 6

The activities are split out into two meetings, in meeting 5 and 6. It is due to the activities in meeting 6 were too many to be delivered in one meeting.

5.1.4. Post- test Cycle 1

After about two weeks from the last meeting, students took a post-test (appendix D). The duration of the post-test was longer due to students might have improved their strategies dealing with the problems. In this post-test, the researcher provided the cutting tools.

First item asked students to compare areas of two figures. Students cut and reshaped one figure to make the second one. Some students overlapped and fitted one figure into the second one. It is obvious that students understand how to compare areas of two figures.

In dealing with the second item, students had to determine the area and perimeter of an irregular figure. Students made partitions or made squares on the irregular figure and count the number of squares to find the area. Therefore, students learn how to use square to measure an area in meeting 4 and 5. One student reshaped the figure into a square and measured its area and perimeter. Hence, this student learned the reshaping strategy. Students correctly answer the area of the figure. Students measured the perimeter of the reshaped figure instead

the original figure. Therefore, the next post-test, the question should be the perimeter first to be looked for and then the area. The area will not change if it is reshaped but not the perimeter.

In the third item, students had to compare area of two leaves. All students tried to make squares or grid on the leaves to measure their areas. Hence students had a new strategy to compare area learned from the meeting 5. Students also combined the non-fully squares to make fully squares to measure the area of each leaf.

The fourth item consisted of four problems. Student firstly had to measure areas of a rhombus and a kite. Some students reshaped the rhombus and the kite to measure the area. Hence, students learned the reshaping strategy. Other students directly used the area formula. In solving the isosceles trapezoid, students reshaped this figure into a rectangle and applied the area formula of rectangle. Students also proved it by applying the area formula of trapezoid and resulted in the same answer. The next problem, student had to find the area of a parallelogram and a rectangle. Students reshaped the parallelogram into a rectangle and applied its formula. The last problem, students dealt with the triangles problem. Students reshaped the triangles into a rectangle to determine their areas. Hence, it clear students learned the strategy of reshaping into a rectangle.

5.1.5. Conclusion of cycle 1

Based on the students' work and the discussion during the lessons, we may conclude that overlapping strategy could ignite students' strategy of reshaping. Students also learned that area is inner region since what they compared is the inside of a figure. Meanwhile, reshaping strategy could support students' understanding of the concept of conservation of area. Students understand the when they reshape a figure it would not change its area. Though reshaping activity, students also could differentiate between area and perimeter. Students deepened their understanding of area of rectangle though tiling activities. Students also could make use of the unit of measurement to estimate area. In estimating area, students also applied their knowledge of the concept of conservation of area.

Students also make use the reshaping in dealing with parallelogram floor. Students could derive the area of quadrilaterals by reshaping them into a rectangle. Students reshaped an isosceles trapezoid into a rectangle but it is not easy to derive its formula. Students also reshaped the triangle into a rectangle to find its area. Student also could realize that area formula of triangle is half of the parallelogram of rectangle. To sum up, reallotment activities though comparing and reshaping could support students understanding of concepts of area measurement and how to derive area formulas. However, we still need to revise the instructional activities in the cycle 2. Detail revisions will be on the improvement of the HLT based on the remarks in each meeting.

5.2. Retrospective Analysis of Teaching Experiment (cycle 2)

During the teaching experiment, the researchers tested out the instructional activities and types of instruction in the revised HLT to a real classroom environment. Twenty three seventh grade students from secondary school PUSRI Palembang participated in six meetings and they were divided into seven groups; three to four students in each group. These students and small group students are from different classroom. Before, conducting teaching experiment in cycle 2, the researchers did a classroom observation to know how the teacher teaches and condition in the real classroom. In cycle 2, the home classroom teacher taught the students. Therefore, she cooperated with the researchers to conduct the lessons in each meeting. The teacher and the researcher also had discussions how to deliver the activities based on the HLT and the teacher guide. Before conducting the preliminary teaching, these students did a pre-test lasting for 30 minutes. Six students were interviewed after they finished the pre-test. One day after the last meeting, students took a post-test.

5.2.1. Classroom Observation and Teacher Interview

We observed how the classroom teacher conducts the teaching and learning with the students. The data collected though video recording and notes. The observed classroom is the classroom that will be used to conduct the teaching experiment (cycle 2). Hence, the teacher can conduct the teaching and the learning by reflecting herself and collaborating with the researchers.

a. The classroom activities and the teaching approach

The students were sitting in pair like normally set in Indonesian classroom. There was no group discussion instead of working in pair. From the interview, we found that the teacher rarely organizes students to work in groups or pairs. In making a group, she just let the students who are sitting next to each other. But sometimes, students have to discuss with their friends. When the students were asked to work on the problems in pair, they tended to do it individually. The data analysis reveals that the teacher still tends to use a traditional approach in teaching mathematics. She made students understand the concept at the beginning and then gave exercises. The students did not really have an activity that leads them to find the concept by themselves. However, we found that the teacher is not dominant the classroom. The topic that was being delivered is about angle. To begin the class, the teacher did not give any contexts but just asked students to mention angles in the classroom. However, this did not lead students to explore angles by themselves. There was no any kind of media or tools used during the teaching and learning process. Mostly, the students' activities are doing the problems both on blackboards and in their school books.

b. The classroom and socio-mathematical norms

As mentioned before, the teacher is not dominant. She poses some questions to students and values students' contributions (words, statements, arguments). The teacher asked the angle's definition. Students answered in the same time with different answers. Therefore, the classroom was so noisy. To deal with the crowd, the teacher asked one student to answer and asked to other students. She kept the answer and continued asking some other students. She used students' answers to conclude what an angle is. Mostly, the students responded in choir. However, there was one moment that the teacher asked students to raise their hands before answering.

The teacher gave some problems about measure of angles (converting angles' measurement) and let students solve them. After students solved the problems, the teacher asked other students to confirm the answers whether they are correct or not. The students were so enthusiastic to answer the problems. The

teacher was selective in choosing the students to solve the problem in the blackboard. This is in line with the interview that the teacher gives opportunities to other students to give feedback or responses. She also selects the rarely active students or students who are still confused to solve the problems. The clever students will later do the more difficult problems in the end. When the teacher asked whether students have some questions, the students tend to say no. The teacher had an initiative by posing another problem.

The next activity was solving problems on the students' hand book. The teacher asked students to think the problems that will be difficult for them. Then again, she asked one student to solve it in the blackboard. After solving the problem, the student had to explain what he or she did to solve the problem. The teacher also asked other students whether the solution is correct or not or whether other students agree or disagree with the answer. From the interview, students have to pay attention when the teacher explains or gives information.

c. The teacher' background and point of view of mathematics

The teacher has taught mathematics in secondary level for seven years. She always handles the grade 7 and 9 during her teaching career. We found that the teacher thinks that in learning mathematics, students are able to use the concept to solve daily problems. However, she realizes that it is difficult to do that due to time constraint and many materials in the curriculum. Therefore, it results in in a way of teaching that enables students only to solve mathematical problems. In addition, she puts on important aspects on the goal why students need to learn the topic.

The teacher knows PMRI since 2002 when she was taking her undergraduate. She know that teaching and learning mathematics in PMRI uses contexts, the connection with the real applications, moving from horizontal to vertical mathematization, guided reinvention. She also had involved in a seminar workshop PMRI. However, she never implements PMRI approach in her teaching. She thinks that she has difficulties designing the materials and needs more time to focus on the design. She says that it is possible to implement PMRI approach in her classrooms. She is enthusiastic in collaborating with the

researcher to implement PMRI to teach area measurement of quadrilaterals and triangles. The students' abilities are heterogeneous and close to medium average level. The students are relatively active.

The topic area measurement is just a repetition from the previous levels. Her first experience in teaching area measurement was conventional. She gave the area formulas and then problems or exercises afterwards. She also tried to make an innovation by making students groups. Each group should present a plane figure with its descriptions and properties. She thinks that if students are able to solve mathematical problems in a test or examination, they understand the concepts. She has no idea to teach the concept of conservation of area. However, she thinks it is important to learn the concept. She is confused how to teach the concept. She usually uses a media like the two dimensional shapes provided by the school. She usually teaches area measurement of quadrilaterals and triangles in twelve meetings. In each meeting students learn one plane figure, for instance only a trapezoid. Therefore, within the activities designed by the researchers are suitable to use in her teaching and learning of area measurement of quadrilaterals and triangles.

d. Students' abilities

In the interview with the teacher, the researcher asked about students' abilities related to area measurement. Based on her experience, she rarely gives students to find areas of irregular figures. However, students are able to make partitions to find an area of a compound figure (irregular figure made of regular figures). The teacher usually uses a paper with a parallelogram and cuts its part of one side then pastes it to another side. Since students know the base and the width of a rectangle, then they will now that in a parallelogram the length becomes a base and the width becomes a height. However, she did not tell that cut and paste embed the concept of conservation of area.

In teaching area of triangles, the teacher uses a rectangle or a square divided into two parts through its diagonal. Students will get some triangles such as right-triangles, and isosceles triangles. Students will see that area of one triangle is half of area of the rectangle or the square. From that point, students will

generalize the area formula of triangle; ½ (base x height). Students have to know the height should be perpendicular to the base. Therefore, students did not grasp the area of non-right triangles have the same area formula as the right triangle. In the pre-test cycle 2, we could see students' understanding of area measurement.

5.2.2. Pre-test Cycle 2

Twenty three students took a 30-minute pre-test. The result of the pre-test in cycle 2 is not so much different from the result in cycle 1.

a. Students' understanding of a figure's orientation

All students could compare two figures with different orientations. They rotated the first figure in order to get the same position as the second figure. They easily recognized that those figures have an equal area since the shape is just the same. Most students successfully explained that if the first figure is rotated, the shape is the same and lengths of the respective sides are equal. It could be used to make students understand the commutative law in the floor problem of meeting 4.

b. Justification based on lengths of the sides, the angles, and appearance.

As in the pre-test in cycle 1, students most students were not able to compare a parallelogram and a rectangle with an equal length of the base and the height. They mistakenly judged on the parallelism property, the angles, and the appearance or the look of the figures. One student said that since the sides are parallel, their areas are equal. For instance, since both figures have four angles, they have an equal area.

Most of students, who judged based on the appearance of the figures, concluded that the parallelogram has a larger area than the rectangle. From the interview, one students decided the parallelogram has larger area than the rectangle due to the slant height id longer that the width of the rectangle. In comparing the triangles, students also judged by the edges and the look of the triangles. Most of students could not solve the comparing areas of two figures. Only six students who reshaped the parallelogram into are rectangle to compare their areas. It seems that to some extend they understand when they reshape the parallelogram into a rectangle, the area remains the same.

c. The knowledge of area formulas

In measuring area of parallelogram, only five students applied area formula of parallelogram. The rest only made up their own formulas and also said they forget the formula. Students used all given numbers to make their own formulas. Also some students also mistakenly divided by two when applying base times height to the parallelogram. In measuring the parallelogram and trapezoid, some students made partitions. Students made triangles and made the formulas from the partitions. Student mostly made mistakes when creating their formula. All given numbers were used to create the formula.

In measuring areas of a rhombus and a kite, students mostly applied the formula by multiplying the diagonals and then dividing by two. However, when they were asked how the formula works and where it comes, they did not know because it's the formula they remembered and from the books or the teachers. Students also just multiplied the diagonals to find the area. In solving the triangles problems, students could not solve it because they did not remember the formula. Therefore, if they forget the formulas, they will have difficulties finding the areas of quadrilaterals. Students also have difficulties in determining the height of the triangle because they could not make use the information provided on the picture. Students were accustomed to the given numbers for the height and the base. Therefore, students depended on the full information and they just used the numbers to the formula. A few students could solve this problem. All students still remember the area formula of rectangle and successfully measured the area of a rectangle.

d. The ability to do overlapping

Students did not come up with the idea of comparing two figures by overlapping. It is obvious when they dealt with the leaves problem. Students had to compare two leaves to decide which one gets more sunlight. They tended to judge by using their visual perceptions. If the leaf looks bigger, or wider, it means that it is larger. Students also judged based on the color of the leaves. None students gave a sophisticated explanations to determine the

larger leaf. It seems that in school activity, students never or rarely experienced comparing areas of two figures by overlapped the figures. Therefore, students had no idea to overlap the leaves.

e. The ability to do partition a figure

In dealing with finding an area of an irregular figure, students were able to make partitions to find the area. The area of each partition is added to get the area of the figure. Interestingly, students partitioned the irregular figure into some squares or rectangles and added each area of the square or rectangle. Students also tried to make partitions on the trapezoid to measure the area. To some extends, students know that the sum areas of the partitions is the area of the complete figure. To measure area of trapezoid and parallelogram, some students have tried to make partitions such as triangles and rectangle. However, students still make mistakes in determining the length of the edges in the partitions and resulted in a wrong answer.

f. The ability to do reshaping

Only six students who reshaped the parallelogram into are rectangle to compare their areas. It seems that to some extend they understand when they reshape the parallelogram into a rectangle, the area remains the same. Therefore, when this students work with others students, they could share this strategy in the group discussion.

g. The understanding of standard unit measurements

From the students' work and the interview, students do not understand why the standard unit measurement is in square such as cm^2, and m^2. Students use single power in the unit measurement; cm, m. They think that the figure is not a space figure and think that the cm^2 and m^2 are used for space figures. In addition, since students used the wrong formulas or made their own formulas to find areas, it leads to the wrong standard unit measurement. For instance, when the use the wrong area formula of parallelogram (½ *base* x *side* x *height*), they use all given numbers to fit the formula. It resulted in the wrong unit measurement in area; in cubic.

5.2.3. Teaching Experiment Cycle 2

1. Meeting 1

Activity 1 Comparing Leaves and Rice Fields

In this activity, students dealt with comparing two leaves and two rice fields. In group, students had to determine which leaf getting more sunlight and which rice field having more crops (see figure 5.24). This activity is aimed at letting students understand that overlapping strategy can be used to compare areas, an irregular figure still has an area, and an area is region inside of the boundary.

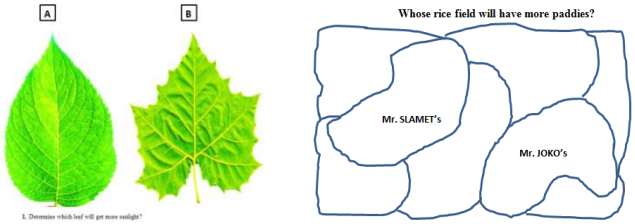
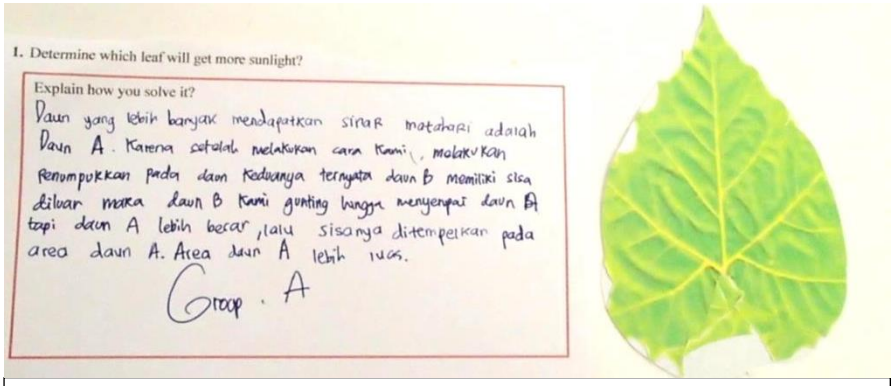


Figure 5.24 Leaves problem and rice fields problem

At first, the teacher did not provide any cutting tools and glue. The teacher asked students to understand the problem and what they would do to the leaves. After students understood what to do, the teacher provided scissors and glue. The following segment shows that students would overlap the leaves and the rice fields.

Teacher	: To compare two areas to find the larger area, what is your strategy? What will you do? Do you want to look at them only? If you just look at them, can you find the larger area?
Prizqa, Hasbi	: No, we cannot
Teacher	: What can only you do now?
Hasbi	: Cut them
Teacher	: Cut them, ok, do it. After cutting them, what will you do?
Alif	: **Compare them**
Hasbi	: **(showing his hands overlapping)**
Teacher	: How to compare them?
Hasbi	: **(showing his hands overlapping)**
Alif	: **Put them close**

From the transcript, it is evidence that students came up with an overlapping strategy to compare two areas after cutting the leaves from the worksheet. Students said that they will cut the leaves and compare them. Therefore, to support their ideas, the teacher allowed them to cut the leaves and provided with cutting tools. As conjectured, students overlapped the leaves. After students overlapped the leaves, they glued them together and cut non-overlapping parts of leaf B in order to fit the leaf A. The following figure shows students' work.



Group A
The leaf that gets more sunlight is leaf A, because after we did our strategy; overlapping the two leaves. In fact, parts of leaf B exceeded leaf A, and these parts were cut in order to make it similar to leaf A, but leaf A is bigger. The cut-parts were glued (pasted), area of leaf A is larger.

Figure 5.25. Students overlapped, cut and glued the leaves

Group B also has the same strategy as Group A. This following figure explains their argumentations in solving the problem.

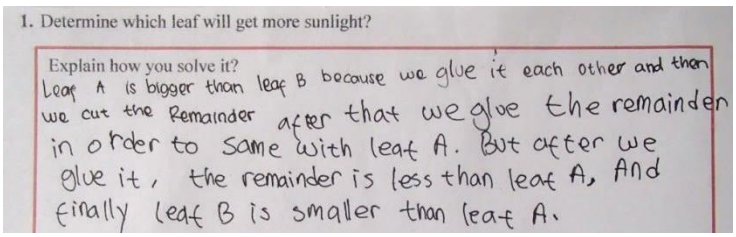


Figure 5.26. Group B explanation on leaves problem

From two students' work, it is clear that students overlapped the leaves and cut the non-overlapping area of leaf B and pasted them to fit leaf A. This is in line

with the conjectures on HLT; students would overlap and cut the leaves. They found that leaf A is larger because leaf B cannot fit leaf A.

In dealing with the rice field problem, students solved this problem in groups. Most of students used the same strategy as used to solve the leaves problem. This is in line with the conjecture on HLT. Students cut Mr. Slamet's rice field and Mr. Joko's rice field from the provided worksheet. They overlapped them and cut the non-overlapping parts of Mr. Joko's rice field to fit Mr. Slamet's rice field or vice versa. This following figure shows student's work.

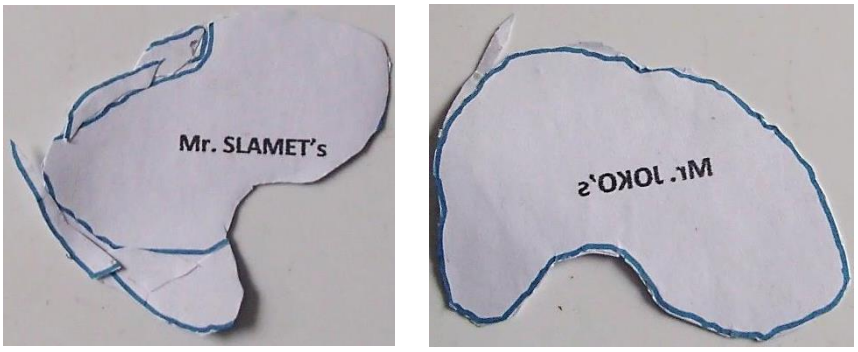
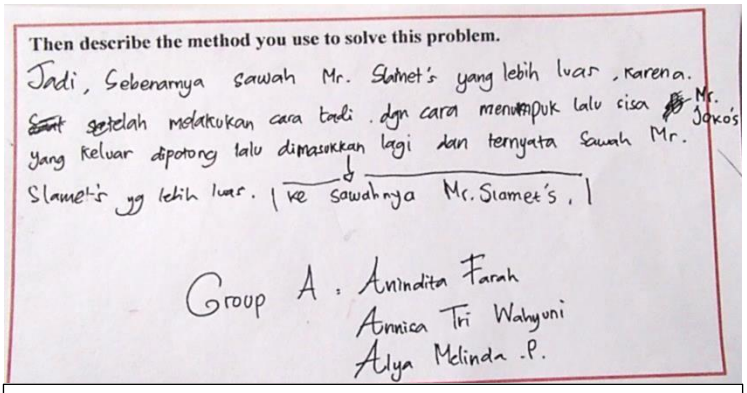


Figure 5.27. Students overlapped, cut, and pasted rice fields



So, the truth is that Mr. Slamet's rice field is larger because after we did the same like on the leaves; by overlapping, cutting the exceeding parts of Mr. Joko's and pasting these parts on Mr. Slamet's . At the end, in fact, Mr. Slamet's is larger.

Figure 5.28. Group A's explanation in rice fields problem

From figure 5.27 and 5.28, students in Group A knew that Mr. Slamet' rice field is larger because Mr. Slamet's rice field fit Mr. Joko's rice with leftover or

remainder. On the figure 5.28, students made mistake by wrongly writing "*cutting the exceeding parts of Mr. Joko's and pasting these parts on Mr. Slamet's*" what they did is they cut the exceeding parts of Mr. Slamet's and pasting these parts on Mr. Joko's (figure 5.27). Mr. Joko's rice field was not cut. Students did not get used to write their explanations. Their time was also limited; therefore the names of the owners of the rice fields were used incorrectly. However, their strategy and answer are correct.

Interestingly, Group B overlapped Mr. Slamet's rice fied onto Mr. Joko's rice field. This group cut the non-overlapping parts of both rice fields and got an overlapping part. They compared the cut-parts of Mr. Slamets with cut-parts of Mr. Joko's. As they found that the cut-parts of Mr. Slamet's is larger than the cut-parts of Mr. Joko, this group concluded that Mr. Slamet's rice field is larger. Their strategy was not predicted in HLT. But this group also resulted in the correct answer that Mr. Slamet's rice field is larger than Mr. Joko's rice field.

In the discussion, Group B also presented their work on the rice field problem. The following segment tells about how this group solved this problem.

Hasbi	: Based on our group (Group B), the rice fields were cut (from the worksheet) and glued them together (overlapped) and cut the non-overlapping parts and it results in…
Researcher	: A same shape?
Hasbi	: (nodding)
Hasbi	: **The largest rice field is Mr. Slamet's**
Researcher	: Why?
Hasbi	: **Because the cut-parts of Mr. Slamet's rice field is bigger**

Hasbi explained the strategy used to compare areas of the rice fields. As mentioned before, that this student made the same figure of overlapping part and cut the non-overlapping area of each rice field. He compared the non-overlapping parts called as the cut-parts. He knew that the cut-parts of Mr. Slamet's rice field are bigger. Therefore, he knew that Mr. Slamet's rice field is larger.

The second activity was not done because of the limited time in this meeting. Therefore, the teacher and the researcher decided to let students discuss

their work and made the second activity as homework. There were two groups presented their work in the class discussion. Both groups have the same strategy in comparing the leaves. The following segment shows the class discussion on how students explain their work.

Prizqa : From Group B, we think that leaf A is bigger than leaf B because when we cut and glued them (bell ringing)
Teacher : It's okay tell us a little more
Prizqa : **We glued (overlapped) the leaves (showing how they do it) and cut the exceeding parts**
Dwi : **And we pasted the cut-parts**
Teacher : Okay, so it is similar to Raflay's group and the answer, which one is larger?
Prizqa : **A, the leaf A because there are some spaces on it.**

It is clear that students applied overlapping strategy and cut the non-overlapping parts of the first figure and pasted them in order to fit another figure. Students understand that if one figure cannot fit another one by leaving some spaces then the second figure is larger.

In the end of this meeting, the teacher and students made conclusions. The following segment tells how they could understand an irregular figure has an area.

Teacher : Are the shapes of the leaves and the rice fields regular or not?
Students : No, they are not
Teacher : But they have…., what did you look for? Was it width, area, or else?
Students : Area
Teacher : Area, they have areas, **even though their shapes are irregular, they still have areas.**

It shows that students also could understand that irregular shapes still have areas. In addition, students could compare two figures to compare their areas by overlapping. They could overlap the leaves and the rice fields to compare their areas. Therefore, the teacher posed some questions and let students continue the teacher's statements.

Teacher : To compare two areas, what did you do**? What can you do to compare areas?**
Students : **Cutting and overlapping**

The teacher gave an opportunity to students to say it by their words. They still did not used to make conclusions.

Teacher	: Is there anyone who wants to repeat what we just conclude the first, the irregular figure still has …?
Rafly	: Area
Teacher	: After you cut and paste, what happens to the area?
Students	: The same, remains the same
Teacher	: Is an area a region inside or in the boundary?
Students	: Inside
Teacher	: An area is a region…?
Students	: Inside

In conclusion, the comparing activity led students to overlap the leaves and the rice fields. By providing cutting tools and glue, it helps students to ignite this strategy. This activity also led students to cut and paste in order to fit one leaf into another one and to fit one rice field into another one. In line with the strategy used by ancient mathematician in comparing areas, students overlapped one figure into another one, cut and pasted the first figure to fit the second one. This activity could invite students to use overlapping strategy, cut and paste to compare area. By comparing areas, students get insight that an area is a region inside not in the boundary because they compare the inside parts of the leaves and the rice fields. Students grasped the concept of conservation of area through cutting and pasting. Therefore, the goals of this meeting were achieved.

2. Meeting 2

As one activity could not be done in the first meeting due to the limited time, student had this activity as homework. In this activity, students had to determine the rice field that will get more crops (figure 5.29). There are two rice fields, one belongs to Mr. Slamet and another one belongs to Mr. Joko. These farmers argue about who will get more crops from their rice field. Logically, the more area the more paddies can be planted. This activity is aimed at letting students grasp the idea of unit of measurement. In this case, the units of measurement are dots as new paddies.

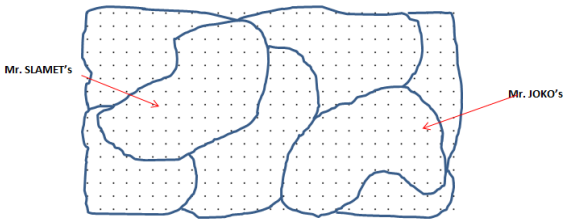


Figure 5.29. The dotted rice fields problem

The problem is similar to the rice field problem in the previous activity. In addition, the rice fields now had new paddies as dots. This meeting, students presented their homework. As, conjectured, most of students counted the dots one by one to compare the number of dots in each rice field. It seems that it is the easiest way to compare the areas of the rice fields.

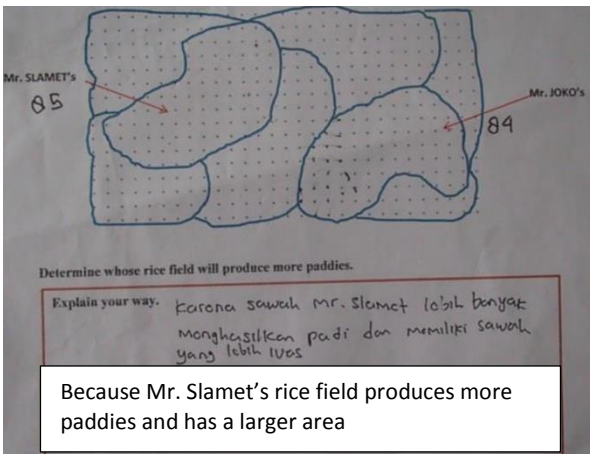


Figure 5.30. Student counted the number of dots

From the figure above, this student counted the dots one by one because he marked the dots by his pen. Another student also used strategy conjectured in HLT (figure 5.31).

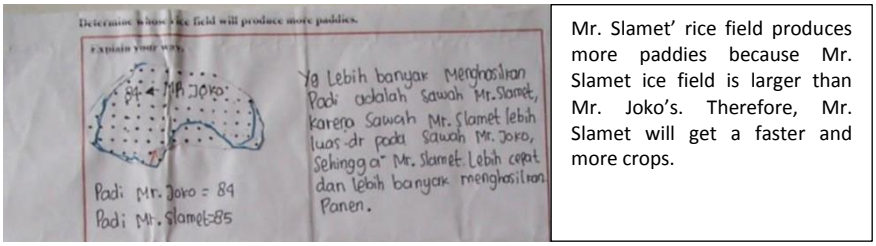


Figure 5.31. Grenaldy overlapped and counted the dots

From figure 5.31, Grenaldy overlapped the rice fields and cut Mr. Joko' rice field to fit Mr. Slamet. However, the researcher only predicted that students would overlap the rice field without fitting them. It is not predicted in HLT that he used the overlapping strategy and cut-paste one rice field to fit another one. The researcher conjectured that students will just overlap without cutting and pasting. It seems that overlapping, cutting and pasting strategy are strong strategies to compare areas. After fitting Mr. Joko's rice field into Mr. Slamet's rice field. Grenaldy counted the dots in overlapping area (Mr. Joko's) is 84 and 1 more dot in the non-overlapping area (belongs to Mr. Slamet's). Therefore, Grenaldy found that Mr. Joko's rice field and Mr. Slamet's rice field have 84 paddies and 85 paddies respectively.

Only one student who solved this problem by making squares on the rice fields.

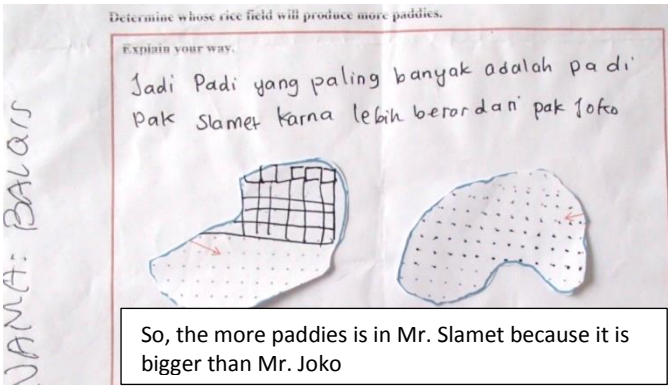


Figure 5.32. Balqis made squares on the dotted rice field

She said that it is a faster way to count the dots. Her strategy was conjectured in the HLT. The following segment tells how Balqis gave her explanation.

Teacher : Here, Balqis will explain her strategy, she made some squares, I do not understand what it means, so please Balqis, tell us why you made squares, what is your intention?
Balqis : To get a faster way
Teacher : Please pay attention to Balqis! What is your reason (Balqis)?
Balqis : **To get a faster way**
Teacher : In order to get a faster way to count the dots, then you?
Balqis : **Made squares**

It could be that she firstly counted one by one because from the right side rice field (Mr. Joko's) has some pen marks of counting one by one. Therefore, she might think of a faster way to count the dots by making squares to compare.

From the students' work, it is evidence that students compare the number of paddies (dots) in the rice fields. They counted the dots located inside the rice fields (Mr. Joko's and Mr. Slamet's). It seemed that overlapping strategy became a powerful strategy to compare areas even one student still do this strategy. It is also evidence that to some extents students tried to make squares units to compare areas. It can be concluded that some students grasped the idea of unit of measurements to compare areas by using the dots.

Activity 1 Transactional Deal

The teacher delivered the worksheet and asked students to understand the problem. The problem is about transactional deal. This activity is aimed at letting students understand the concept of conservation of area. There is a farmer's rice field near two factories will be exchanged by a factory owner (figure 5.33). There are six options offered by the factory owner. Students had to decide which rice field that can fairly exchange the famer's rice field. The teacher helped students to understand the problem since they still have difficulties solving contextual problem like this. Some students came with an idea of area.

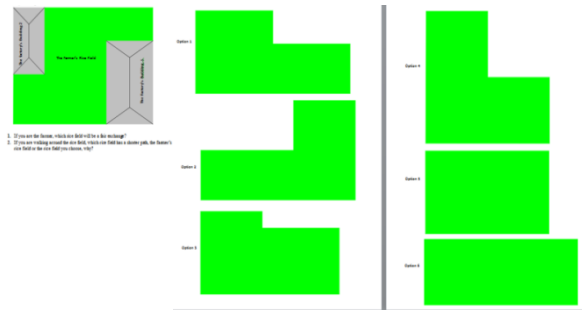


Figure 5.33. The farmer rice field and the six options

The teacher provided students with scissors, glue, strings, needles and styrofoam. Students came up with an idea of cutting the rice fields and overlapping the famer's rice field into the options or vice versa. All students chose option 1 and 3 that fit the farmer's rice field (figure 5.34).

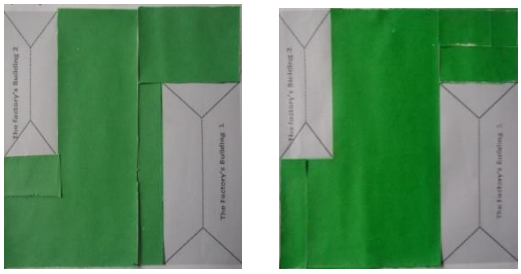
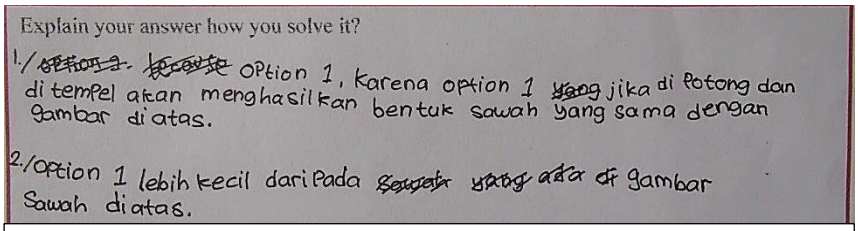


Figure 5.34. Students' fitted rice fields with option 1 (left) and option 3 (right)

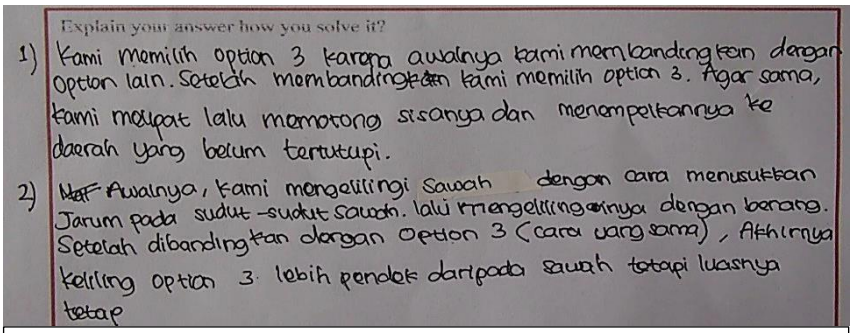
From the students' work, it is clear that they could fit the option 1 and 3 into the farmer rice field. They overlapped, cut and paste option 1 and 3 to fit the farmer's rice fields. Before they found the option 1 and 3, they tried other options by overlapping them into the farmer' rice field.



1. Option 1, because option 1 if it is cut and pasted will produce a shape which is similar to the figure above.
2. Option 1 has lesser (string) than the figure above

Figure 5.35. Group A's explanation in choosing option 1

Another group chose option 3 as their solution. The following figure shows how Group B solved this problem.



1. We chose option 3 because initially we compared it with other options. After comparing, we chose option 3. To fit it, we flipped and cut the remainders and pasted again to cover the uncover parts.
2. Initially, we walked around the rice fields by putting needles on the rice field corners and using the string. After we compared with option 3 (using the same strategy), finally the perimeter of option 3 is shorter than the farmer's rice field but the area remain the same

Figure 5.36. Group B's explanation in choosing option 3

Based on their explanations, students cut and pasted option 1 and 3 to fit the farmer's rice field. In dealing with the perimeter, students answered that options they chose have shorter or lesser perimeter than the farmer's rice field. They used needles on the styrofoam to put the rice fields and strings to compare the perimeters. As conjectured, students used one string to measure the perimeter of the rice fields. The string used to measure the perimeter of the chosen option is not enough to measure the perimeter of the farmer's rice field. Therefore they could conclude that the perimeter of the chosen option is less than the perimeter of the farmer's rice field.

Another strategy conjectured in revised HLT is that students used two strings. One string was used to measure the perimeter of the chosen option and another one was used to measure the perimeter of farmer's rice field. They compared the strings and found that the string to measure the chosen option is lesser than the string of the farmer's rice field. Hence, students concluded that the perimeter of the chosen option is lesser than the perimeter of the farmer rice field. The following segment shows how students used one string to compare the perimeters.

Teacher : Just tell and explain to us, you do not need to do it again. What you did is…
Sherly : We measured option 1, the string is this long
Teacher : Option 1 is that long, how about the farmer's rice field
Sherly : It's not enough (measuring the farmer rice field with the string)
Teacher : Firstly, you get this, how long?
Safira : This long (showing the string)
Teacher : Then?
Sherly : We use this to measure the...
Teacher : With the same string (helping students to continue)
Safira : **With the same string we measured this** (pointing the farmer's rice field)
Teacher : What is the result?
Safira : It's different
Adin : This is shorter (pointing option 1)
Safira : **That (pointing option 1) is shorter than this (pointing farmer's rice field)**

From the transcript we can see that students used one string to compare the perimeter of option 1 and farmer's rice field. By using this strategy they could conclude that the perimeter of option 1 is shorter than the farmer's rice field.

In the classroom conclusion, the teacher and students concluded together what they have learned. The teacher asked one student to voluntarily give the conclusion. The following transcript tells how this student understands the concept of conservation of area.

Anisa : **Even though their shapes are different**
Teacher : After cutting and pasting, they…?
Anisa : **They have an equal area**
Teacher : But, do they have the same perimeter? The one you chose and the farmer's rice field
Anisa : (confused with the question)
Teacher : You measured that right, so?
Anisa : It's not equal, it's different
Teacher : It's different, therefore **when we reshape what does remain the same?**
Anisa : **The area**
Teacher : **What does change?**
Anisa : **The perimeter.**

From this point, Anisa understands that even though the shapes are different, after reshaping the rice field still has the same area but not the perimeter. Interestingly, one student, Rafly, asked a question related to area and perimeter. He asked why figures with an equal area have different perimeter. The following segment explains how this question was answered by the teacher.

Teacher : To all students, when the three different shapes (rice fields) were reshaped, cut and pasted, what happens to their areas?
Students : Equal
Teacher : It remains the same, or equal, but how about the perimeter?
Students : It's different
Teacher : Is it the same when you measured them with the string?
Students : No, it's different
Rafly : Mom, may I ask a question?
Teacher : Yes, please Raflay
Rafly : **Why do they have equal area but have different perimeter?**

Teacher	: Please repeat it again?
Rafly	: **Why do they have equal area but have different perimeter?**
Teacher	: Because they have different shapes. **What does an area mean in the previous meeting?**
Adin	: **Inside parts**
Teacher	: If the inside parts are moved and pasted (showing by hands), does the area change when we move to this, this, and this (showing by hands)
Wafiq	: No, It does not
Teacher	: It means the area…
Rafly and others	: **Remains the same**
Teacher	: The area will remain the same, but how about the perimeter? Which part did you measure?
One student	: **Outer parts**
Teacher	: Outer parts, what part is that? It is the edges, right? For instance, Mom changes the shape like this (showing hands), is the perimeter different?
Students	: **It's different**
Teacher	: Because they have different shapes. Because the area is inside region so that if we reshape it, it remains the same. But the perimeter is outer part, Ok, do you now understand Raflay?
Rafly	: Yes, I do Mom

From the segment above, a few students still wonder why the area remains the same but not the perimeter after reshaping the figure. By having a class discussion and conclusion, it makes clear to students why this concept of conservation of area works. The main focus on learning this concept is that the area is preserved when it is reshaped. Students' understanding of this concept will help them to reshape quadrilaterals into a rectangle to find their areas and derive their area formulas.

Some conclusions can be derived from this meeting. Firstly, students are able to compare areas by overlapping. Secondly, students understand the concept of conservation of area. It is true that cut and paste activities could help students to understand the concept of conservation of area. Cutting and pasting help understand this concept. Lastly, students understand the difference between area and perimeter. Due to the time limitation, the second activity could not be carried

out in this meeting. Therefore, students got the second activity as homework. In the third meeting, students would collect their work and present their work.

Meeting 3

Before students began the activity in the third meeting, they had to present and collect their homework. The homework is to reshape quadrilaterals (parallelogram, rhombus, trapezoid and kite) into a rectangle. This activity is aimed at deepening the concept of conservation of area. Some students really cut and pasted the quadrilaterals to make them into a rectangle. Some students also just shaded and made some arrows to make a rectangle from the quadrilaterals (figure 5.37). The different ways of reshaping were presented by students.

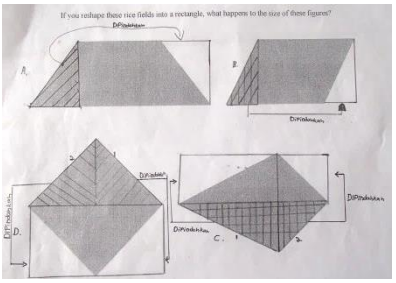
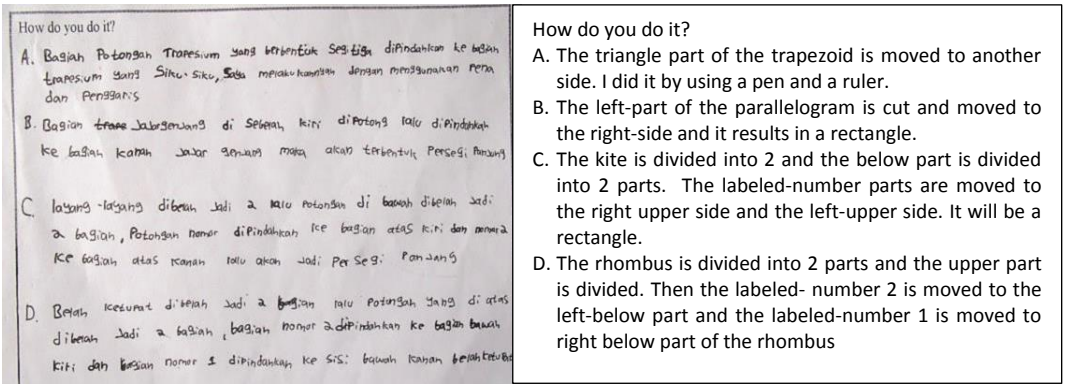


Figure 5.37. Adin drew arrows to reshape the quadrilaterals

From the figure above, this student, Adin, shaded the part(s) that will be moved in order to make a rectangle. He drew arrow(s) to move the shaded part(s) into some spaces in the designed rectangle. He could also explain his way through his writing. The following figure explains how Adin explain his way in writing.



How do you do it?

A. Bagian Potongan Trapesium yang berbentuk Segitiga dipindahkan ke bagian trapesium yang Siku-Siku, Sisi mencakupkannya dengan menggunakan pena dan penggaris

B. Bagian ~~trapesium~~ Jajargenjang di sebelah kiri dipotong lalu dipindahkan ke bagian kanan jajar genjang maka akan terbentuk Persegi Panjang

C. layang-layang dibelah jadi 2 lalu potongan di bawah dibelah jadi 2 bagian, Potongan nomor 1 dipindahkan ke bagian atas kiri dan nomor 2 ke bagian atas kanan lalu akan jadi Persegi Panjang

D. Belah ketupat dibelah jadi 2 bagian lalu potongan yang di atas dibelah jadi 2 bagian, bagian nomor 2 dipindahkan ke bagian bawah kiri dan bagian nomor 1 dipindahkan ke sisi bawah kanan hingga terbentuk

How do you do it?

A. The triangle part of the trapezoid is moved to another side. I did it by using a pen and a ruler.
B. The left-part of the parallelogram is cut and moved to the right-side and it results in a rectangle.
C. The kite is divided into 2 and the below part is divided into 2 parts. The labeled-number parts are moved to the right upper side and the left-upper side. It will be a rectangle.
D. The rhombus is divided into 2 parts and the upper part is divided. Then the labeled- number 2 is moved to the left-below part and the labeled-number 1 is moved to right below part of the rhombus

Figure 5.38. Student's explanation in reshaping the quadrilaterals

Interestingly, one student, Anisa, just drew some figures to explain how she made a rectangle from the quadrilaterals (see figure 5.39). She made steps how to make the rectangle. She did not really cut the figure but used her drawing to reshape the quadrilaterals. It seems that some students could reshape quadrilaterals into a rectangle without really cutting and pasting. It seems that students move to more abstract way to reshape.

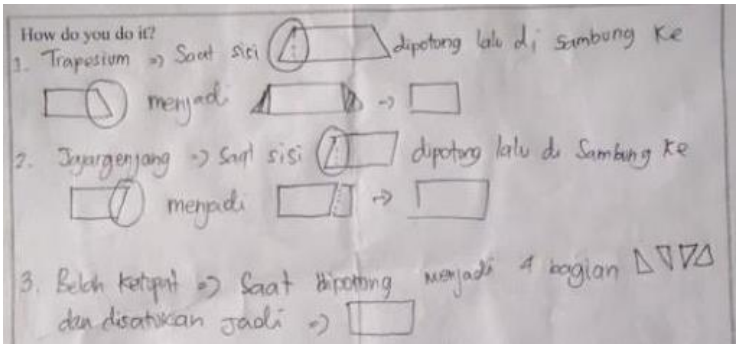


Figure 5.39. Anisa drew the steps of reshaping

They could just make some arrows or steps to reshape quadrilaterals into a rectangle. After students presented their work, together with the teacher they made conclusions as the following:

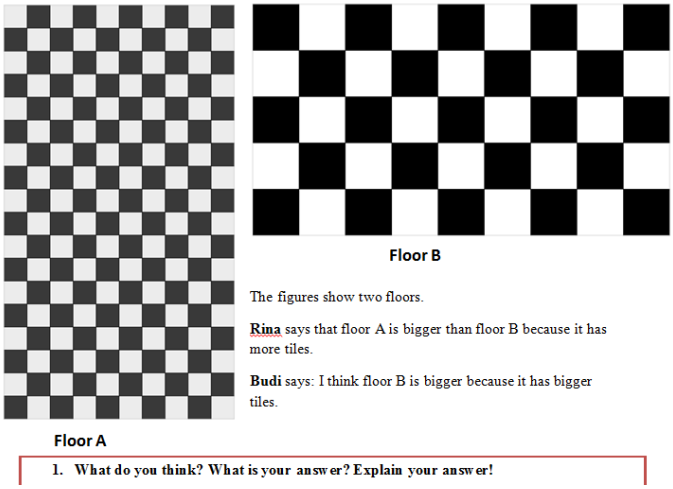
Teacher : Now, the question is, based on what we have learned in previous two meetings, if we reshape an initial figure, trapezoid into…?
Adin : A rectangle
Teacher : A rectangle (repeating)
Teacher : Did you throw away some parts?
Students : No
Teacher : You did not. Now, the question: Is the area of the trapezoid equal area to the area of the rectangle you made?
Adin : Yes
Teacher : **Equal or not**
Students : **Equal**
Teacher : Are you sure that they are equal?
Students : Yes
Teacher : If it is equal, for instance, you have a problem to determine an area of a trapezoid, we know that most of you forgot what the formula is, can we use the area formula of rectangle to find an area of a trapezoid
Adin : Yes, we can, we can, we can

Teacher : Can we use it?
Students : Yes
Teacher : **Why can we use it?**
Student : **The area is equal**
Teacher : Why?
Students : The area is equal
Teacher : The area is equal (agreeing). Then, if we forgot area formula of trapezoid, we can use the area formula of…?
Teacher : Rectangle
Adin : Rectangle
Teacher : What is the reason? The area is equal. Which one is easier to remember, the trapezoid or the rectangle?
Students : The rectangle
Teacher : Do you still remember the formula?
Students : Yes. Length times width
Teacher : What?
Students : Length times height

From the segment above students could understand that they can use the area formula of a rectangle to find an area of a quadrilateral (trapezoid). They can use it because the area of trapezoid after it is reshaped into a rectangle is equal. They understand the concept of conservation of area. The area of the trapezoid remains the same after reshaping it into a rectangle. Most students also still remember the area formula of rectangle; length x width. It is really helpful because students do not have to memorize all the formula.

Activity 1 Tiled Floors

In this activity students will compare two tiled floors. The floors have different sizes of tile. Floor A has bigger tiles than floor B (see figure 5.40). This activity is aimed at refreshing students' knowledge of area formula of rectangle by using unit of measurement. In this case, the unit of measurement is a square tile. This activity is also aimed at supporting students' understanding of the use of unit of measurement in comparing area. It will be useful to students when they estimate an area of irregular figure.



Floor B

The figures show two floors.

Rina says that floor A is bigger than floor B because it has more tiles.

Budi says: I think floor B is bigger because it has bigger tiles.

Floor A

1. **What do you think? What is your answer? Explain your answer!**

Figure 5.40. Problem 1 comparing tiled floors

As conjectured, most of students realized that one tile of floor B is equal to four tiles of floor A. Therefore, students could compare the areas of the floors by comparing the number of tiles they have. Students finally found that both floor have an equal number of tiles.

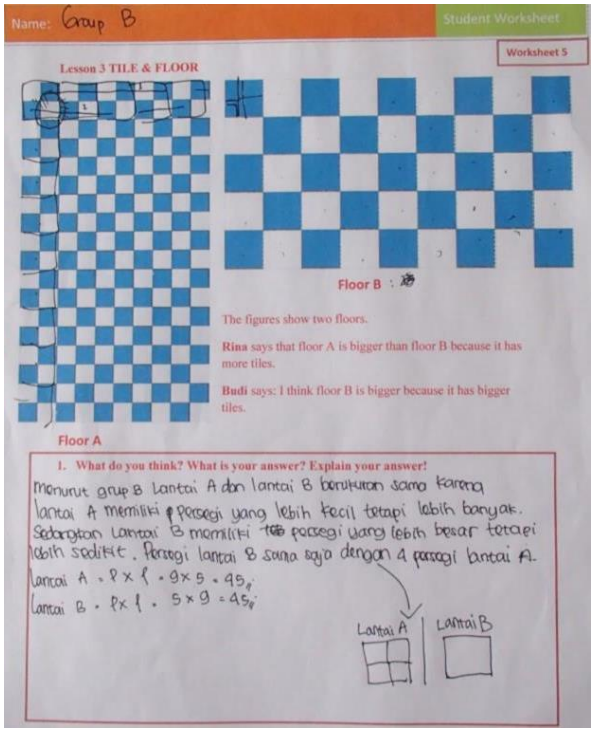
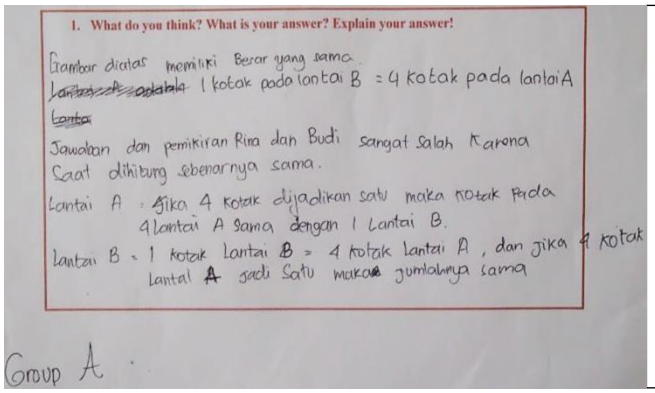


Figure 5.41. Group B's work on tiled floor

This group concluded that floor A and floor B have an equal size. A square (tile) in floor B is equal to four squares in floor A. Therefore, both floors have an equal area, which are 45 bigger squares (tiles). Another group, Group A, solved in the same way as Group B



Those floors above have an equal size. 1 square of floor B = 4 squares of floor A. Therefore, Rina's and Budi's answers are really incorrect because we found the floors have an equal size.
Floor A: if 4 squares is united in floor A, it equals 1 square in floor B.
Floor B: 1 square of floor B = 4 squares of floor A, and therefore they have an equal number of squares

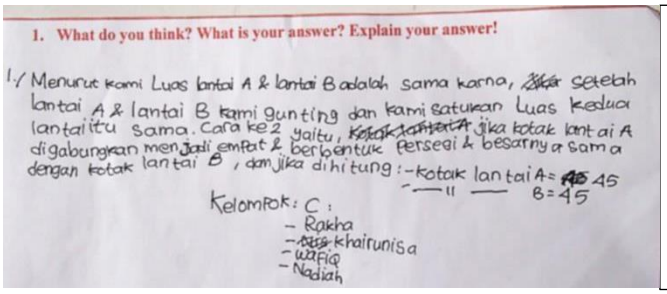
Group A

Figure 5.42. Group A' explanation on the tiled floors problem

From the students' work, it is clear that students realized that one tile of floor B is equal to four tiles of floor A. Students also converted the tiles of floor A into tiles of floor B. They found a same result 45 bigger tiles. It seems that using different sizes of tiles could lead students to think of the same unit to compare. In counting the number of tiles, students directly used multiplication strategy. They multiplied the number of tiles in the first row with the number of tiles in the last column. However, students did not really understand why this strategy works. Therefore, in the class discussion, the teacher led students to understand how the multiplication strategy works.

Interestingly, one group did differently in comparing the area of the floor. Group E cut the floors from the worksheet and overlapped them. It seemed that when they overlapped the floors, it did not fit perfectly due to the cutting process. Therefore, students also measured the length and the width of each floor with a ruler and calculated the areas. More interestingly, since they used a ruler, they made an error. They resulted in different sizes of the floors. Floor A and B have an equal width but not the length. Floor A and floor B have 10.9 cm long and 11 cm long respectively.

In a case that students cut the floors neatly, Group C could overlap the floors perfectly. This group solved this problem with two different strategies. Firstly, they cut the floors out of the worksheet and overlapped them. Secondly, they compare the tiles, one tile of floor B is equal to for tiles of floor A.



1./ We think that floor A & floor B is equal. After we cut floor A and floor B and overlapped them, both floors are equal (in area). The 2nd strategy is that if four squares of floor A are combined, it will be a square that has an equal size of a square of floor B. If we count it: squares in floor A = 45, squares in floor B = 45

Figure 5.43. Group C's explanation on the tiled floor problem

Activity 2 Cfvvvvhjjjomparing floors by tiling

In this activity, students worked individually. They had to compare areas of floors from a given tile (figure 5.44). This activity is aimed at supporting students' understanding of unit of measurement and the area formula of rectangle.

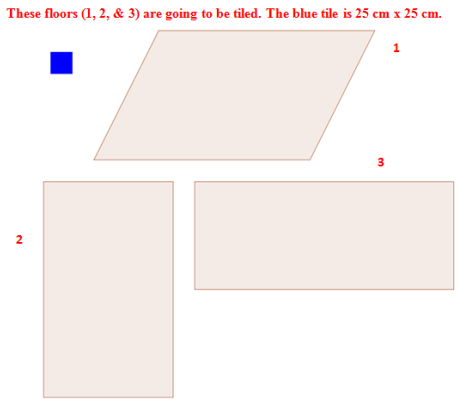


Figure 5.44. The problem of tiling floors

Students solved this problem in different ways. Some students only marked some tiles on the edges of the floors. Some students drew all tiles on the floors. The following figure shows how students solved this problem.

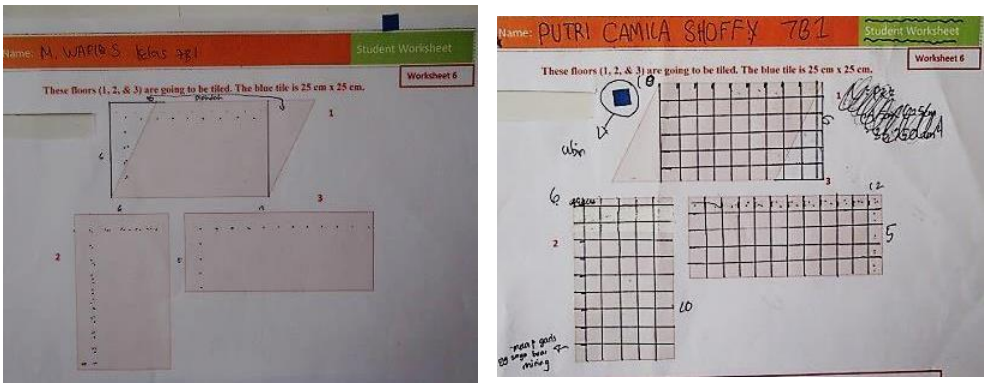


Figure 5.45. Students' work on tiling floors

Students used the area of one tile, 25 cm x 25 cm to make marks or lines. Prizqa drew some lines based on the size of one tile (see figure 5.46).

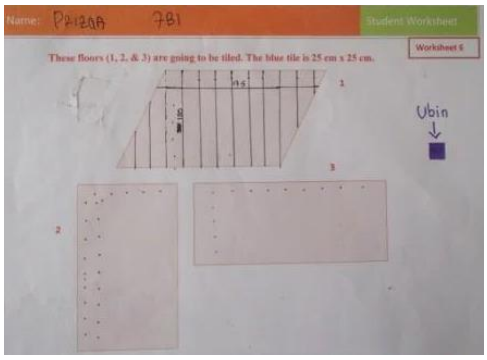


Figure 5.46. Prizqa strategy in tiling the floors

Her strategy was conjectured in revised HLT. She found that the base and the height of the parallelogram are 10 tiles and 6 tiles respectively. Therefore she found the area of the parallelogram floor by multiplying the base with height (the number of tiles) and with the size of one tile. In determining the area of the rectangular floor, Prizqa only made some marks on the edges of the floors. In a similar way, she found the area of each rectangular floor by multiplying the number of the tiles with the size of one tile. However, she resulted in incorrect answer in floor 3. She mistakenly made unequally distances in her marks. As we can see from her work, in making marks in floor 2, she tried more than one. But in floor 3, she just marked once without rechecking it again.

Another student, Adin, reshaped the parallelogram floor into a rectangle. His strategy was conjectured in revised HLT. He then marked the edges of the floor by using a bigger tile, used in the previous problem (figure 5.47).

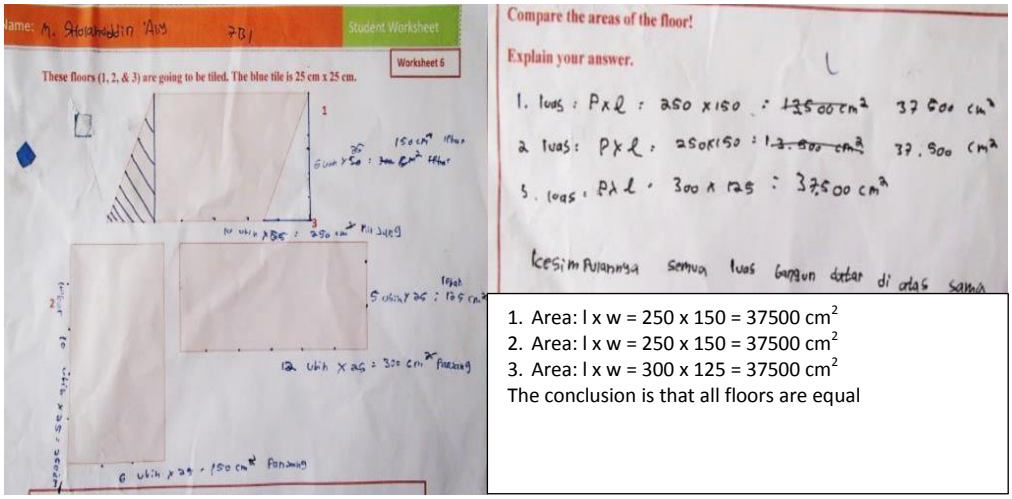


Figure 5.47. Adin strategy in tiling the floors

He knew that the size of the bigger tile is twice the tile used in this problem. Adin found the area of each floor by applying the area formula of rectangle. He firstly determined the length and the width of each floor by multiplying the number of tiles in that length and width with 25 cm. For instance, the parallelogram has 10 tiles in its edge; the length is 10 x 25 cm, or 250 cm. He successfully found the area of each floor and gave a correct conclusion.

Students made mistakes when they put the tile on the floors. They drew the tiles improperly. Therefore, they resulted in different number of tiles in their work. In the class discussion, the teacher explained why this happened. She told students that they were not careful in drawing the marks. She also told students that their strategy is correct.

In the end of this meeting, the teacher orchestrated a class discussion. Selected students presented their work. They (Prizqa and Adin) were selected because they had different strategies.

Figure 5.48. Prisqa and Adin presented their work

In line with her group work, Prizqa explained her answer as follow:

Teacher : Ok, listen to her, if you have different answers, you may tell later.
Prizqa : This ten, I got it from the horizontal tiles, and six is from the vertical ones, and then multiplied them. And this 25 x 25 is from the given information
Prizqa : This is also (floor 2) similar, the horizontal edge has 6 tiles and the vertical one has 10 tiles. The third floor has 6 vertical tiles and 10 horizontal tiles.
Teacher : What is your conclusion?
Prizqa : **Floor A, B, and C is equal**
Teacher : **What is equal?**
Prizqa : **The areas**
Teacher : The areas are equal

Meanwhile Adin had a different way in solving this problem. The following segment describes how Adin presented his answer.

Adin : To get this 250, Mom, this length is 10 tiles, I measured it with this tiles (showing) having twice length as the given tile. **This 10 was multiplied with 25 and I got 250.** Therefore its length is 250 cm
Teacher : Ok, please continue
Adin : And this 150 is the width which has 6 tiles. **Then it was multiplied with 25 and resulted in 150**. **Therefore 250 and 150 was multiplied and I got 37500**
Teacher : Did you do this to all problems?
Adin : Yes, I did it like that
Teacher : So, you multiplied the length with 25 and also the width. What is your conclusion?
Adin : All floors have an equal area

From the class discussion, we can see that both students presented their different strategies. Both strategies are correct. Some students had different solutions. They had different solutions due to their errors in drawing the tiles. They did not draw the tiles or marks carefully. Therefore the teacher explained to students that it could be that they measured (made errors in drawing tiles on the floors). The teacher also explained that their strategy is correct. After having a class discussion, it came to conclude what they have learned in this meeting. The following segment describes how the teacher and students concluded the lesson.

Teacher : Okay, before we close this session, we will conclude what we have learned today, without given any sizes of a floor; we can find the area by using…
Students : Tiles, tiles
Teacher : They are units, or small tiles in the floors can be used to find their… area
Students : Area
Teacher : An area can be measured by, what Prizqa and Adin did, by measuring the sizes, or length, or the edges, by knowing the length of edges we can find the area
Teacher : To compare areas, we can use the same unit, what is the unit you used?
Alif and others : The tile
Teacher : What is the size of your tile?
Anisa : 625 square centimeters
Teacher : Was it used to all of the floors?
Students : Yes
Teacher : Therefore, we can compare areas if we use a same unit

From this meeting, it can be concluded that the learning goals were achieved. Students could compare areas (floors) using different square-tiles as unit of measurement. Students could compare areas using a same unit of measurement. Students could recall and enrich their understanding of the multiplication strategy in determining an area of rectangle. Tiling is helpful to lead students understand the area of rectangle by structuring array. In addition, it seems that overlapping strategy still becomes a powerful strategy to compare area. Some students still did it to compare the floors.

Meeting 4

Activity 1 Living Room Floor

This activity is to determine an area of a floor from a given tile (see 5.49). The tile is 20 cm x 20 cm. The floor is seen from above and some furniture was set up there. It was designed to let students not to count the tiles one by one. In groups, students had to find another way to count the tiles or determine the area faster. This activity is aimed at empowering students the multiplication strategy.

Figure 5.49. Living room problem

Most of students solve this problem by finding the number of tiles on the floor and multiplied it with an area of one tile (figure 5.50). As conjectured, they sought the number of tiles and multiplied it with the area of one tile.

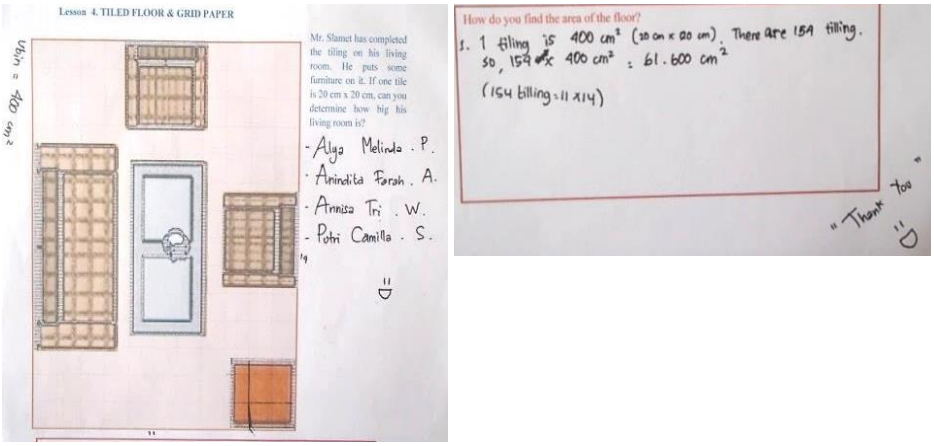


Figure 5.50. Group A's work on living room floor

This group firstly noted that one tile has an area 400 square centimeters. Therefore, students found the number of tiles by multiplying the tiles on the row and the column (edges). They multiplied the number of tiles with an area of one tile. Group B also did in a same way (figure 5.51)

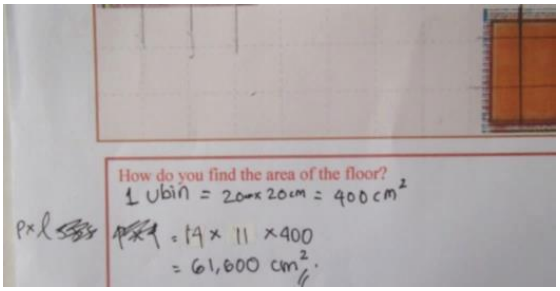


Figure 5.51. Group B's work on living room problem

To find the number of tiles, students traced the lines of the tiles on the floor. It is evidence that students applied multiplication strategy to find the number of the tiles. These students also understand how to find the area of the floor by multiplying the number of tiles with an area of one tile. This group successfully gave a correct answer. Another strategy used is that students looked for the length and the width of the floor (see figure 5.52)

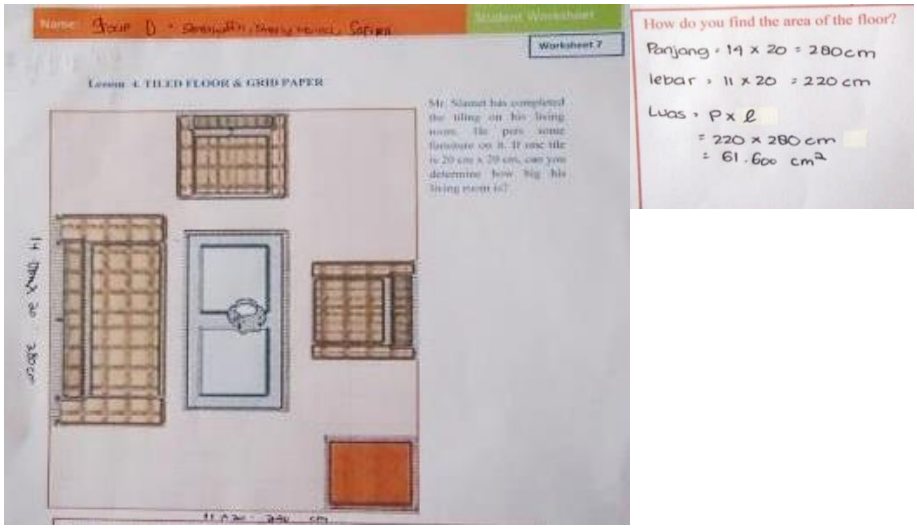


Figure 5.52. Group D's work on living room problem

From the figure above, Group D solved this problem by finding the length and the width of the floor. Firstly, students determined the number of tiles in the length and the width by combining the visible tiles on the edge and on the space between the furniture. To get the length and the width, students multiplied the number of tiles with 20 cm. Therefore, they found the length and the width are 280 cm and 220 cm respectively. To find the area of the floor, they multiplied the length and the width. This group successfully answered the problem correctly.

After students finished their work on the floor problem, two groups presented their work. They wrote their work on the whiteboard and explained their work to other students.

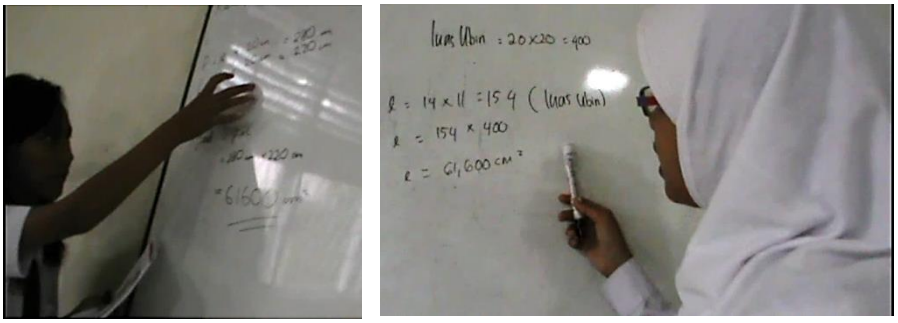


Figure 5.53. Group C and D presented their work

These two groups had different ways to solve the floor problem. Group C solved the problem as group D. Meanwhile, group C had a same way as Group A.

Activity 2 Dotted Rice Field and Leaves

This activity is same with the activity in the meeting 1. This activity is aimed at enriching students' strategy in comparing areas. Students were expected to have a new strategy to solve this problem. They have learned about tiles, as a square unit of measurement. Students worked on this problem individually. Some students made squares in Mr. Slamet's rice field and Mr. Joko's rice field. The rest still counted the dots one by one. The following figure shows student's work dealing with this problem.

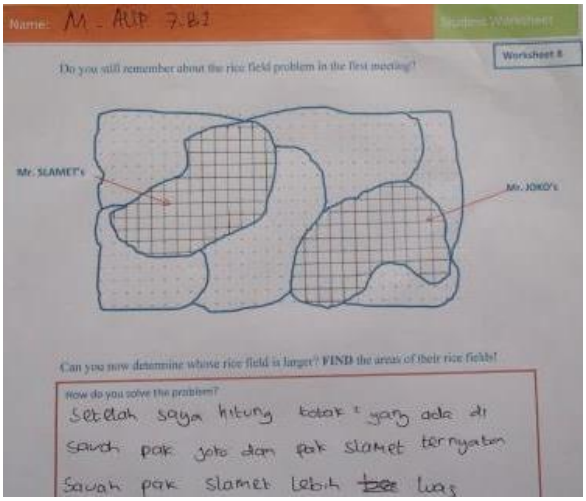


Figure 5.54. Alif made squares on the rice fields

Alif solved this problem by making squares on the rice fields with a ruler as conjectured. He counted the number of squares in each rice field and compared them. He found that Mr. Slamet's rice field is larger after counting the squares. Another student from this group also made squares on the rice fields (figure 5.55)

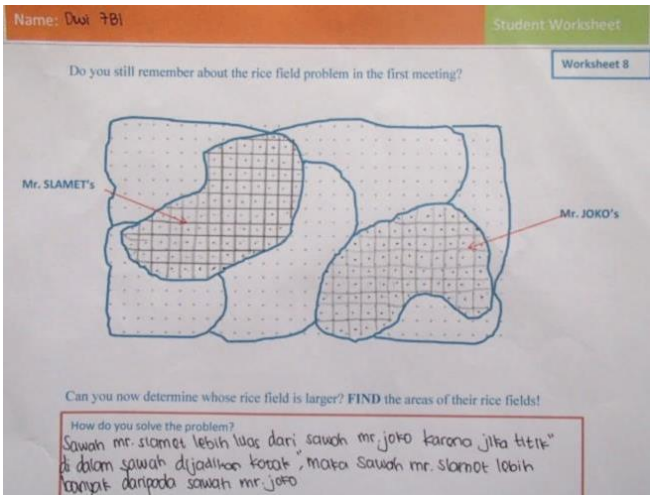


Figure 5.55. Dwi made squares and counted the squares on the rice fields

From her work, Dwi made squares by connecting the dots. She concluded that Mr. Slamet's rice field is larger because after making squares, Mr. Slamet's rice field has more square than Mr. Joko's rice field.

One student, from Group D did the same way by making squares on the rice fields. The researcher walked around the class to observe and stop in his group.

Wafiq	: This one is non-fully square
Teacher	: Yes, it is a non-fully square, what will you do to it?
Wafiq	: What can I do?
Teacher	: Are there other non-fully squares?
Wafiq	: Yes, there are, we can combine them, cannot we?
Teacher	: Is it allowed?
Wafiq	: Yes, it is
Teacher	: If you combine them, which ones would you combine?
Wafiq	: This one and this one could be equal (pointing non-fully squares)
Teacher	: Okay, how many squares would it be? If this and this is combined, how many squares would it be?
Wafiq	: One
Teacher	: Okay, try other squares. **If you cut this and move to this parts, does the area change?**
Wafiq	: **Moving his head (No)**

From this segment, Wafiq combined the non-fully squares in order to make a fully squares. He also understand when he combined by cutting and moving them will not change the area of the rice field. It seems that he understands the concept of conservation of area. The following figure shows Wafiq's work.

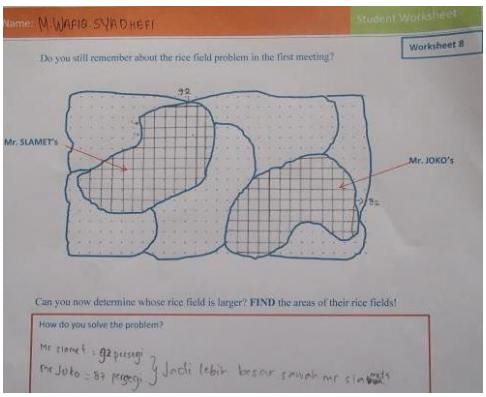


Figure 5.56. Wafiq combined the non-fully squares

From his work, it is clear that he combined and counted the squares to get the area of each rice field. It seemed that he firstly marked the non-fully squares to

combine. Afterward, he just did it in his mind and kept combining without making marks on the non-fully squares. Finally, he found that the area of Mr. Slamet's rice field and Mr. Joko's rice field are 92 squares and 87 squares respectively. He gave a correct conclusion that Mr. Slamet's rice field is larger than Mr. Joko's rice field. Another student, Farah did in a same way like Wafiq. She combined the non-fully squares to get fully squares. She shaded the non-fully squares as she made the new fully squares. She put some numbers to count the squares (figure 5.57).

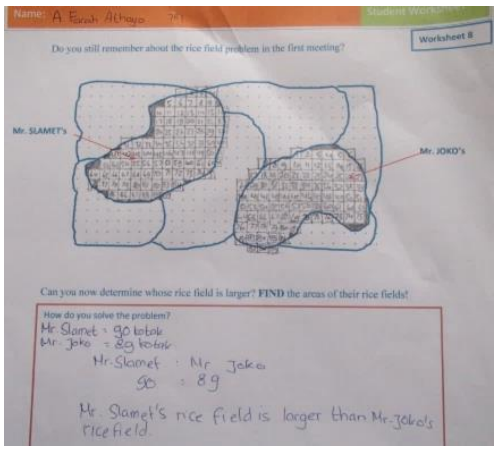


Figure 5.57. Farah combined non-fully squares

She is more precise in combining the squares and counting them than Wafiq. She gave the correct conclusion. She found the area of Mr. Slamet's and Mr. Joko's are 90 squares and 89 squares respectively.

In dealing with leaves problem, most students made squares on the leaves. The squares sizes varied. Some students made squares like a grid paper with a size 1 cm x 1 cm, 1.7 cm x 1.7 cm or other sizes. One student from the focus group, Prizqa solved this problem by making squares with a size 1 cm x 1 cm.

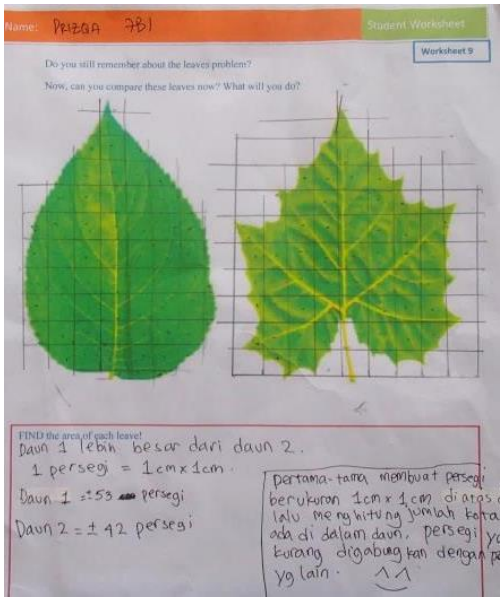


Figure 5.58. Prizqa made squares with dimension 1 cm x 1 cm

Prizqa estimated the number of squares by counting the full squares added with the non-fully squared. The non-fully squares were combined to get fully squares. She found that the number of squares in leaf A and leaf B are about 53 squares and 42 squares respectively.

However, in making squares, students still have difficulties in drawing the grid. Students used a ruler improperly so that their squares are not precisely equally sized. It seems to be natural because students are not used to drawing grid by themselves. It is still good because by drawing grid by themselves, students are expected to have a deeper understanding in measuring area of irregular figures.

Interestingly, the researcher noted during the observation that one student drew the squares using the tile used in the previous activity. She cut one tile from the worksheet and used it to make squares on the leaves. Most students found that leaf A is larger than leaf B because leaf A has more squares. However, due to the limited time, some students did not finish this task because they slowly made their squares. Students have made squares on one leaf or they did not finished making squares on both leaves.

In conclusion, in the first activity of this meeting, students could apply multiplication strategy to find he number of tiles and also the area of the floor.

They have applied the formula, length x width, to find the area. Based on the theory, it is true that tiling support students understanding of area measurement especially in determining area of a rectangular figure. Tiling with square units also would help student to understand why an area is in a square standard measurement, for instance square centimeters (cm^2) and square meters (m^2). In the second activity, it is evidence that working with tiles (squares) could develop students' strategy in comparing area using square units. Students understand that they need to compare area with the same unit of measurement. It is obvious that students made the same size squares to compare areas of the leaves. In a longer meeting, it can be introduced the use of a grid paper. But it is better to let students firstly come to their minds drawing grid rather than directly providing grid paper. In counting squares units, students could combine the non-fully squares to get fully squares because they understand the concept of conservation of area. When they combined the non-fully squares, the area will not change.

Meeting 5

Activity 1 Parallelogram Building

Students had to determine an area of glasses to cover one side of parallelogram building. As a real parallelogram building showed on the screen, students could imagine that this building exists. In group, students had to compare the area of two buildings (figure 5.59). In comparing the areas, students need to determine the area of each building first. The area of rectangular building is easier to find because students can apply multiplication strategy.

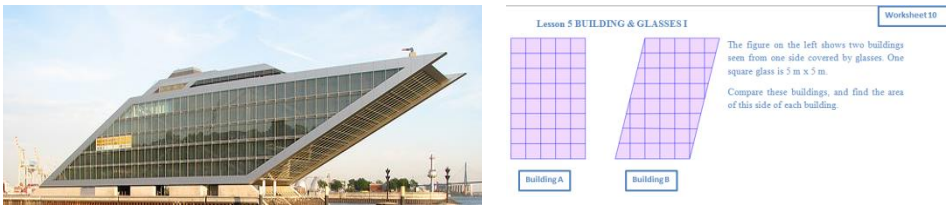


Figure 5.59. The parallelogram building and the parallelogram problem

To find the area or parallelogram building might be not as easy as the rectangular building. As conjectured in HLT, students solved the rectangular building by applying multiplication strategy. They firstly they found the area of

one glasses. After that students determined the number of glasses on one side of the rectangular building (see figure 5.60).

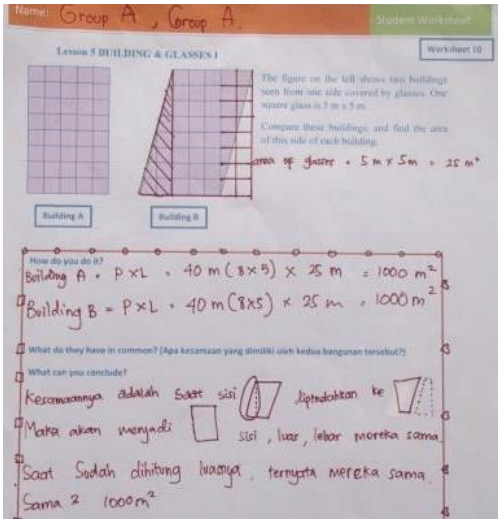


Figure 5.60. Group A reshaped the parallelogram

This group, Group A, found that building A and B have an equal area. However, Students still made mistakes in writing their answer, especially the standard of measurement. They should not put the meter on the 40, because it is the number of glasses. They should put square meters on the 25 not just meter. In addition, this group could answer what the two buildings have something in common. Students applied reshaping strategy to measure the area of glasses of the parallelogram building. It seems that students have understood the concept of conservation of area. They could describe that after reshaping the parallelogram building has an equal length and width, area. After measuring their areas, they have an equal area, which is 1000 m^2.

The focus group, Group B, did almost similar. This group moved and combined the glasses one by one (figure 5.61).

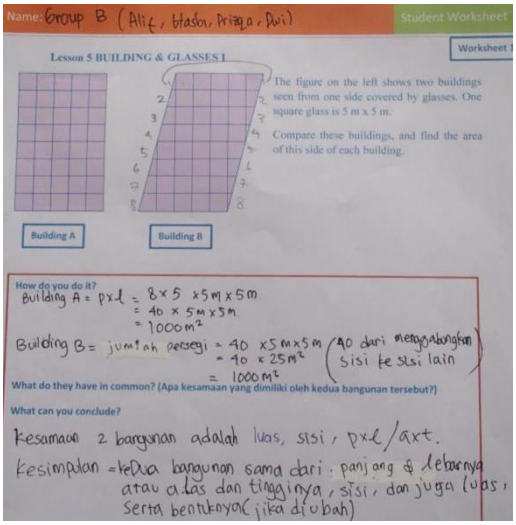


Figure 5.61. Group B moved and combined the glasses of the parallelogram

However, it is actually a same strategy as reshaping. In reshaping the parallelogram, students usually move a big part as a triangle. They made a rectangle after combining the glasses. These students found 40 as they combined the glasses. This group could derive that building A and B have something in common, such as the area, the edges, and the area formula. They concluded that from the two buildings, the length and width are equal to the base and height. The buildings have equal edges, area and the shape after reshaping.

In dealing with the second problem, students had to determine the area of a parallelogram. Most groups reshaped the parallelogram into a rectangle. Only Group F which directly applied area formula of parallelogram (figure 5.62).

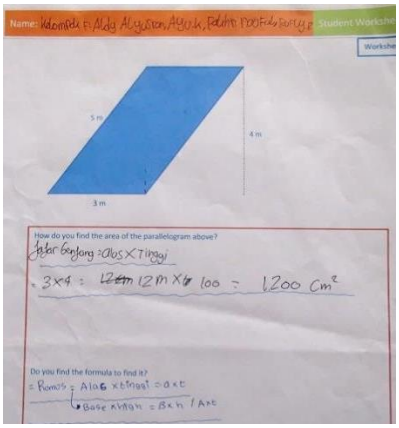


Figure 5.62. Students applied the area formula of parallelogram

The rest groups reshaped the parallelogram into a rectangle. Group B reshaped the parallelogram into a rectangle and applied the area formula of rectangle (figure 5.63).

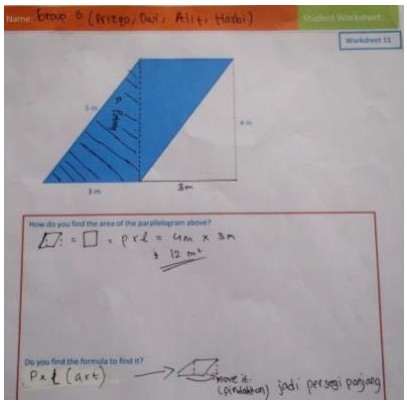


Figure 5.63. Group B reshaped the parallelogram

The researcher walked around the classroom to observe and came to Group D. Group D was solving the problem 2. The following segment is the interview with the students while they were working on the problem.

Sherly : Lost, Los, Lost (shading the part going to be moved) then move to this part. It is just like that
Researcher : **If you move this past, does the area change?**
Students : **No**
Adin : Why did you shade this part, you can directly move it to this part
Anisa : Ok, we can erase it though
Researcher : Now, what is the shape?
Students : A square, a rectangle

From the conversation, this group has understood that the area did not change when they moved (reshaped) the parallelogram into a rectangle. Students have understood the concept of conservation of area.

After students finished the activity 1, they presented their work. Group D reshaped the parallelogram on the first problem as Group A. Group F was chosen to present because this group reshaped the parallelogram in the first problem but just applied formula in the second problem. After Group F presented their work, the teacher led the discussion whether other groups have different strategies. The

following segment describes how the teacher led the discussion and gave a change to another group to deliver their strategy.

Teacher	: Now, the second worksheet, this group; please pay attention! This group (group F) directly found the area by base times height. I want to ask you all now, is there any group that has a different way?
Adin	: Me
Teacher	: Please Adin, what did you do?
Adin	: **I made a rectangle Mom.**
Teacher	: Please stand up
Adin	: So, to find the area is easier Mom by using length times width
Teacher	: Ok, Ok, It means your way is like their previous strategy, right?
Adin	: Yes
Teacher	: Then, what did you do to this parallelogram?
Adin	: Made it into a rectangle
Teacher	: Made it into a rectangle (repeating), then how did you find the area?
Adin and Sherly	: **By using the area formula of rectangle**
Teacher	: Which is …
Students	: Length times width
Teacher	: Is it easier?
Students	: Yes
Teacher	: What if we do not know the formula, we forgot the formula or did not know the formula, it means we can use the area formula of …
Students	: Rectangle
Teacher	: Ok, is the result the same?
Students	: Yes, it is the same

From this segment, it is obvious that students reshaped the parallelogram into a rectangle and use the area formula of rectangle to find its area. Adin said that it is easier to find area of a parallelogram by reshaping it into a rectangle. He then applied the area formula of rectangle after reshaping the parallelogram. He found the area is equal to Group D's answer which is 12 m^2.

In the conclusion, the teacher and students made conclusions on what they have learned from the first activity. The following segment shows the conclusion made for this activity.

Teacher : Please pay attention, we can conclude, in the parallelogram the length is called …
Students : The base (using Bahasa)
Teacher : or in English is..
Students : base
Teacher : How do we say the width?
Students : the height
Teacher : It is called "height"
Raflay : Tall, tall,
Teacher : (Teacher are looking at Raflay)
Raflay : Height
Teacher : So the formula for area of parallelogram is…
Wafiq : **Base times height**
Teacher : Or base times (asking in English)
Adin : **Length times width**
Teacher : Or?
Adi : Length times width

Activity 2 Triangular Building

In this activity, firstly students had to deal with finding area of glasses to cover one side of triangular building. Secondly, they had to find areas of triangles. This activity is aimed at build students' understanding the area formula of triangle.

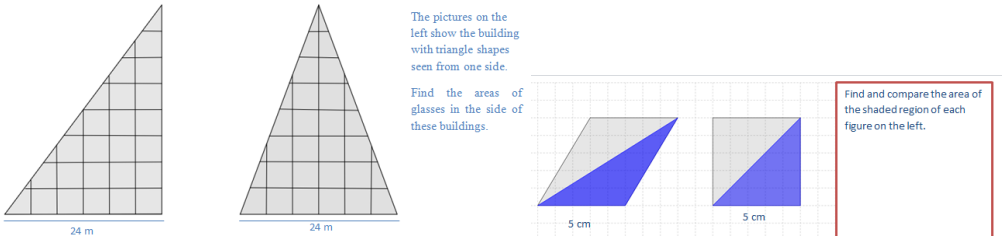


Figure 5.64. The triangles problems

Students solved this problem by reshaping the triangles into a rectangle. They cut and pasted parts of the triangles to make a rectangle. Group A solve the problem as the following figure.

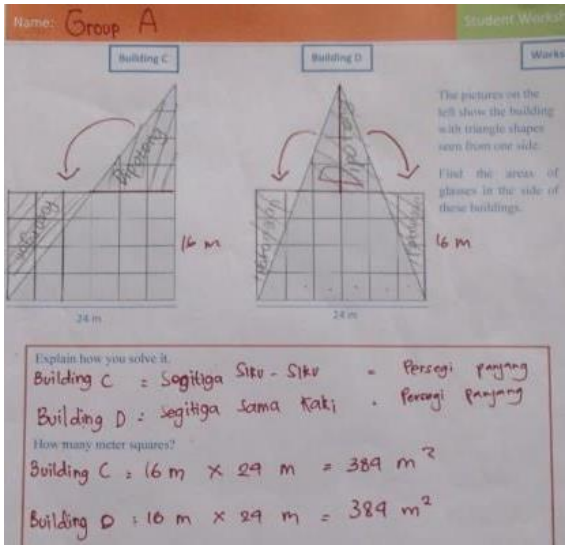


Figure 5.65. Group A reshaped the triangles into a rectangle

This group reshaped both triangles into a rectangle. They found the area of each triangle by applying area formula of rectangle. Another group, Group B, solved the problem by reshaping also. Interestingly, they applied area formula of triangle and also the area formula of rectangle to find the area.

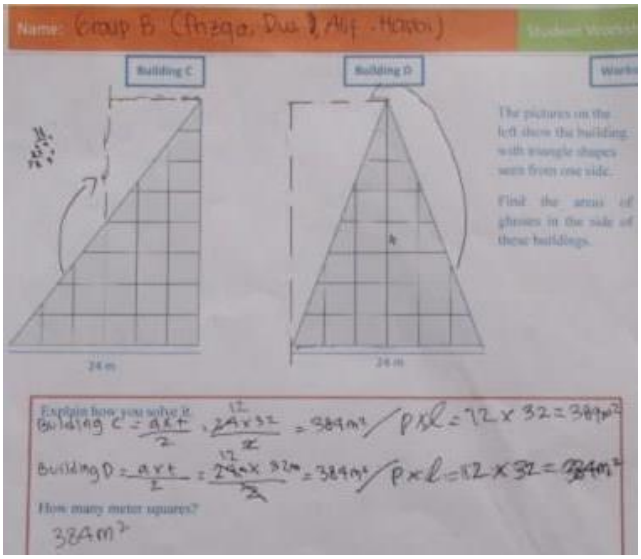


Figure 5.66. Group B reshaped the triangles into a rectangle

In dealing with the shaded triangles problem, student reshaped the parallelogram into a rectangle. Other students also just divided the area formula of the parallelogram by two to get the area of the shaded triangle.

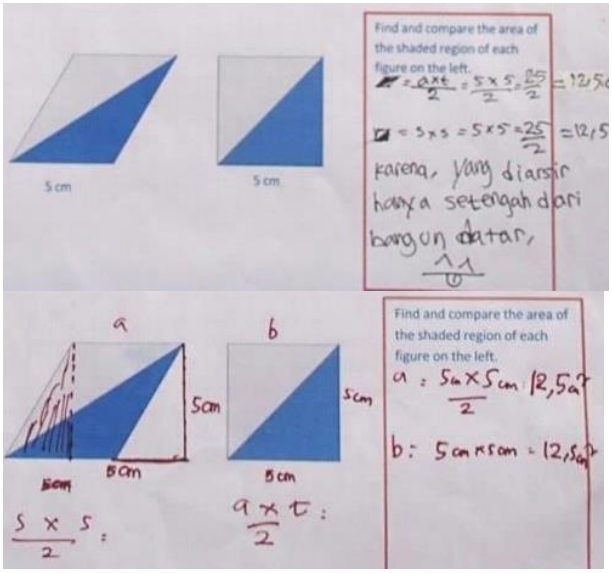


Figure 5.67. Students halved the formula

It can be seen that students have understood how to find an area of triangle and how to get the formula. Students could reshape the triangles into a rectangle to find its formula. Students also could use the strategy of half of parallelogram or rectangle to measure area of all triangles. They have already known the area formula of parallelogram and rectangle.

It can be concluded that reshaping activity helped students to measure areas of parallelograms and triangles. Students could reshape a parallelogram into a rectangle to find its area and derive its area formula. Students also did a same thing to get the area of triangles and derive the area formula.

Meeting 6

Activity 1 Trapezoid building

In this activity, students had to solve two problems related to areas of trapezoid. This activity is aimed at supporting students understanding how to measure areas of trapezoid and how to derive its formula. The first problem asked students to determine the area of glasses to cover a side of trapezoid building (figure 5.68). In the second problem, students had to find areas of some trapezoids. The teacher refreshed students' knowledge of multiplication distributive law before students worked on the problems.

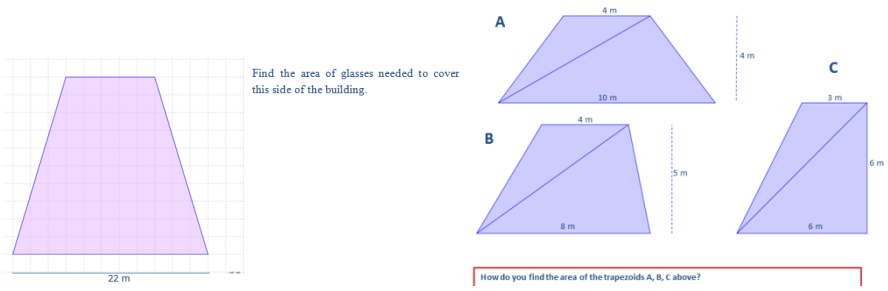


Figure 5.68. The trapezoid problems

All groups reshaped the trapezoid building into a rectangle. Group D simply reshaped the trapezoid to measure the area of glasses covering the side of the trapezoid (figure 5.69)

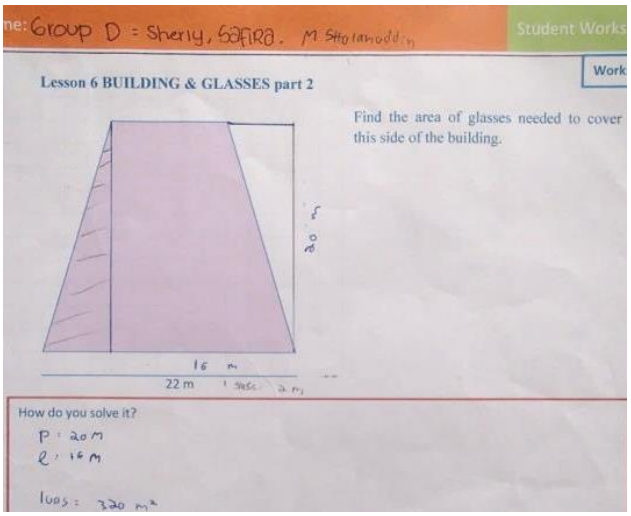


Figure 5.69. Groud D reshaped the trapezoid into a rectangle

It is clear that this group solved the problem by reshaping. Students in this group found that one glass has 2 meters length on one edge. After reshaping, the width of the rectangle consisted of 8 glasses meanwhile the length consisted of 10 glasses. Therefore, students found the length and the width are 16 meters and 20 meters. They applied area of rectangle by multiplying the length with the width to measure the area. They found that the area is 320 square meters.

The focus group, Group B, did the same thing. Students in this group reshaped the trapezoid into a rectangle (see figure 5.70).

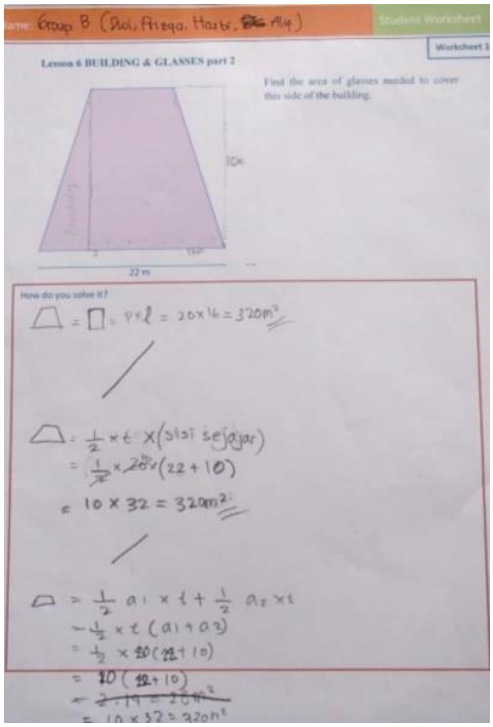


Figure 5.70. Group B reshaped the trapezoid into a rectangle

It is clear that students reshaped the trapezoid into a rectangle and applied the area formula of rectangle. Interestingly, students also solve this problem by using the area formula of trapezoid and using the area formula of triangle. It seemed that this group tried to prove their answer by using different strategies. Their last strategy was inspired by the second problem. In the second problem they saw that the trapezoid was divided into two triangles. In dealing with the second problem, this group used the area formula of triangle to find the area of trapezoids and the area formula (see 5.71)

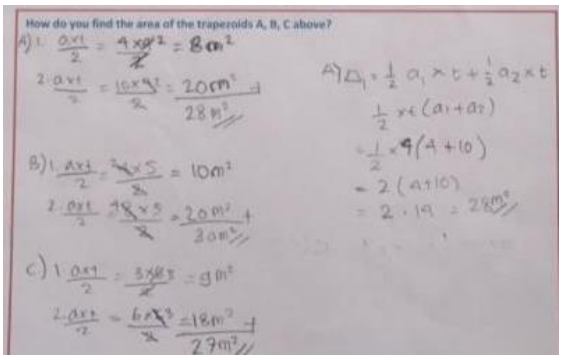


Figure 5.71. Student applied area formula of triangle

It is clear that Group B added the area of each triangle to get the area of one trapezoid. Therefore, they found that the area formula is the sum of two area formulas of triangle. Since the triangles have the same height and half. They simplified the formula and found the formula is a half times height times the sum of the opposite parallel edges. Hence, Group D was able to derive area formula of trapezoid. Another group, Group A and F, solved the problem with two different strategies as the following figure.

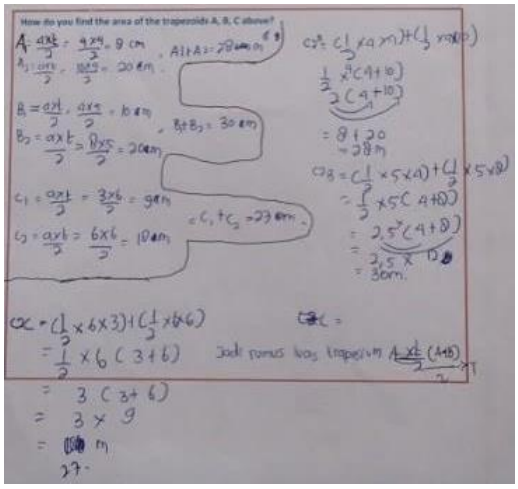


Figure 5.72. Students solved with two different ways

Firstly, they determined the area of each triangle and then added the areas to get the area of trapezoid. Secondly, they used the algebraic way to derive the area formula of trapezoid. They found that the area formula of trapezoid is the sum of the opposite edges times height divided by two. This can be clarified by the presentation of another group. Group F represented by Fadila explained in the class discussion as the following.

Teacher : We will continue to the next problem, please Fadila, there are three figures. Please pay attention
Fadila : The second worksheet, there are two ways, by using triangles, and algebraic way.
Teacher : Please louder Fadila, the first way, what did u use?
Fadila : **The area formula of triangle**
Teacher : The second way?
Fadila : The second way is by using algebraic way

Group D also did in a same way; firstly this group used the area formula of triangle in the first figure. Afterward, they apply the algebraic manipulation. The following how Safira (Group D) explained the strategy.

Safira : The second figure is by using algebraic way
Teacher : Do you use directly algebraic way?
Safira : Heem (Agreeing)
Teacher : What is the five
Adin : The height (helping)
Safira : The height
Teacher : Okay,
Safira : The eight is the base and the four is the upper

Students firstly added areas of two triangles to find the area of trapezoids. It can be seen that Safira's group understood how to apply algebraic method to determine the areas of trapezoid. They knew that the formula can be simplified because it has something in common that is the height and the half.

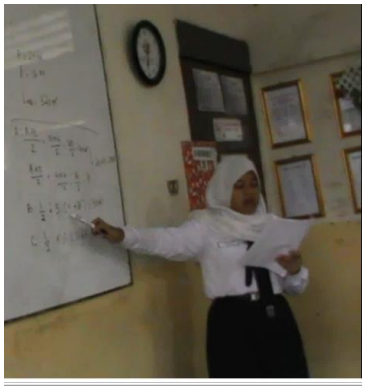


Figure 5.73. Safira presented her group's work

From the figure, we can see also, that she solved algebraically the second trapezoid and third trapezoid. She has simplified the addition of area formula of triangle. She put the half and the height outside the bracket and put the sum of the base and the upper in the bracket. Students need to have a good understanding of multiplication distributive law in order to work with algebraic manipulation.

Activity 2 Rhombus and Kite

In this activity students dealt with rhombus and trapezoid problem. In group, they had to find the area of these quadrilaterals. This activity is aimed at supporting students to understand how to measure area of rhombus and kite and derive their area formulas.

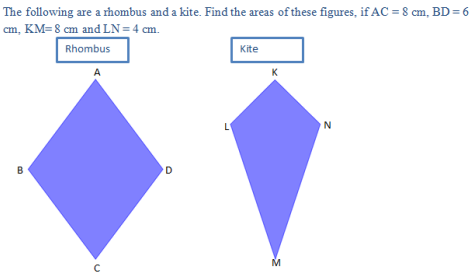


Figure 5.74. Rhombus and kite problem

Most of students used their knowledge in the previous activity that they divided the quadrilaterals into two triangles (figure 5.75)

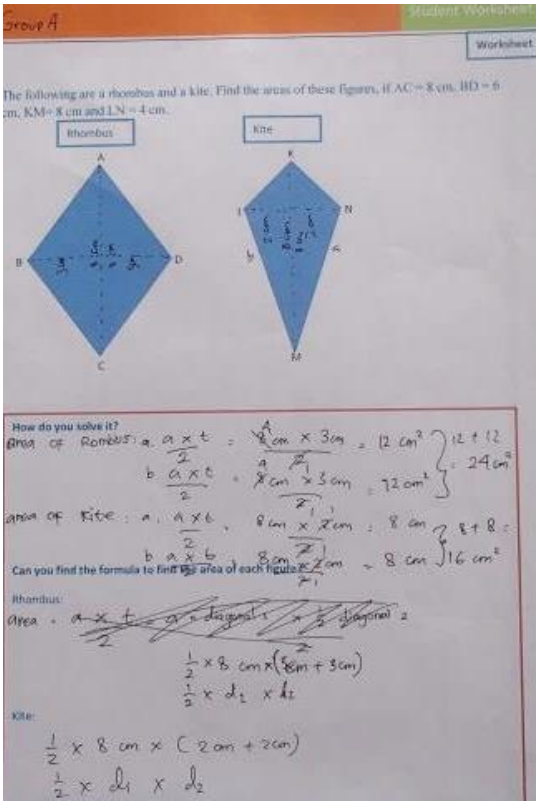


Figure 5.75. Students applied the area formula of triangle

From their work, we can see that this group used the area formula of triangle to find the area of rhombus and trapezoid. They added the area of each triangle to get the area of rhombus and kite. Finally they found the area of the rhombus and the kite are 24 square meters and 16 square meters. Students also could find the area formula of rhombus and kite by manipulating the numbers. Students recognized that by adding the area of triangles, the half and the height belong to both triangles. Therefore, they put the half and the height outside the bracket and put the sum of the bases in the bracket. After doing that, they related the numbers with the diagonals of the rhombus and the kite. They knew that the height is the diagonal 1 and the sum of the bases is the diagonal 2. In the end, they found the areas formula of rhombus and kite as ½ x D_1 x D_2.

Another group, Group B, solved this problem by reshaping the rhombus and the kite into a rectangle.

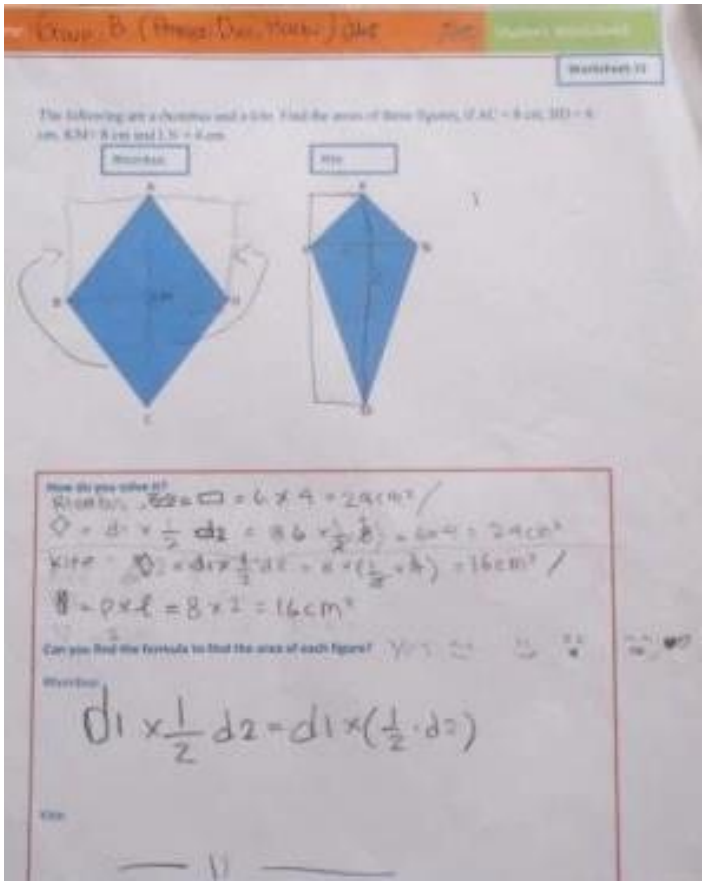


Figure 5.76. Students reshape the rhombus and kite

In the class discussion, Group B presented their work first. The following how the teacher led the discussion.

Teacher : What did you do to the rhombus to get D1 times half D2
Prizqa : This vertical line is diagonal 1
Teacher : Please pay attention. What did you make in reshaping?
Prizqa : **I reshaped into a rectangle**
Teacher : How?
Prizqa : Moving this to upper side (showing)
Teacher : Moving to the upper side (repeating)
Teacher : Did you do the same to the kite?
Prizqa : Yes, this parts were moved to this side (showing)
Teacher : Ok, others can you follow her? Her group reshaped the rhombus and the kite into a rectangle
Teacher : Please show your figure Prizqa
Prizqa : (Showing her work)
Teacher : Therefore, they used the area formula of rectangle, which is…?
Prizqa : **Length times width**
Teacher : **The length is D1 and what is the width?**
Prizqa : **D2**
Teacher and Prizqa : **half D2** (Prizqa realized and reformulated her answer)

From the segment above, the teacher led the discussion and posed some question to Prizqa. The teacher helped make other students understand by repeating what Prizqa said. The following figure is how Prizqa presented her group's work.

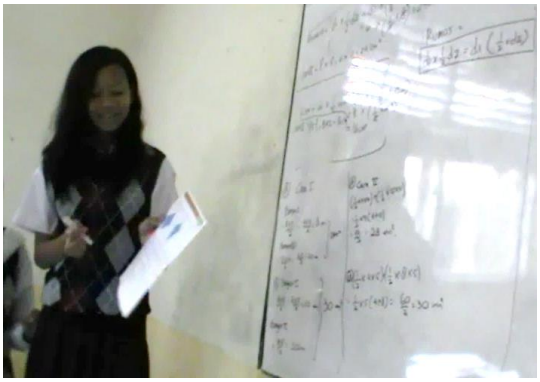


Figure 5.77. Prizqa presented her group's work

In the end of the meeting, the teacher and students concluded together what they have learned. The following segment is a part of the conclusion made my students.

Teacher	: Now, we will make conclusions. Do you still remember the first problem, who knows the area formula of trapezoid?
Safira	: Me
Teacher	: What
Safira	: A (upper) plus B (base) times…
Wafiq	: Half times base times height
Anisa	: **Me, the sum of the roof and the base times height divided by two**
Teacher	: What do you mean by the roof and the base?
Anisa	: **The roof is the upper edge and the base is the lower edge**
Teacher	: **It means the sum of the parallel edges**
Anisa	: Yes

From this segment, to some students, they still remembered the use of area formula of triangle like what Wafiq said. However, Anisa could make her wording of the area formula of trapezoid. The teacher helped her to formulate her words into a more common language. In the conclusion, students could answer the area formula of rhombus and kite which is half diagonal 1 times diagonal 2.

We can say that by reshaping students could determine the area of equilateral trapezoid. Students could derive the area formula of the trapezoid by using area of triangle. In dealing with rhombus and kite, students used strategy in trapezoid to measure the area of rhombus and kite. They made triangles on the rhombus and the kite. Some students also made rectangle from the rhombus and the kite to find its area and derive its area formula.

5.2.4. Post-test Cycle 2

As explained, the use of the post-test is to know what students have learned after participating in the six meetings. Twenty three students participated in this pot-test. The post-ted was carried out one day after the last meeting (meeting 6). The items on the post-test are different from the pre-test. However, each item has an equal level of difficulties.

The first item is comparing areas of two figures. In dealing with this problem, student reshaped the first problem into the second one or vice versa. Therefore, students have learned about reshaping in this case. Students might understand that reshaping will not change the area of its initial figure. It is totally different with their work on the pre-test. Students did not use their perceptual judgment but tried to prove the equality of areas by reshaping one figure to another one.

The second item is determining perimeter and area of an irregular polygon. Students were asked to determine first the perimeter then the area. However, students directly reshaped the polygon into a square and measured the area and the perimeter. Therefore, some students measured the perimeter of the reshaped polygon (the square). It is clear that students tried to reshape the irregular polygon into an easier figure, a square. Therefore, students have learned the reshaping strategy into a rectangle to measure the area in meeting 2. Even though some students made mistake by measuring the perimeter of the reshaped figure, they understand that the perimeter is the boundary or the sum of the edges. It is evidence that students could differentiate between area and perimeter. Students have learned in meeting 2 that the perimeter is boundary. Therefore, students understand how to determine the perimeter which is adding the edges of the figure.

The third item is comparing area of leaves. Students have to determine the larger leaf. In solving this problem, students made squares on the leaves or students imagined overlapped, cut, and pasted the leaves. Most of students made 1 cm x 1 cm squares. It seems that this dimension is easier to make using a ruler. It is totally different with their work in the pre-test. Initially students judge by just seeing the appearance of the leaves. In the post-test, students have new strategies in comparing areas of two figures. Students made squares or could overlap. However, students only imagined they overlap the leaves, because there was no cutting tool provided.

The fourth item is to determine areas of a rhombus and a kite. Some students directly applied the formula, but they also know how to measure the area

by reshaping it into a rectangle. In case, students reshaped into a rectangle, they could relate the length and the width of the rectangle to the diagonals of the rhombus and the kite. Interestingly, some students also used the area of triangle. Students divided the rhombus and the kite into two triangles and sum the areas of the triangles. It can be said that students learned the strategy used in the trapezoid problem. In the pre-test most of students could not solve the rhombus and the kite problem. Their problem was the area formula. Students did not remember the area formula of rhombus and of kite. In the post-test, students just applied the formula without know how it works. In the post-test, students reshaped the rhombus and the kite into a rectangle to derive the area formula.

The fifth item consisted of three problems; measuring an area of trapezoid, parallelogram-rectangle, and triangles. Students used area of triangles, and some directly used area formula of trapezoid learned in meeting 6. They recreated the area formula by themselves. It can be proven from students' answers, the area formula is different from the area formula they used from the book.

Dealing with parallelogram and rectangle, students reshaped the parallelogram into a rectangle and applied formula of rectangle. In measuring area of rectangle, students easily applied the formula they know. In solving the triangles problems, students reshaped them into a rectangle, and some students just directly applied the area formula.

Dealing with triangles, some students reshaped the triangles and some applied the area formula of triangles. Students could solve this problem by those strategies. None students answer that they forget the formula. It seems that they now have strategy to solve areas of triangles with just given the base.

5.2.5. Conclusion of Cycle 2

Based on the teaching experiment in cycle 2, we can draw some conclusions as follows. By comparing areas of two figures, students could develop their strategy in comparing areas. In this study, reallotment activities are termed used to name the activities that involve reshaping. As these comparing areas activities continue students get used to do overlapping, cutting and pasting to compare areas. Students also could understand the meaning of area and the

perimeter are. They could understand that what they compared is the region inside. Hence, students knew that the area is region inside and the perimeter is the boundary or the edges of the geometrical figures. When they reshaped a figure, the area remains invariant but not the perimeter. In addition, it seems that this strategy is powerful to compare areas. Some students still did it when they compared the areas of two tiled floors. Students wanted to prove that the two floors really have an equal area beside the number of tiles.

Students learned that the area will not change if it is reshaped. Students understand the concept of conservation of area. They grasped this concept, because when they reshaped no parts were thrown away. Students could make use of this strategy when it came to measure areas of leaves and the rice fields. Students make squares on the leaves and the rice fields to measure areas. Students combined the non-fully squares to make a fully squares. Students moved the non-fully squares to make fully squares. They knew that it would not change the area when they moved the non-fully squares. Therefore, reallotment activities could support students understanding of the concept of area measurement.

Students also could develop their understanding of the area formula of rectangle in the tiling activities. Students knew why multiplying the edges would result in the area. Students could measure the area of a floor by multiplying the number of tiles with the area of one tile. Another strategy, students multiply the length and the width of the floor. Therefore, students can use this strategy since it works and results in the same answer. From this point, students learned not only the area formula of rectangle but also how the formula works.

Classroom discussions did not run successfully. When one student presented, other students were busy with their work and did not pay full attention. It is still difficult to students get used to listen to other students. Therefore, the teacher posed questions to invite students give attentions. However, the classroom still discussion worked. The teacher chose groups that had different strategies. The teacher played important roles in the discussions by giving good questions such as, how and why questions. Therefore, students could explain their own strategy

and gave their arguments. The teacher also refined students' articulations or explanations when they made mistakes. It can be seen that students, still took the conclusions from each meeting. When it came to a conclusion session, student could make conclusions with the teacher's help.

Reshaping also helps students to measure area of quadrilaterals and triangles. Each quadrilateral and triangle in this study could be reshaped into a rectangle. Since students already understand that reshaping will not change the area of its initial figure, students used this strategy to measure areas. Therefore, students used their new strategy of reshaping to measure the areas of quadrilaterals. Even though for some students still had difficulties relating the length and the width with the diagonals of the rhombus and the kite, at least students could solve this problem without memorizing area formulas.

CHAPTER VI
CONCLUSION AND DISCUSSION

The purpose of this present study is to contribute to a local instructional theory of area measurement. This chapter provides two main parts, conclusion and discussion. The conclusion consists of the answers to the research questions and the local instructional theory developed in this study. Meanwhile, in the second part we will discuss some important issues in this study. Therefore, the researchers have designed HLT and tested it with the actual learning activities. Through the data analysis, we may answer the research questions of this study as the following.

6.1. Conclusions

6.1.1. Answer to the first research question

1. *How can reallotment activities support students' understanding of the concept of area measurement?*

Some activities set in our revised hypothetical learning trajectory were designed to mostly focus on the understanding of the concept of conservation of area. This study uses reallotment activities to support students' understanding of area measurement; comparing areas, the meaning of area, and the concept of conservation of area. Reallotment means the act of reallocation or redistribution of something by cutting and pasting. In area measurement, it reshapes a figure into another one without changing its area. To let students grasp the concept of conservation of area, students need to compare areas by using overlapping strategy. As explained in chapter V that comparing areas of two figures could be used to ignite students overlapping strategy. The comparing activities were done through some problems; comparing leaves, rice fields, dotted rice fields, regular rice fields, and tiled floors. Overlapping strategy could invite students to do cutting and pasting in order to fit two figures to see which one is larger. Without any parts thrown away, students grasped that the area remains the same when it is reshaped. From the post-test revealed that students could reshape one figure into

another one to compare area without really cutting them. In addition, students also reshape quadrilaterals into a rectangle by cutting and pasting. These cutting and pasting activities are the reallotment activities. In other words, the area of a figure remains the same when it is reshaped into other shapes. Students develop their understanding of the concepts of area measurement though these activities. Firstly, students could understand that area is region inside of the figures they compared. In line with this, students could compare areas as what ancient mathematicians did to compare areas. Secondly, students could understand that an area of a figure will not change when they are reshaped. Lastly, in combining the non-fully squares to make fully squares to estimate an area, students could understand that it is allowed to do so due to the concept of conservation of area. Therefore, through comparing areas, students will develop overlapping strategy, and understand the concepts of area; such as area is region inside the boundary. The post-test analysis revealed that students develop their strategies to compare areas and improve their argumentation and explanation. Reallotment activities support students' understanding that the area of a figure is preserved when it is reshaped or combined to its parts. Students could compare areas by reshaping one figure into another one.

6.1.2. Answer to the second research question

2. *How can reallotment activities support students to measure areas of quadrilaterals and triangles?*

The answer to this question can be found from the activities carried on the meeting 5 and 6. The reallotment activity carried out is reshaping into a rectangle to measure areas and derive area formulas of quadrilaterals and triangle. Students reshaped the quadrilaterals and triangles into a rectangle to measure their areas. For instance, students reshaped the parallelogram into a rectangle to measure its area. As students understand the area formula of rectangle, it is beneficial for students because it is easier. In addition, the area formulas of other quadrilaterals and triangle can be derived from this formula. Students applied the area formula of rectangle after reshaping the parallelogram to get the area. Students also applied this strategy to other quadrilaterals. In addition, students also could

reinvent the area formulas by relating the rectangle and its original quadrilateral. In reshaping, students have understood the concept of conservation of area. Therefore, when they reshaped the quadrilaterals and triangles into a rectangle, students understood that their areas are preserved.

6.1.3. The implementation of PMRI on the learning design

As the first characteristic of PMRI, the familiar contexts were used to be a starting point for students. The contexts invited students to solve the problems in the contexts. As students involved in solving the problems, students develop their strategies using the provided materials. As the materials or tools disappear, students could just imagine using it. In other words, students move from a non-formal way to more a formal (abstract) way. Students not only learn area measurement but also other topic such as commutative, distributive multiplication laws. Students also had opportunities to reinvent the area formulas by themselves with help of the teacher if needed. The classroom discussions played important role to let students communicate, defend their answers and argue or question others' answers. The teacher helped students by posing how and why questions. The teacher also asked other students to respond on their friend's explanation during the presentation.

6.1.4. The contribution to a local instructional theory of area measurement

Teaching and learning of area measurement is mostly dominated by memorizing formulas and applying them to find areas. Rarely do students understand the basic concepts of area measurement. Students also do not understand why the area formula works and how to get the formula. Studies show that learning through memorizing algorithms or procedures will not support students understanding. In Indonesia, studies related to area measurement have been conducted and contribute to a local instructional theory of area measurement. This study also contributes to a local instructional theory of area measurement. Through this study, the designed activities could support students understanding of area measurement.

The local instructional theory is that students firstly learn the overlapping strategy through comparing areas. This activity also helps students to understand

what an area means. Later students develop their understanding of the concept of conservation of area ignited by the overlapping strategy. Next, students learn to reshape figures into a rectangle to deepen their understanding of the concept. As students develop their understanding of the concept then they learn unit of measurements through tiling activity. Tiling activity helps students to deepen their knowledge of area of rectangle. Tiles (square units) also help students to measure area of irregular figures. Here, students still used the knowledge of the concepts of conservation of area when students combine the non-fully square units to get a fully square unit. Students can reshape any figure into a more familiar figure to help them measure its area. Therefore, students apply this strategy to measure area of quadrilaterals and triangles and derive their area formulas. To sum up, focusing on the concept of conservation of area will be benefit for students and can be integrated well to other concepts, such as unit of measurement, and area formula.

6.2. Reflections

During the studies, the researchers and the teacher cooperate well to deliver the instructional activities. Discussion before conducting the lesson and reflecting after conducting the lesson were done well. If the teacher did not know what to do, she discussed with the researcher about it. As from the observation, she was not giving students change to communicate or present their work, now she has changed to ask her students how and why questions. She also gets used to ask other students to confirm the presenter's work. It seems that now she is aware of giving these kinds of questions to let her students think. If a teacher willingly to change to be better and aware of students' development, she will be motivated to improve her teaching style and willingly to cooperate with the researchers. Importantly, as the researchers, we should not create any gaps with the teachers. The teacher will feel comfortable and enjoy the teaching. However, as she has difficulties designing the materials and also HLT, she would probably come back to use the book from the school. She realizes that she needs help to find the materials that use PMRI approach.

We found that students had difficulties explaining their strategy or giving their justification. As the researcher and the teacher asked students to write down what they did, students get used to do it in the following activities. It can be seen their improvement in giving justification from their pre-test and post-test. As students' understanding improved, they confidently deliver their argumentation orally or in text.

We found that students also develop their understanding through hands-on activity. In comparing activities, overlapping strategy becomes a strong strategy to compare areas. It seems that through hands-on activities students experienced doing it and kept it in their mind. We found also that a classroom discussion could help students to develop their understanding through the presentation of their friends. Through others' explanation and justification, students refined their own understanding.

6.3. Suggestions

Suggestion for teachers

We witnessed that Indonesian teachers have difficulties implementing PMRI approach in their classrooms. They have difficulties designing materials and HLT and delivering the materials. This is one of the constraints when researching through PMRI approach in Indonesia. In order to carry out the designed instructional activities well, the teacher should make conducive learning environment. To do so, the teachers should prepare themselves. The teachers who usually teach using a traditional approach now should change little by little to refine their teaching approach. It is obvious that teaching through traditional approach will not support students' understanding. Therefore, the teachers who become the center of knowledge should give students opportunities to develop their understanding. It is a challenge for teachers to change their behavior in teaching. It is believed that changing students is easier than changing teachers. Teachers have experienced the teaching and learning of mathematics in traditional approach for many years. It is possibly hard to change their perspective in teaching. Therefore, the teachers should willingly change their behavior in teaching.

As the teacher willingly to change their perspective in teaching, they should understand the social classroom norms and socio-mathematical norms. Social classroom norms are very important. This norm consists of rules or agreements in the classroom even they are not written. Yackle & Cobb (1996) state that social classroom norm is sustained by inquiry based discussion and argumentation. For instance, students should challenge others' thinking and justify their own answers. Therefore, the teacher should make students to be brave to communicate and argue with other students. If a student presents his work, others should listen to him and pay attention. When students give a correct answer, the teacher should ask other students to clarify it. More importantly, the teacher should ask how and why questions to students. As the consequences, students will slowly get used to this agreement. It might be difficult at first time but students will adapt to this new situation.

Yackle & Cobb (1996) state that socio-mathematical norm is unique to mathematics. What count as mathematically different, sophisticated, efficient and elegant in a classroom are socio-mathematical norms (Yackle & Cobb, 1996). They state that socio-mathematical norms also include what counts as acceptable mathematical justification and explanation. Therefore, the teachers should develop students' mathematical beliefs and value and help them to be intellectually autonomous in mathematics. To do so, the teachers should let students understand these agreements. For instance, when students just explained that his strategy works in that way and results in the same answer it is not an acceptable mathematical justification. Students should get used to this norm if we want to make them intellectually autonomous in mathematics.

In brief, the teachers play important role to reform mathematics education in Indonesia. The teachers' willingness and awareness of social and socio-mathematical classroom will contribute to supportive learning environment. If a supportive learning environment is ready, the teacher will not face difficulties using PMRI approach.

Recommendation to further research

As area measurement mostly involve geometrical figures, it could be useful to further research on algebra that initially uses geometrical figures to help. For example, the completing squares method can be represented by a square made from a rectangle. This method also uses the concept of conservation of area. The further research could be a study on the concept of conservation of area to support students' understanding of quadratic equations; finding roots of a quadratic equation. This study is conducted in secondary school students since students in this level have more understanding in algebra. We also suggest carrying this study in lower level to see whether students can derive area formulas or not.

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APPENDICES

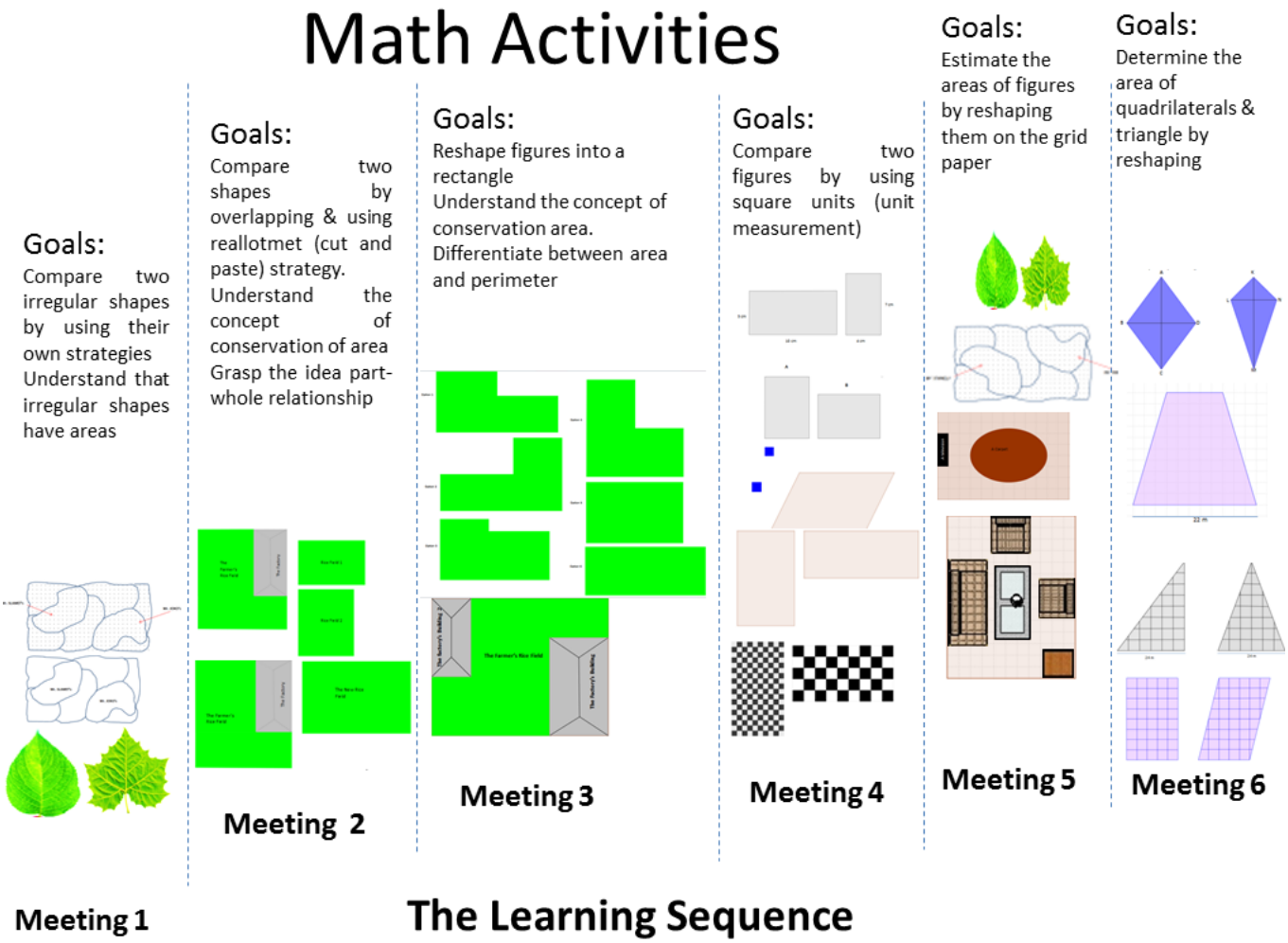
THE TIMELINE OF THE STUDY

	Date	Description
Preparing for the Experiment		
Studying literature and designing the learning activities and the initial HLT	July 2013 – January 2014	Looking for and reading the existing studies and literature about the topic area of measurement. Designing learning activities and making conjectures of students' strategies.
Discussion with the teacher	February 2014	Communicating the intention of the research and discussing the plans of the study and the learning activities.
Preliminary teaching experiment (The First Cycle)		
Observing the teaching and learning process in grade 7 and interview	February 2014	Investigating the social norm and mathematical norms. Investigating the knowledge and belief of the teacher of mathematics and area measurement
Pre-test and interview	February 2014	Investigating students' prior knowledge of area measurement
Conducting the preliminary teaching	February – March 2014	Trying out and testing the initial HLT
Post-test and interview	March 2014	Seeking for the improvement of students understanding of area measurement.
Revising the initial HLT and learning activities	March 2014	Refining the learning activities and the initial HLT based on the preliminary teaching
Teaching Experiment (The Second Cycle)		
Pre-test and interview	March 2014	Investigating students' prior knowledge of area measurement
Meeting 1	March 2014	Comparing leaves and rice fields
Meeting 2	March 2014	Transactional Deal
Meeting 3	April 2014	Tiled Floors
Meeting 4	April 2014	Living Room Floor and Estimating Areas
Meeting 5	April 2014	Parallelogram and Triangle Building
Meeting 6	April 2014	Trapezoid Building, Rhombus and Kite
Post-test and interview	April 2014	Describing the development of students' understanding of the area measurement
Retrospective Analysis		

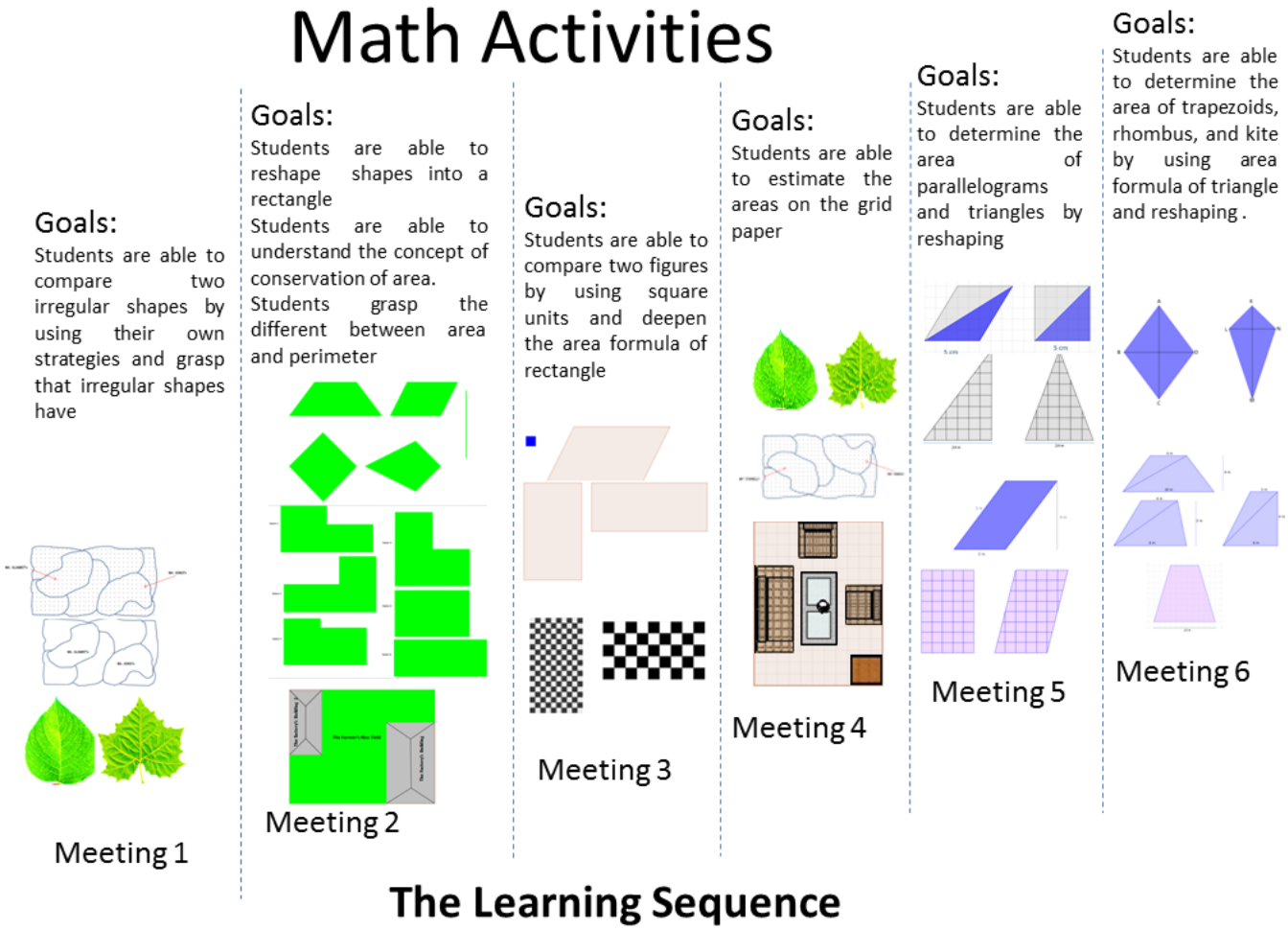
Data Analysis	April – June 2014	Analyzing the collected data from the experiment

LEARNING ACTIVITIES

Learning sequence in Cycle 1



Learning sequence in Cycle 2



Biography

Wahid Yunianto born in Jakarta, 2 June 1988, is a student of International Master Programme on Mathematics Education of Sriwijaya University – Utrecht University 2012. He is the first son of Katena and Sumiyatun. He spent his childhood and gained his education (TK Pertiwi Kemudo I, SDN Kemudo II, SMPN I Prambanan, SMAN I Jogonalan,in Klaten, Central Java. He got his undergraduate degree at Yogyakarta State University in 2011.

The writer was awarded a scholarship in 2012 to continue his master degree called International Master Programme on Mathematics Education (IMPoME) focusing on Realistic Mathematics Education. He got an English training from Dikti for 1.5 months at Sriwijaya University. Finally, in January 2013, he took some parts of his study at Utrecht University, the Netherlands. He completed his study for two years. The writer actively participated and joined students' organizations during his study. He joined Student Activity of Foreign Languages (2007-2009). He also joined Students Activity of Radio Broadcasting (2009-2011).He also did part time jobs as radio announcer and mathematics tutor.

The writer lives in Prambanan, Central Java and can be reached through HP: 085643763865 or email wahid_yunianto@yahoo.co.id. After completing his study, he plans to continue his study and do research on mathematics education.

THESIS BOOKLET

SUPPORTING 7TH GRADE STUDENTS' UNDERSTANDING OF AREA MEASUREMENT OF QUADRILATERALS AND TRIANGLES THROUGH REALLOTMENT ACTIVITIES

By: Wahid Yunianto

Supervisors:
Dr. Darmawijoyo
Dr. Ratu Ilma Indra Putri, M.Si

PREFACE

I am so grateful and all praise to My Lord, Allah SWT, who gives me such blessing to finish this booklet of my thesis "Supporting 7^{th} Grade Students' Understanding of Area Measurement through Reallotment Activities". My salutation to Prophet Muhammad, SAW.

This thesis has produced some research products of innovation in mathematics education. The researchers have contributed to a local instructional theory of area measurement. This study has been conducted at one of PMRI pilot school in Palembang, South Sumatra. Students developed their understanding of the concepts of area measurement though reallotment activities carried out in six meetings. Firstly, we conducted a pre-test followed by an interview in cycle 1 to know students' prior knowledge of area measurement. As the last meeting ended, students did a post-test to see what they have learned from the designed mathematical activities. A small group of students participated in the preliminary teaching cycle 1. We observed how the teacher taught before we begin the teaching experiment cycle 2. Twenty students participated in the teaching experiment cycle 2. They firstly did a pre-test and had an interview to some students. Students participated in six meetings with their classroom teacher. The teacher used the provided teacher guide and the revised HLT to teach. During the teaching and learning, students worked on the students' worksheet. All materials are compiled in this booklet.

We realize that this booklet is not perfect. Therefore, any suggestions will be appreciated and welcomed. We hope that this booklet will be useful for readers and teachers.

Palembang, June 2014

Wahid Yunianto

TABLE OF CONTENT

APPENDIX A

THE CLASSROOM OBSERVATION

Practical Classroom setting

• How many students in the class? How many boys and girls?
• Are students working and sitting in a group or not. If it's in group, how many students in each group.
• Who are the most active and the least active students?
• Time allocation of the teaching the lesson, the discussion, if it exists.

Teaching process

• How does the teacher start the class?
• How does the teacher conduct the lesson?
• How does the discussion run, if it happens?
• In the discussion, is the teacher bossy or not? Does she give the opportunity to students to explain their thinking?
• Does the teacher move around when the students do their work?
• Does the teacher pose question to stimulate or help students?
• What do usually the students use during the class, textbook or worksheet, tools, media?
• Is there any mathematical model used in the lesson?
• How many students do response to the teacher question? Enthusiastic or not?
• What the teacher usually do to get students' attention?
• How does the teacher deliver question to the students?
• How does the teacher reaction toward the students' answer, opinion or question?

Class organization

• How does the teacher interact with students?
• How do students interact among others?
• How do the students participate in the lesson?
• Does the teacher give a chance to other students instead of the best achiever students?
• How are the social norms on that class?
• Is there any irrelevant behavior during the lesson?

TEACHER INTERVIEW

Background:

• How long have you been teaching secondary students?
• In which grade(s) you have experienced in teaching mathematics?
• How long have you been teaching the seventh grade students?
• What do you think the goal of learning mathematics for students?
• Do you know about PMRI?
• Do you have any experience about PMRI, workshop, seminar or teaching with this approach?
• Do you think it is possible to implement PMRI as a teaching approach in your classroom?

Teaching process:

• What do you think about your class?
• What do you think about the students?
• What is your experience teaching area measurement for the first time in the seventh grade student?
• How do you usually teach the concept of area measurement?
• What do you usually use in your teaching?
• What do you think important students need to know in learning area measurement?
• How many meetings do you take in your lesson of area measurement?
• Based on your experience, what do you think the students will do if they face the problem like this (comparing two shapes without numbers and the area of irregular polygon) in the seventh grade?
• How do you usually guide the students to find the area of a parallelogram and a triangle?
• Have you ever taught the concept of conservation of area by reshaping in the process of learning area measurement?
• Do you know the importance of the concept of conservation of area in the process of learning area measurement?
• Do you think reshaping activities can to be included in the topic of area measurement in your teaching?

Class organization:

• How often do you make group work for students?
• How many students are in a group?
• What is your consideration for grouping the students?
• Do you make any special rules for the students during the lesson?
• What is the consideration of pointing a pupil during the class discussion?

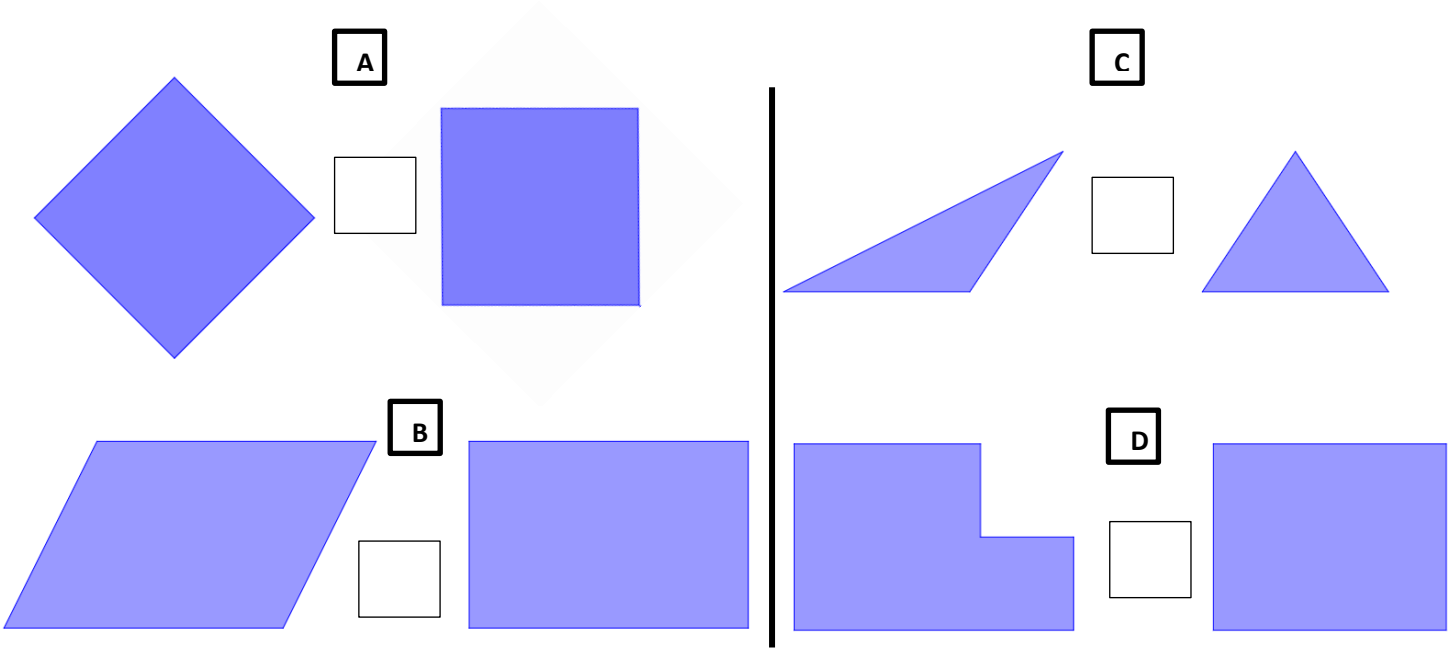
APPENDIX B

PRE-TEST

1. **Compare** the **areas** of these figures by giving a sign:

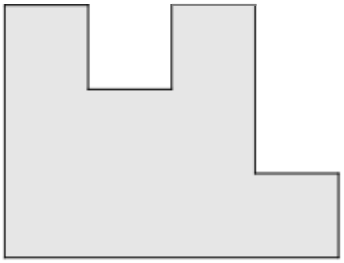
> or < or = between the figures

> means that the area is larger
< means that the area is smaller
= means that the area is equal



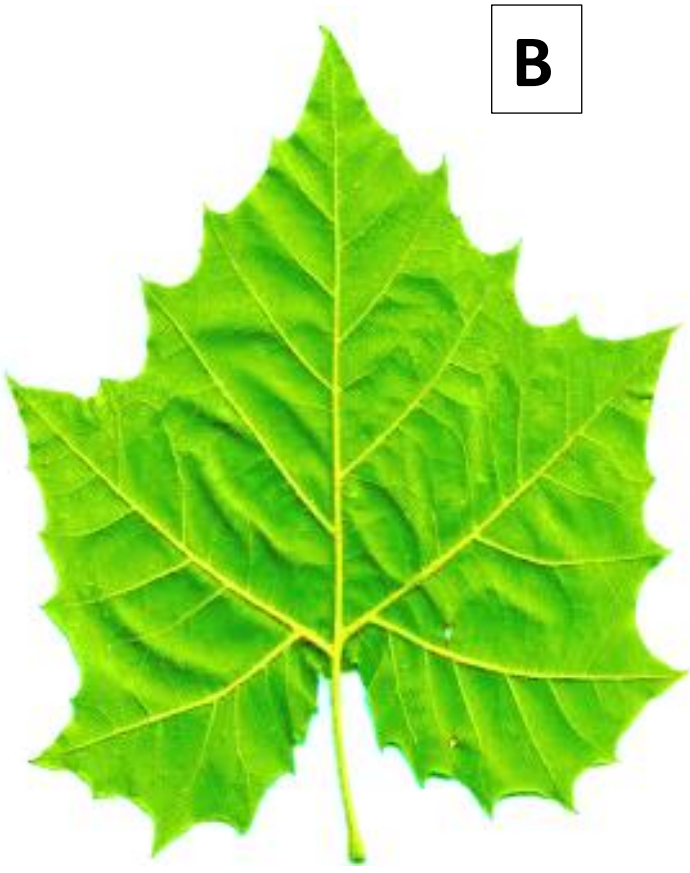
How do you solve it? Give your explanations

2. Determine the area and the perimeter of this shape.



How do you solve it? Give your explanations

3. Look at the two leaves below. Suppose that these leaves get the sunlight to do photosynthesis.

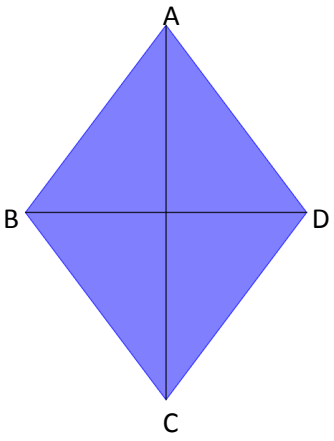


Determine which leaf will get more sunlight? **Hint:** the larger the leaf, the more sunlight it will get.

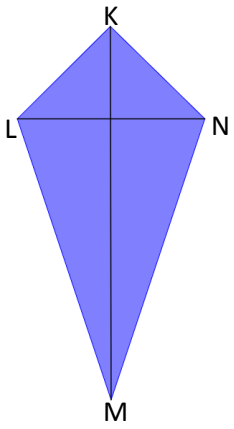
Explain how you solve it?

4. The following are a rhombus and a kite. Find the **areas** of these figures, if AC = ***8*** cm, BD = ***6*** cm, KM= ***8*** cm and LN = ***4*** cm.

Rhombus



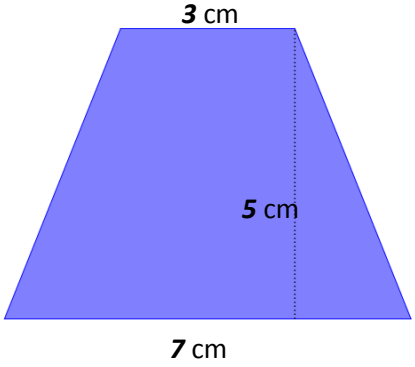
Kite



How do you solve it?

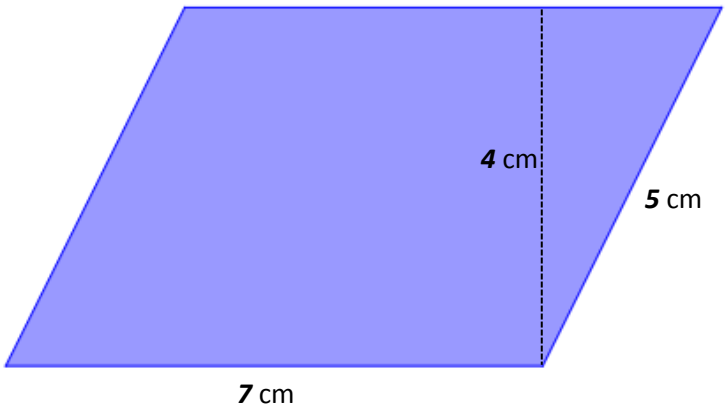
5. Find the areas of following figures.

Trapezoid

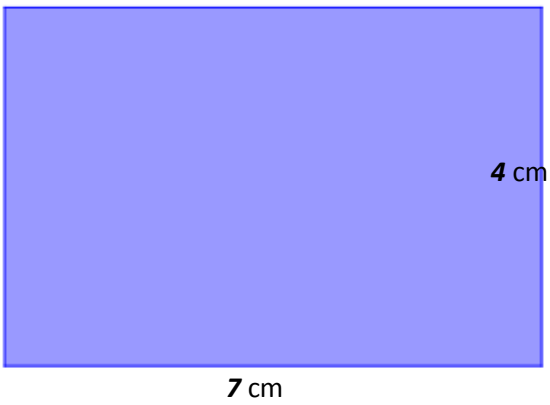


How do you find the area of this trapezoid?

Parallelogram



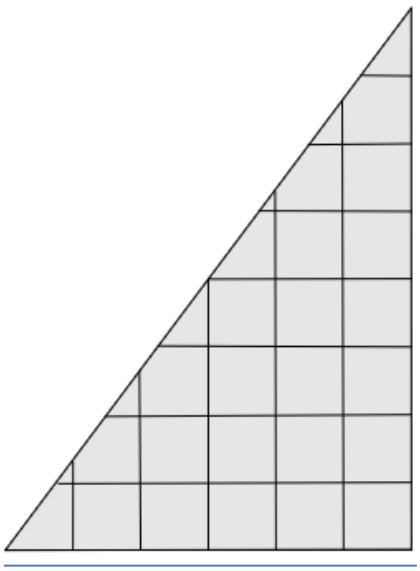
Rectangle



How do you find the areas of this parallelogram and rectangle?

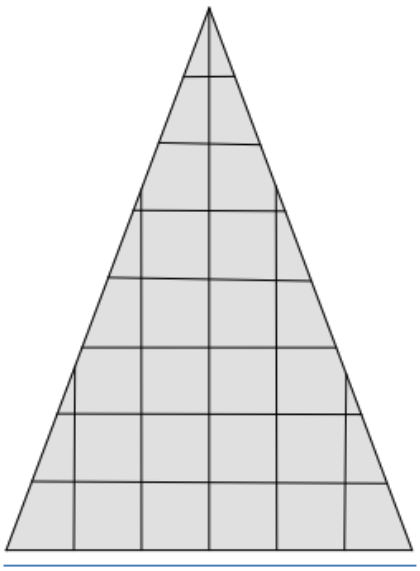
6. Find the area of each triangle?

A



24 m

B



24 m

How do you find the areas? Give your explanations

APPENDIX C

STUDENTS' WORKSHEET

Worksheet 1

Lesson 1 LEAVES AND RICE FIELDS

Look at the two leaves below.

Suppose that these leaves get the sunlight to do photosynthesis. **Hint:** the larger the leaf, the more sunlight it will get.

A

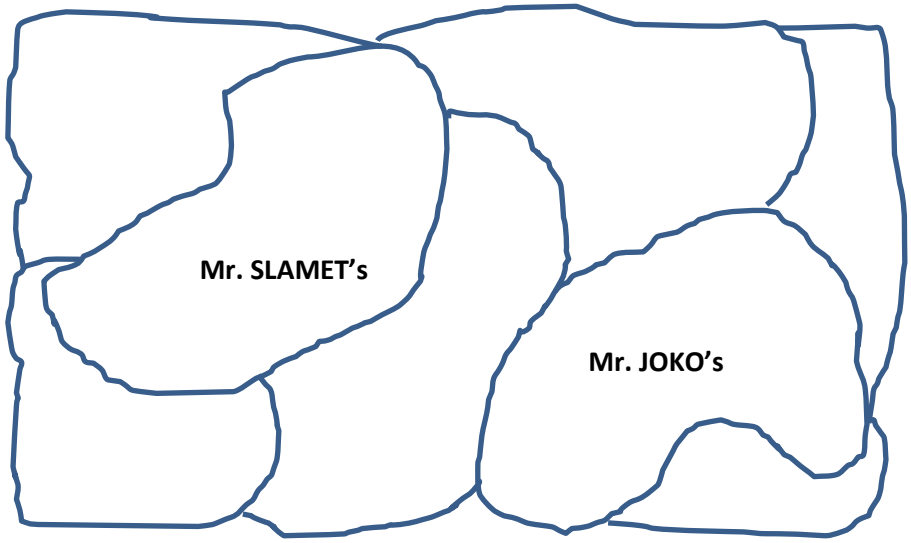
B

1. Determine which leaf will get more sunlight?

Explain how you solve it?

The picture on the left shows the rice fields in a mountainous area. Mr Joko and Mr Slamet are having a discussion about their crops. Mr Slamet argues that his rice field will produce more crop than Mr Joko's rice field. In this case they are going to plant the same type of paddy. Help them to solve this problem. Determine whose rice field will produce more crops.

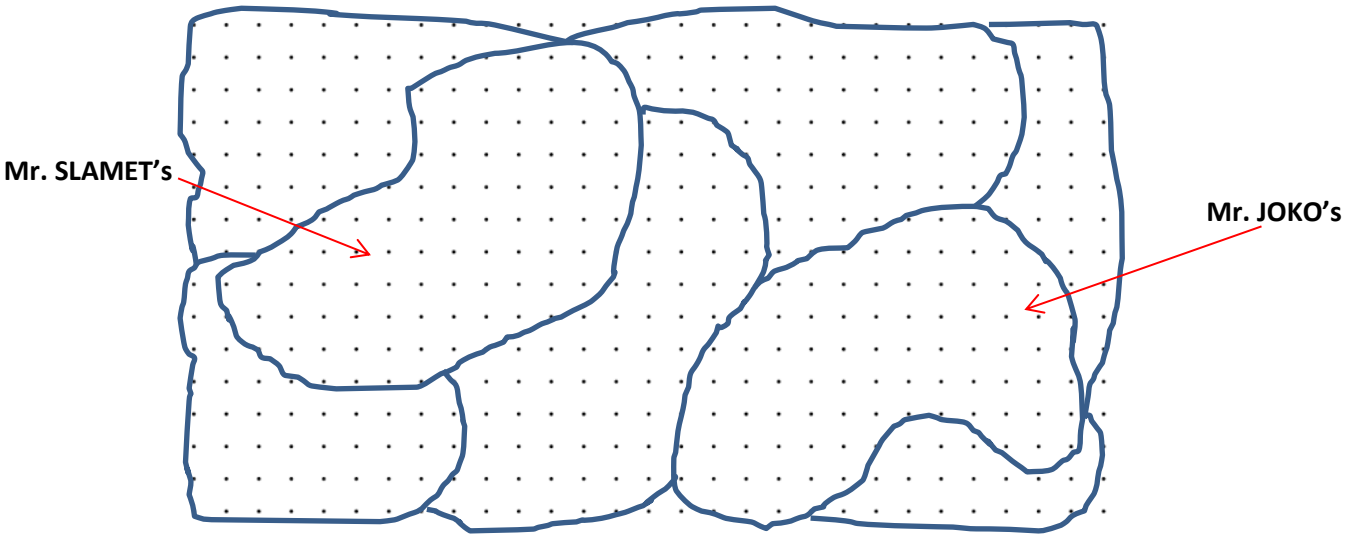
Whose rice field will have more paddies?



Then describe the method you use to solve this problem.

Worksheet 2

This month is the period for farmers to seed their paddies on their rice fields. Therefore, after the seeding we can see new paddy plants grow up in the rice fields. The picture below shows the situations after seeding period.



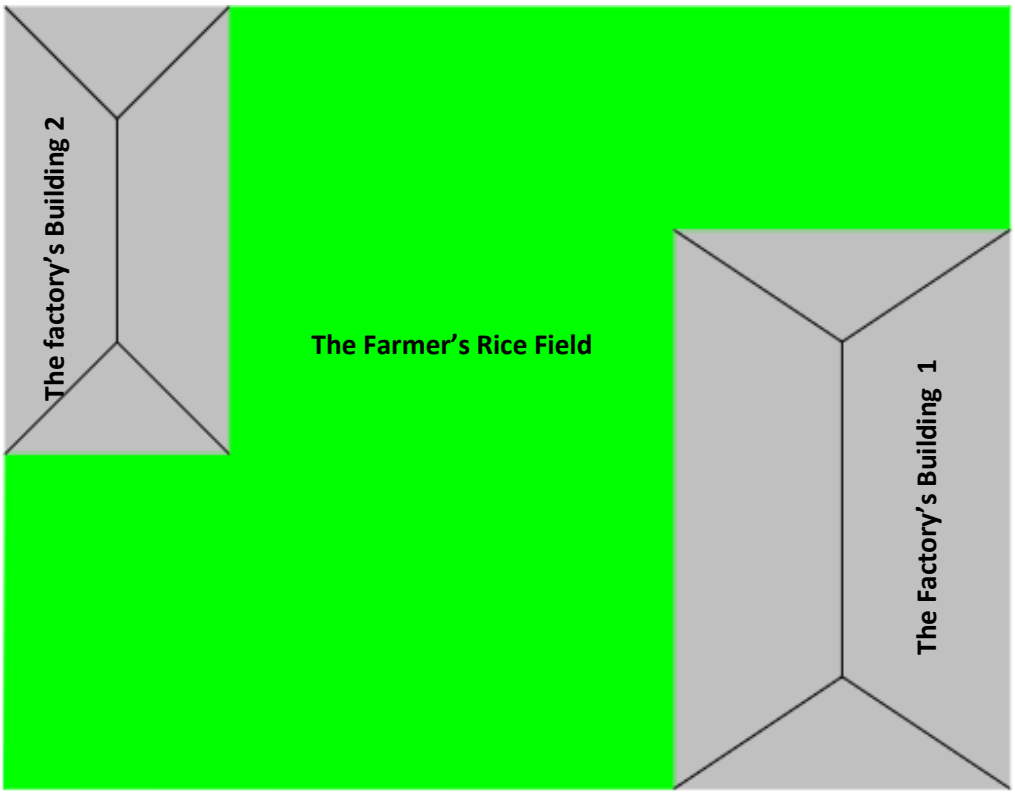
Determine whose rice field will produce more paddies.

Explain your way.

Worksheet 3

Lesson 2 RICE FIELDS

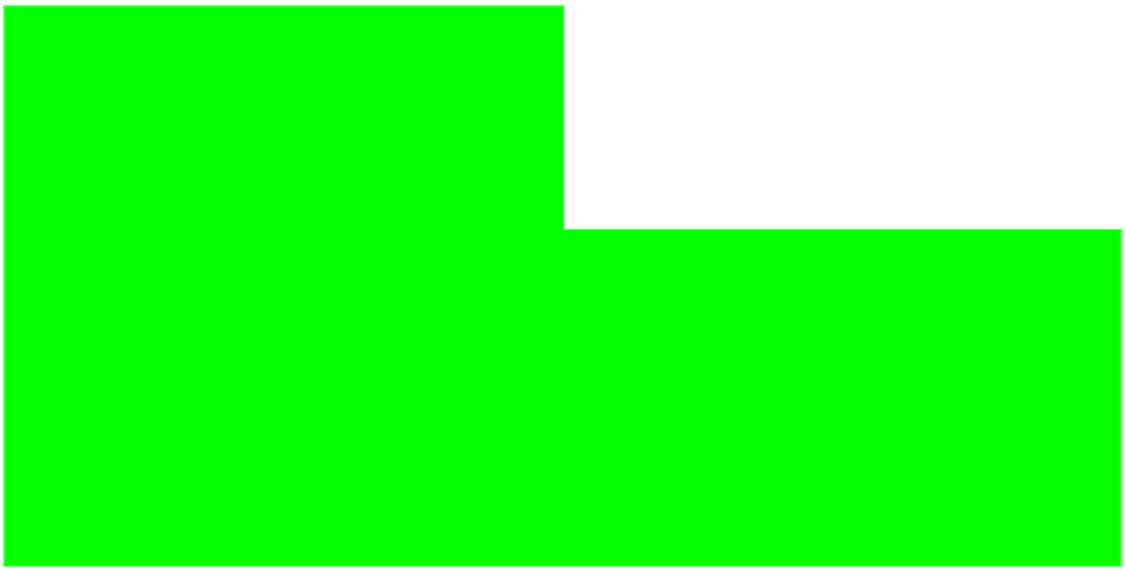
There are two factory buildings built near a rice field. The factory owner offers six different rice fields (options) to exchange the farmer's rice field. If the farmer wants to exchange this rice field, what will the farmer choose to exchange his rice field? The picture below shows the factory building and the farmer's rice field.



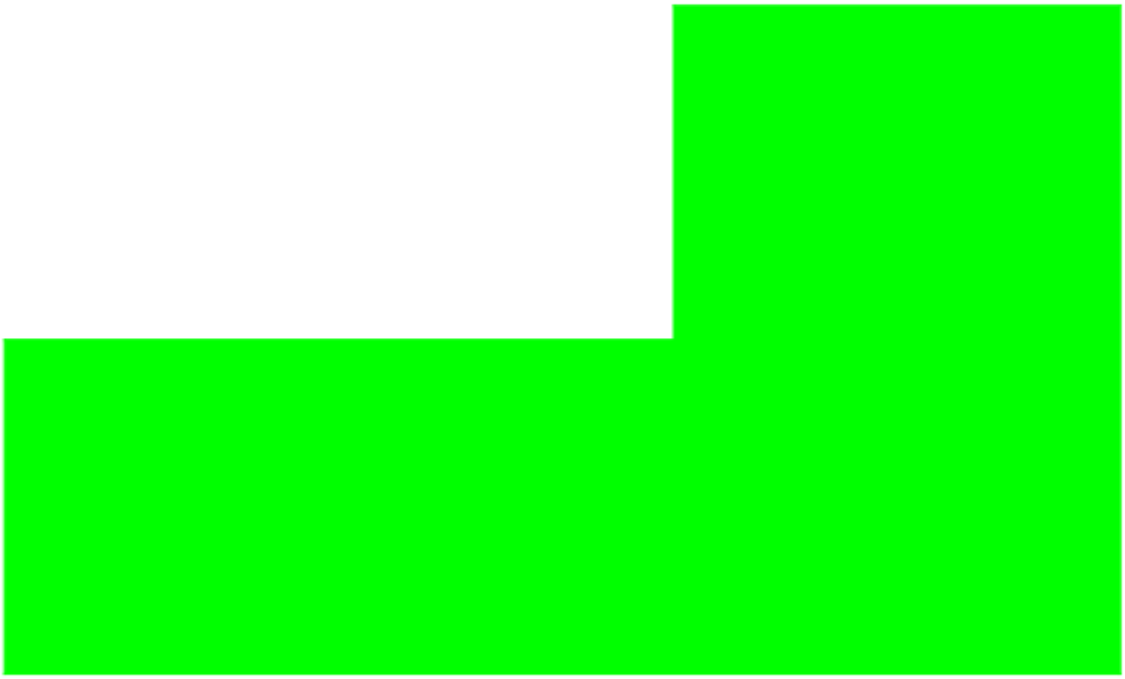
1. If you are the farmer, which rice field will be a fair exchange?
2. If you are walking around the rice field, which rice field has a shorter path, the farmer's rice field or the rice field you choose, why?

Explain your answer how you solve it?

Option 1

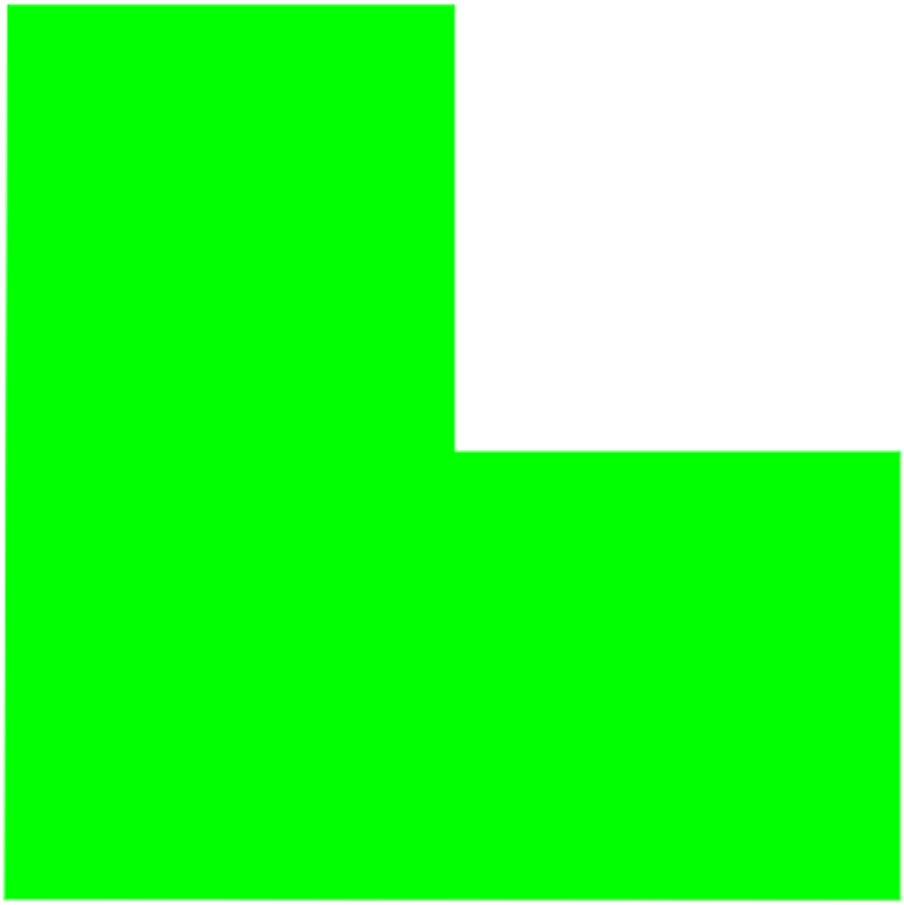


Option 2

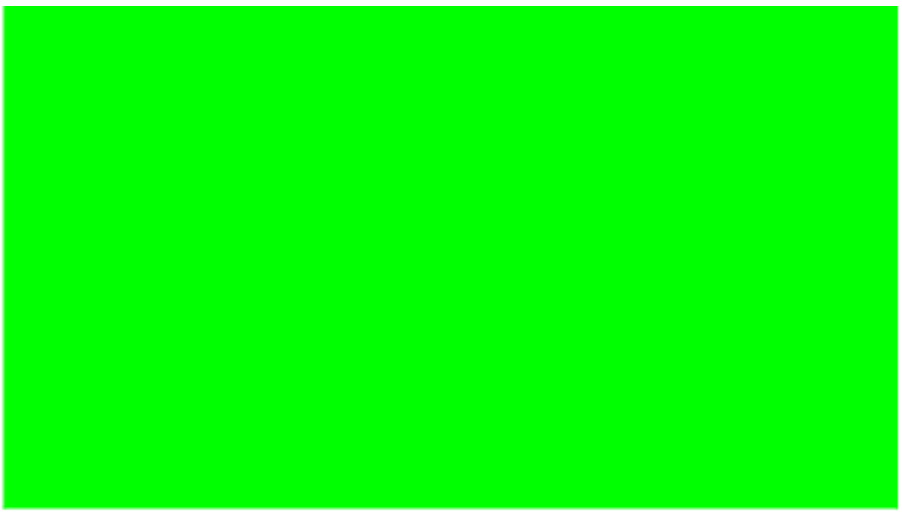


Option 3

Option 4



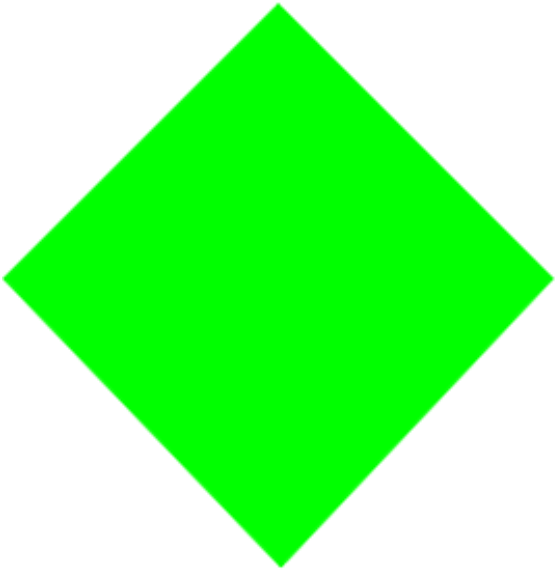
Option 5

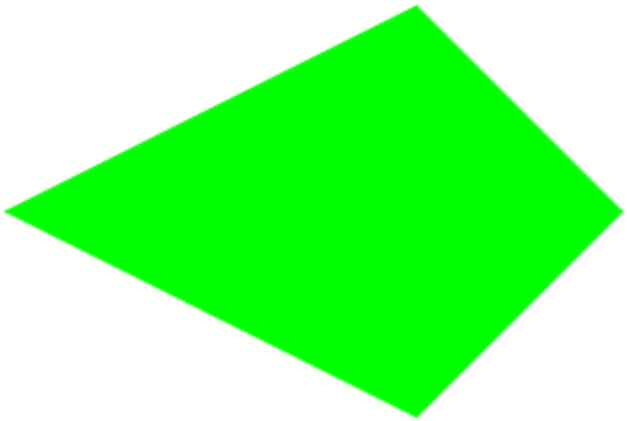


Option 6

Worksheet 4

If you reshape these rice fields into a rectangle, what happens to the size of these figures?

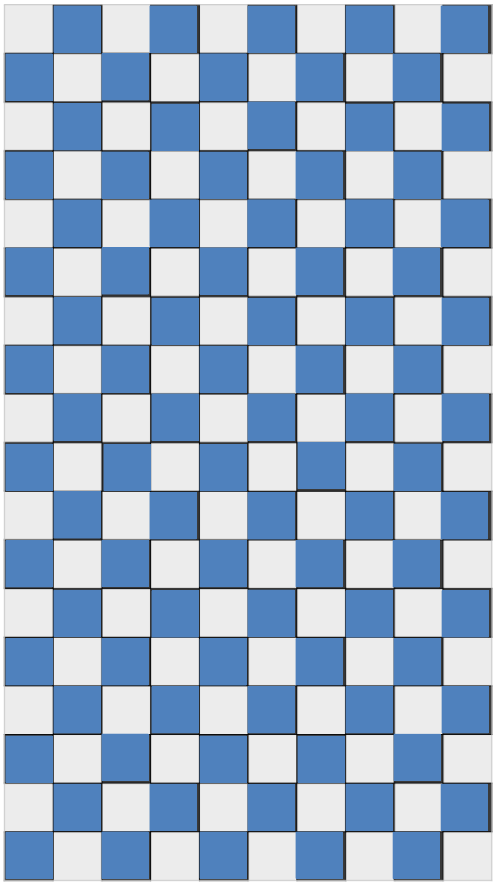




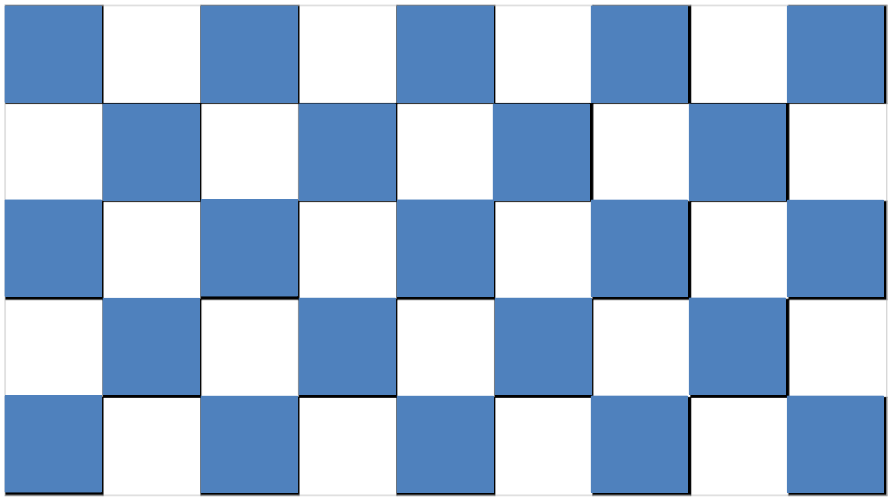
How do you do it?

Worksheet 5

Lesson 3 TILE & FLOOR



Floor A



Floor B

The figures show two floors.

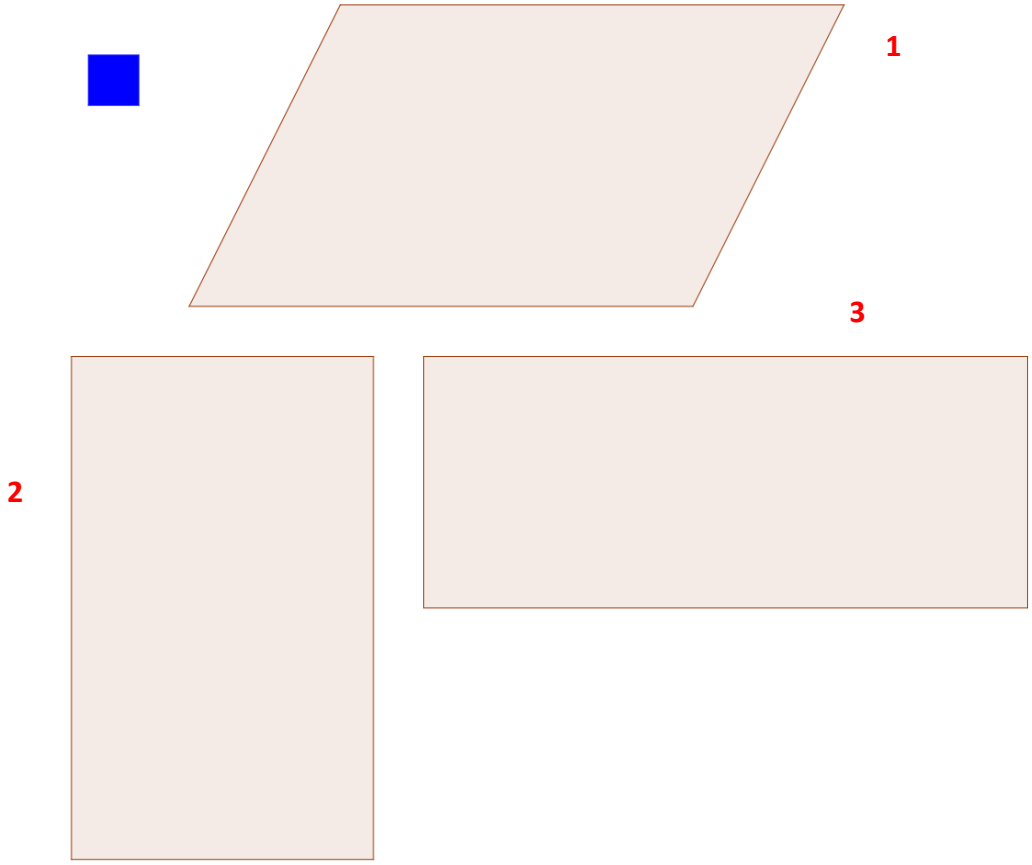
Rina says that floor A is bigger than floor B because it has more tiles.

Budi says: I think floor B is bigger because it has bigger tiles.

1. **What do you think? What is your answer? Explain your answer!**

Worksheet 6

These floors (1, 2, & 3) are going to be tiled. The blue tile is 25 cm x 25 cm.

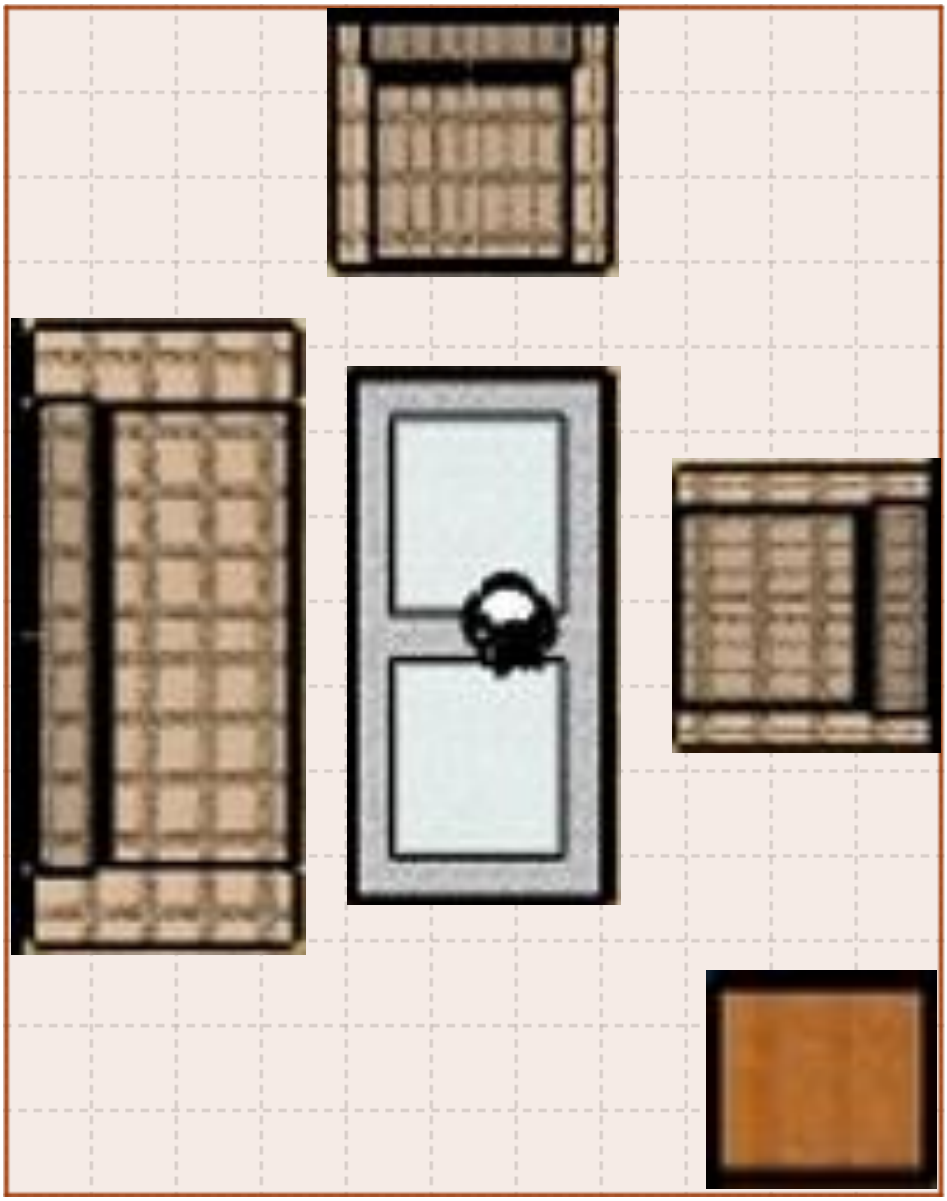


Compare the areas of the floors!

Explain your answer.

Worksheet 7

Lesson 4. TILED FLOOR & GRID PAPER

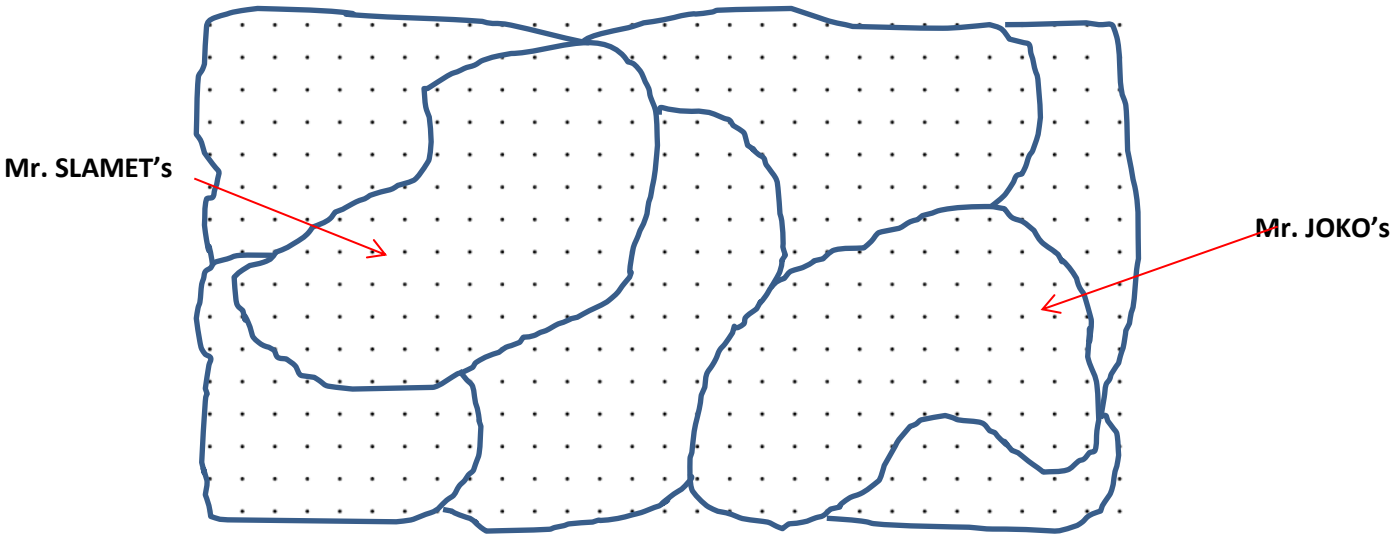


Mr. Slamet has completed the tiling on his living room. He puts some furniture on it. If one tile is 20 cm x 20 cm, can you determine how big his living room is?

How do you find the area of the floor?

Worksheet 8

Do you still remember about the rice field problem in the first meeting?



Can you now determine whose rice field is larger? **FIND** the areas of their rice fields!

How do you solve the problem?

Worksheet 9

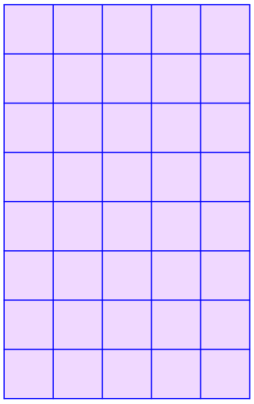
Do you still remember about the leaves problem?

Now, can you compare these leaves now? What will you do?

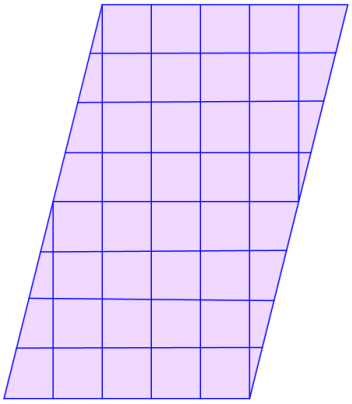
FIND the area of each leave!

Worksheet 10

Lesson 5 BUILDING & GLASSES I



Building A



Building B

The figure on the left shows two buildings seen from one side covered by glasses. One square glass is 5 m x 5 m.

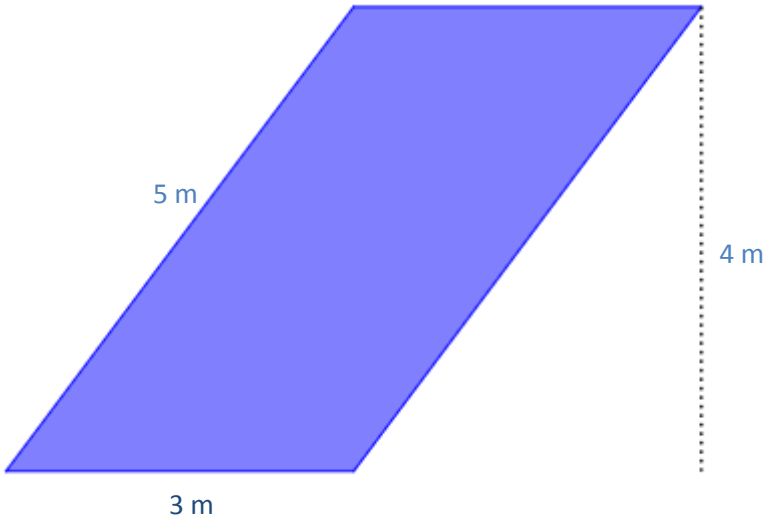
Compare these buildings, and find the area of this side of each building.

How do you do it?

What do they have in common? (Apa kesamaan yang dimiliki oleh kedua bangunan tersebut?)

What can you conclude?

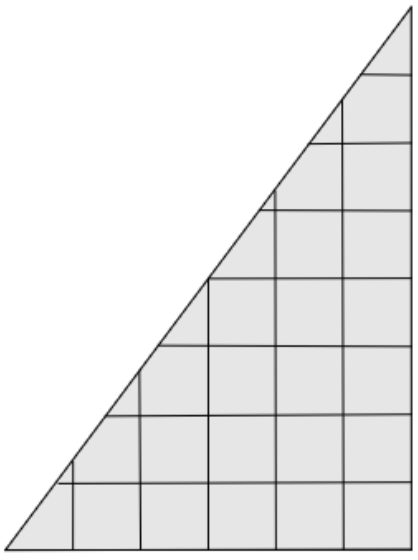
Worksheet 11



How do you find the area of the parallelogram above?

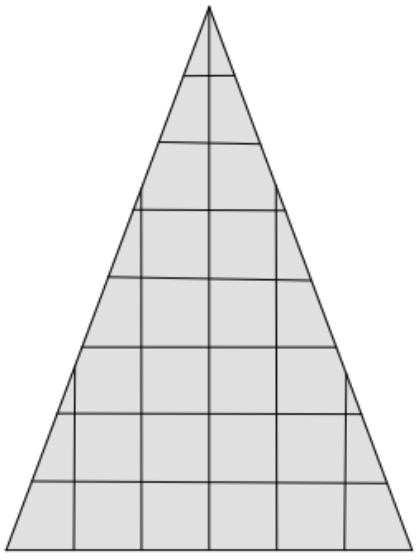
Do you find the formula to find it?

Building C



24 m

Building D



24 m

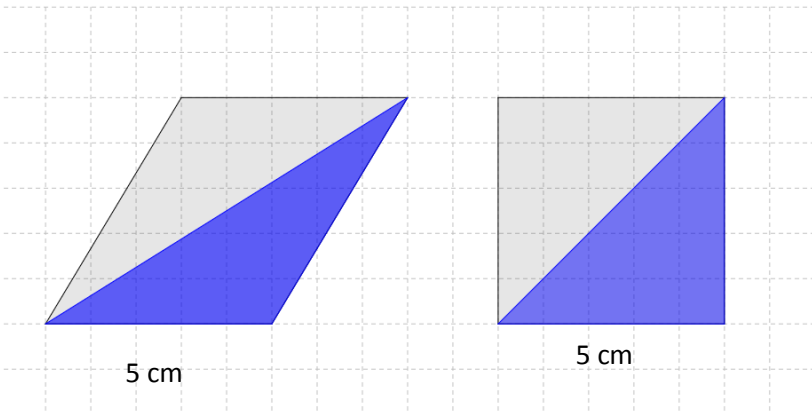
Worksheet 13

The pictures on the left show the building with triangle shapes seen from one side.

Find the areas of glasses in the side of these buildings.

Explain how you solve it.

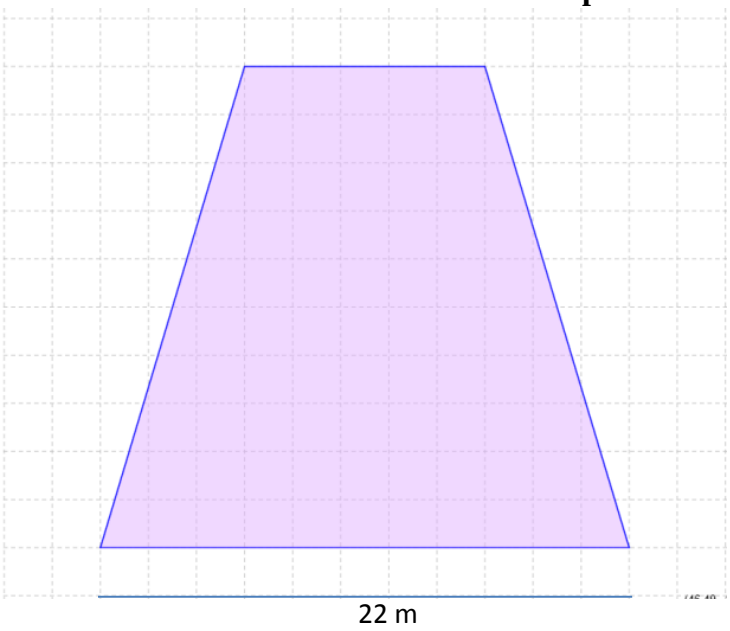
How many meter squares?



Find and compare the area of the shaded region of each figure on the left.

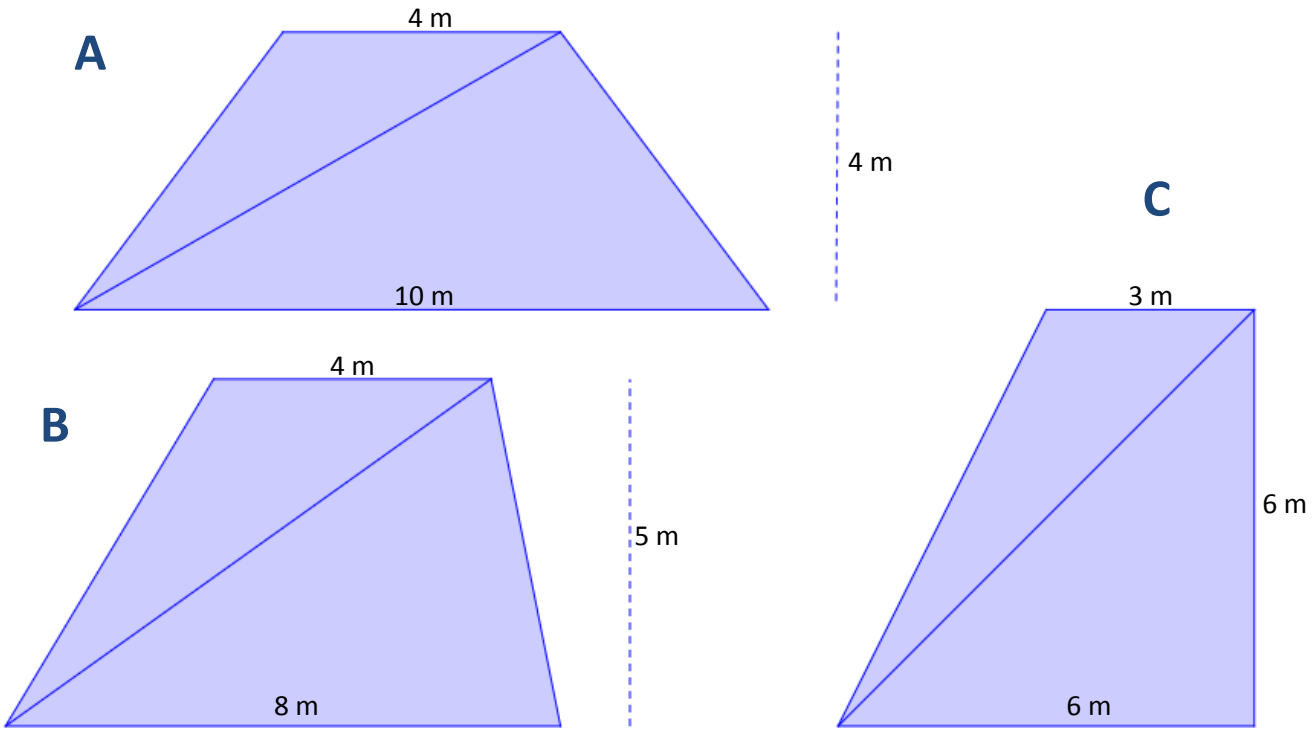
Worksheet 14

Lesson 6 BUILDING & GLASSES part 2



Find the area of glasses needed to cover this side of the building.

How do you solve it?

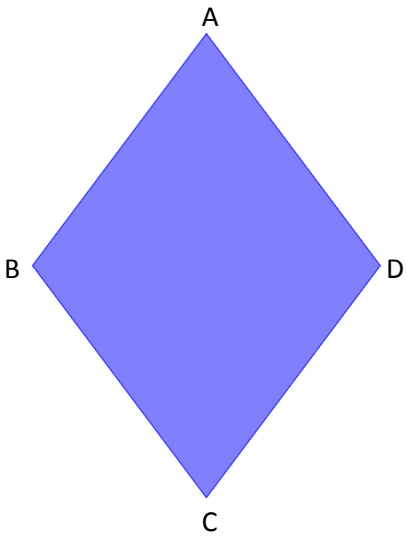


How do you find the area of the trapezoids A, B, C above?

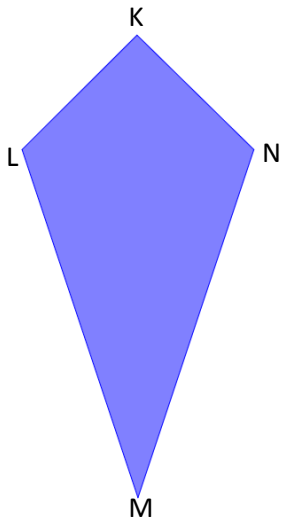
Worksheet 15

The following are a rhombus and a kite. Find the areas of these figures, if AC = 8 cm, BD = 6 cm, KM= 8 cm and LN = 4 cm.

Rhombus



Kite



How do you solve it?

Can you find the formula to find the area of each figure?

Rhombus:

Kite:

APPENDIX D

POST-TEST

1. **Compare** the **areas** of these figures by giving a sign:

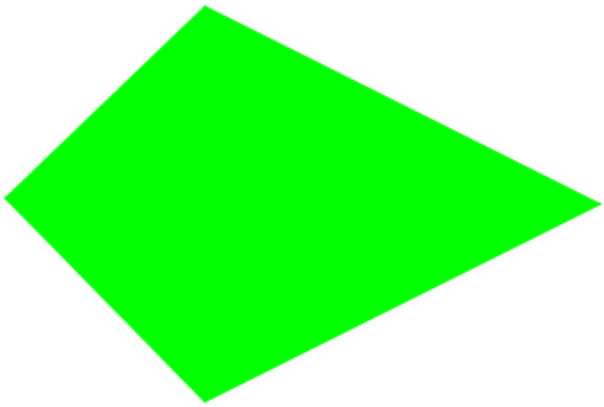
> or < or =

> means that the area is larger
< means that the area is smaller
= means that the area is equal

A

B

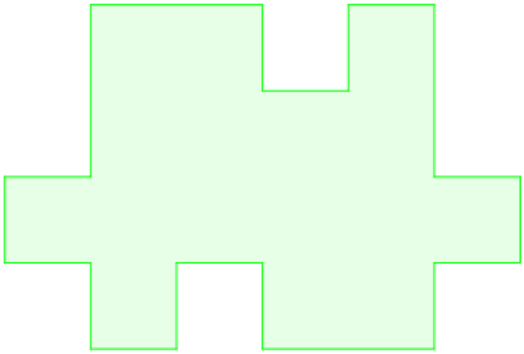
C



D

How do you solve it? Give your explanations

2. Determine **the perimeter and the area** of this shape.



How do you solve it? Give your explanations

3. Look at the two leaves below. Which one is larger?

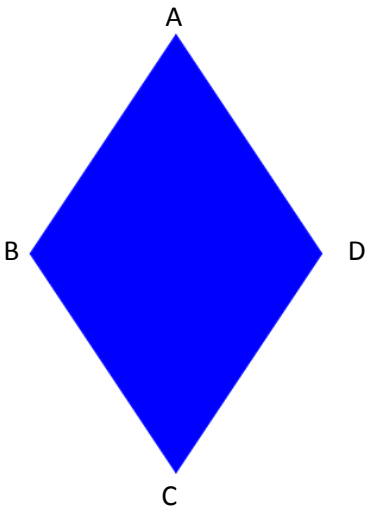
A

B

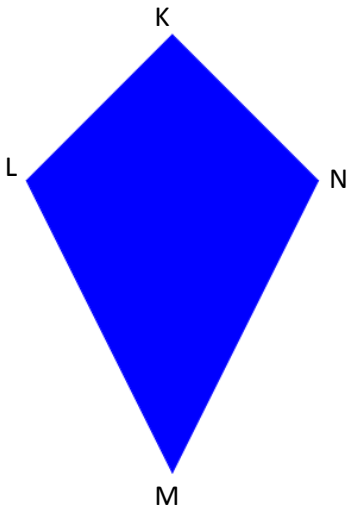
Explain how you solve it?

4. The following are a rhombus and a kite. Find the **areas** of these figures, if AC = ***6*** cm, BD = ***4*** cm, KM= ***6*** cm and LN = ***4*** cm.

Rhombus



Kite

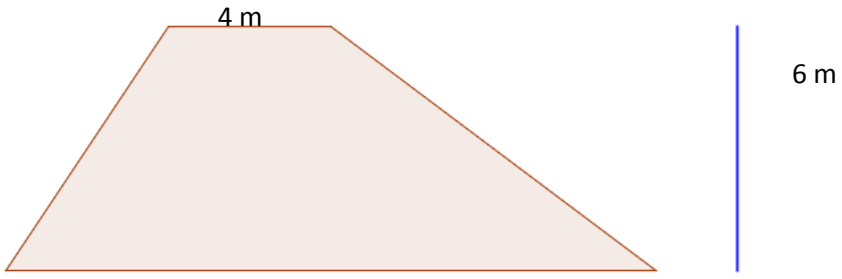


How do you solve it?

How do you know the formula?

5. Find the areas of following figures.

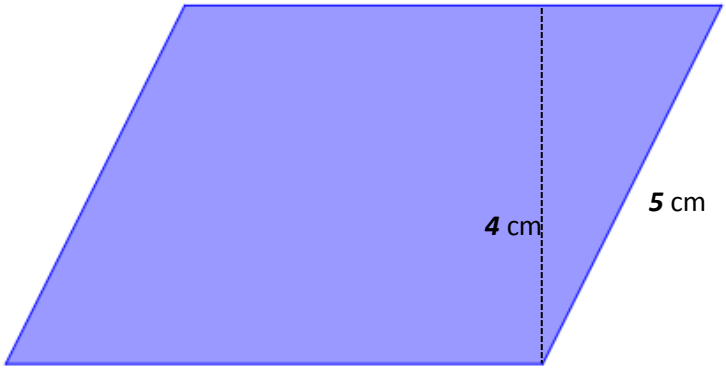
Trapezoid



How do you find the area of this trapezoid?

How do you now area formula of a trapezoid?

Parallelogram

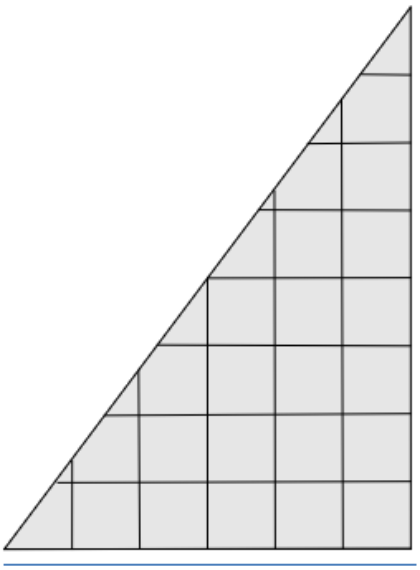


Rectangle

How do you find the areas of this parallelogram and rectangle?

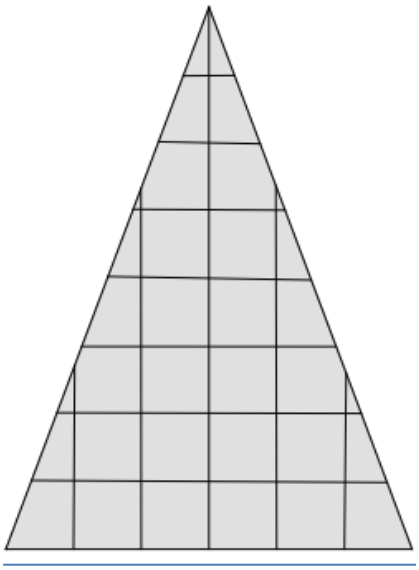
Find the areas of these triangles

A



30 m

B



30 m

How do you find the areas? Give your explanations

APPENDIX E

REALLOTMENT
AREA FORMULAS OF QUADRILATERALS AND TRIANGLES

Area conservation for area formulas for seventh grade students

Teacher guide

1st lesson

COMPARING LEAVES AND RICE FIELDS

Duration of lesson

2 x 40 minutes

Material

Scissors (two per group)

Glue or tape (one bottle or roll per group).

Worksheets of lesson 1

Learning Goals

1. The students are able to grasp the idea that the irregular figures still have area
2. The students are able compare areas of two irregular figures.
    2.1. The students are able to grasp the concept of area that is region inside of the boundary.
    2.2. The students are able to do overlapping to compare two figures
    2.3. The students are able to do cut and paste
    2.4. The students understand that cut and paste of a figure will preserve its area
3. The students grasp the idea of unit of measurements

The teaching and learning activities

1st session (Group) 18 min

The students are given a chance to refresh their knowledge of photosynthesis and the concept of area. The teacher shows on display of a tree and asks the students about parts of the tree that help the photosynthesis process. The students are expected to answer that the leaf is important to do photosynthesis. Then the teacher asks students about what influence the photosynthesis. The teacher will ask whether the area of leaf will influence the photosynthesis process or not.

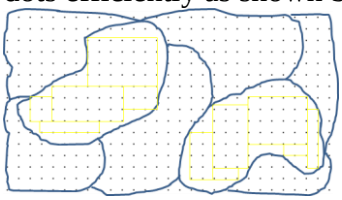
The teacher asks students about plants that produce food for human and where they can find those plants. The students are expected to reply "paddy" as their answer. The teacher asks students about rice field they know and later shows different shapes of rice fields. Each student is given worksheet 1

The activity	The role of the teacher
The refreshment of photosynthesis process and rice fields (max 5 min)	The teacher displays on the screen a picture of a tree and the sun or shows a video of photosynthesis process. "*How does a tree produce its food"* The teacher asks what photosynthesis is. Then asks students about parts of the tree that play important roles in the photosynthesis process. "*What plays important role in the photosynthesis process?"* The students are asked whether different shape of leaves will influence the process or not. Ask students about shapes of leaves they

	know. The teacher relates the photosynthesis process to the food and asks students to find plants that produce food for human. *"Can you mention plants that produce food for human and where do you find them?"* The teacher displays pictures of rice fields on the screen. The teacher distributes the worksheet 2
Understanding the problems (max 3 min)	After the teacher distributes the worksheet 1 to each group then ask students whether they understand the problems on the worksheet or not. *"Could you tell me what the problem is?"*
Working on leaves and rice field problem (10 min) The students will answer that leaf A will have more sunlight but the leaves have almost the same size. It is possible that students will only use their superficial judgment (perceptional judgment) by just looking at two leaves and say that leaf B is larger because it looks bigger or wider.	Ask students how they can be confident about their argument? *"How do you know it?" "How to prove it?"" How to convince others?"* If students have difficulties, then the teacher asks students if they have the leaves on their hands, what they will do. *"What will you do if you have those leaves in your hands?"* or *How can you compare the two leaves you are holding?* Ask students what they can do from the leaves on the worksheet. "*What can you do to the leaves on your worksheet? Do you need something?"* If students reply that they need something to cut, then provides the materials. Otherwise, just provide the materials.
Students will overlap and trace the leaves and cut some parts of the leaves and put it in the non-overlapping parts. 	Ask students whether when they cut and paste it will change the area or not. *"What happens when you cut the leaves? Will the area remain the same or not, why?"* Notice whether students throw away some parts of the leaves of not and bring this case in the discussion. Also notice how they cut the leaves. After students finish the worksheet 1, the teacher tells that they will discuss it later. In the discussion, present two groups that have different strategies or let group with the less sophisticated strategy to present first.
Students will cut the rice fields from the provided worksheet and overlap them. Then they will cut and paste like in comparing leaves.	Make notes how students cut the rice field and how they compare the rice fields. Tell students that they will have a discussion of their work later.

2nd session (Individual) 7 min

After students finish the worksheet 1, the teacher distributes the worksheet 2. The teacher also tells that the paddies are growing up now on both rice fields.

The activity	The role of the teacher
Comparing rice fields	The teacher asks students what they understand of the problem. *"Tell me what you know about the problem?"* The teacher asks students: "*What is the difference from the previous rice fields?"* *"What is the difference on the rice field now?* Now, Let students work on the worksheet 3 individually.
Students may count one by one the dots in each rice field and compared them. Student will make rectangles to count the dots efficiently as shown below:  Some students may use the similar strategy but they make a rectangle that contain the rice field and use multiplicative strategy to find how many dots in the rectangle. After that, students will subtract the dots with the dots outside the rice field.	If students count one by one the dots, the teachers may ask students whether they have another strategy to find the number of dots in a faster way. *"Do you have a faster way to count the dots?"* If student make rectangles and use multiplication strategy to count the dots, the teacher may ask: *"What do you do in counting the dots?* *" How does it work?"*
Students combine overlapping and counting strategies and count only the dots in the non-overlapping parts as shown below: 	If students only count the dots in the non-overlapping area, the teacher may ask: *"Why do you only count the dots only in the non-overlapping area?"* The teacher may make notes how students cut the rice field and how they compare them. Tell students that they will have a discussion of their work later.
Classroom Discussion (12 min) The chosen group or students will present their work. **The main conclusions are:** The leaves and the rice fields have irregular shapes but still have areas and we can compare their areas. The area is region inside the boundary. When we cut and paste the leaves or the rice fields, it will not change its original area, or the area remains the same. The dots may help also to compare the areas.	The teacher will not give the correct answer but just lead the discussion in the right track. The teacher may ask students who do not present the question: *"Do you know what they have just explained?"* *"Could you tell me what they explain your words?* *"Do you agree with what they say?, Do you have another solution or strategy?* After the discussion, the teacher and the students will conclude together what they leaned today.

Teacher Guide

2nd Lesson

RICE FIELD'S TRANSACTION DEAL

Duration of lesson

2 x 40 minutes

Material

Scissors (two per group)
Strings (one bundle per group)
Pins (one packs for each group)
Glue or tape (one bottle or roll per group).
Worksheets of lesson 2

Learning Goals

1. The students are able to do overlapping to compare two shapes
2. The students are able to understand the concept of conservation of area.
   2.1. The students are able to do cut and paste
   2.2. The students are able to understand that when they cut and paste (reallot) the rice field and make into another shape preserve its original area but the perimeter will be different.
3. The students understand the difference between the perimeter and area
4. The students are able to reshape figures into a rectangle.

The teaching and learning activities

1st session (Group) 25 min

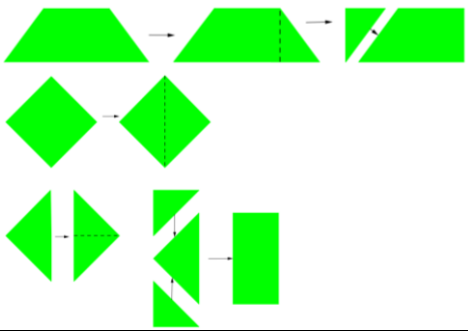
The students are given to deepen their strategy in comparing area of two figures. The teacher now asks students to decide which rice field to fairly exchange the farmer's rice field by providing some options of rice fields.

The activity	The role of the teacher
Transaction deal	Here, the teacher tells that the office owner has some options to the farmers. The teacher distributes the worksheet 3 to each group. The teacher asks students what they understand of the problem. *"Tell me what you know about the problem?"* The teacher asks students what is called fair in this transaction? *"What do you think of the fairness in this transaction?* Now, let students work on the worksheet 3 in group
Some students may choose one of the options and maybe more than one. Students only judge superficially based on their visual. They will say that it is fair because the farmer will get a longer rice field or it is not fair because the shape is different.	Ask students to convince their arguments *"Tell me the reason why you think so?"* *"Can you convince others?"* *"Maybe the materials can help you"*
Students will choose rice field which has the same perimeter as the farmer's rice field by using the string. Students will choose the rice field which has the same area by reshaping the farmer's rice field.	If students choose the rice field with the same perimeter, just let them to do so and this group will present in the classroom discussion. If students cut and paste the farmer's rice field to fit the optional rice field, ask students

Students will choose the rectangular rice fields because it is regular and common.	*"Why do you do that", What is your goal by doing that?* If students choose only the rectangular rice fields, ask: *Why do you choose them? Do they have the same area?* After students finish worksheet 3, tell students that they will discuss their work later.

2nd session (Individual) 20 min

After students are able to differentiate between area and perimeter and they understand the concept of conservation of area, they will explore to reshape geometrical figures into a rectangle.

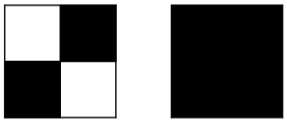
The activity	The role of the teacher
Reshaping into a rectangle	The teacher asks students whether the area of a figure remains the same or not when they reshape it. *Will the area change when you reshape a figure?* Then, distribute the worksheet 4 and let students work individually.
As students are able to do rehaping in previous activity since this geometrical figures are easier to reshape. 	Ask students how they reshape it. *What did you do first? Did you do trial and error? Or do you have your way to reshape them?* Ask also Ask also: *If you reshape, what will remain the same and what will not?* *What do you know about area and perimeter? Do you think it will help you to find the area of the geometrical shapes after reshaping them? why?*
Classroom Discussion (20 min) The chosen group or students will present their work. **The main conclusions are:** Reallotment activity by reshaping or cutting and pasting will preserve the area but not the perimeter. The area is region inside within the boundary. The perimeter is the boundary of the figure	The teacher will orchestrate a class discussion of students' work on worksheet 3 and 4. The teacher will not give the correct answer but just lead the discussion. The teacher may ask students who do not present the questions: *"Do you know what they have just explained?"* *"Could you tell me what they explain in your words?" "Do you agree?, why and why not?"* After the discussion, the teacher and the students will conclude together what they learned today.

Teacher Guide
3rd Lesson
TILES AND FLOORS

Duration of lesson
2 x 40 minutes
Material
Worksheets of lesson 3
Learning Goals
1. The students are able to compare two floors with different size of tiles as their unit measurements.
2. The students are able to grasp the need of unit of measurement
   2.1. The students are able to compare two floors with the same unit of measurement.
   2.2. The students are able to cover the floor with the same unit measurement
3. The students understand the area formula of rectangle
4. The students are able to determine areas of rectangles from given length of its sides.

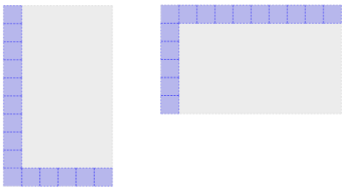
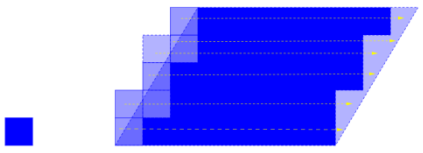
The teaching and learning activities
1st session (Group)
The students are given to deepen their strategy in comparing area of two figures integrated with unit of measurement. The teacher now asks about the floors that they ever see, and how they look like. Ask student whether they can determine which floor is larger without any measurement tool?
The teacher distributes worksheet 5 to each group

The activity	The role of the teacher
Comparing tiled floors	The teacher asks students whether they understand the problem on worksheet 8 or not. *"Could you tell me what do you about the problem?"* After the students understand the problem, let them work on the worksheet 5. Do not provide materials like scissors or tools to cut. Let students use their strategies to compare the floors.
Students will count the number of tiles on each floor either one by one or using multiplication strategy. Students will compare the number of tiles from the floors and says that floor A is bigger since it has more tiles or some students will say that floor B is bigger since it has a bigger tile. Students will take one tile of each floor and compare them. 	If they found that the floors has the same size. Ask: *How do they have the same area? They have different size of tiles? Can you explain why?* If students count the tiles *How do you find the number of tiles in each floor?* If there is an answer that they judge the floor based on the number of tiles, let this group present in the class discussion. If students compare the tiles, ask them, *"How do you compare them?" Do you think that you need the same tiles to compare the*

Students may realize that the tile on floor B is for time as big as the tile on floor A. 	*floor?* Tell students that they will discuss their work later

2nd session (Individual)

After students compare the tiled floor, the ask students whether they know how to tile a floor? How to determine the number of the tiles to tile a floor? The teacher distributes the worksheet 6 to each student.

The activity	The role of the teacher
Tiling floors	The teacher asks students whether they understand the problem on worksheet 8 or not. *"Could you tell me what do you about the problem?"* After the students understand the problem, let them work on the worksheet 6.
Students will easily tile rectangle floors by putting some tiles on the edges of the floors and use multiplication strategy to count the tiles as follows:  Or they continue to tile fully the floor by using a ruler and count the tiles. Students will tile with possible position of full tile unit and cut the remaining parts then paste then to the untilled parts. Students may reshape the floor into a  rectangle and then tile it. Students may do trial and error.	The teacher prepares the material such as rulers if students need them. The teacher will not provide the tools to cut. Ask students: *What do you do to cover the floors?* Or suggest: *You may use pencil to draw your tiles.* *If students only draw or tile only some parts on the edges of the floor, ask:* *Can you determine the number of the tiles by tiling some parts? Why?* *When students cover all the floors by tiles, ask them how they count the number of the tiles?* *How do you count the number of the tiles?* *If they count one by one, ask do you have a faster way to count them?* When students have difficulties in covering the parallelogram floor, suggest: *You may cut the tiles.*

Classroom Discussion The chosen group or students will present their work.	The teacher will orchestrate a class discussion of students' work on worksheet 5 and 6. The teacher will not give the correct answer but just lead the discussion. The teacher may ask students who do not present the questions: *"Do you know what they have just explained?""Could you tell me what they explain in your words?" "Do you agree?, why and why not?"* After the discussion, the teacher and the students will conclude together what they learned today. **The main points of conclusions :** We can compare area of two figures by using the same unit of measurement. The area formula of rectangle is *length x width* or *base x height* We can find the area of a rectangle by multiplying its length of base and height.

Teacher Guide

4th Lesson

TILED FLOOR AND GRID PAPER

Duration of lesson

2 x 40 minutes

Material

Worksheets of lesson 4

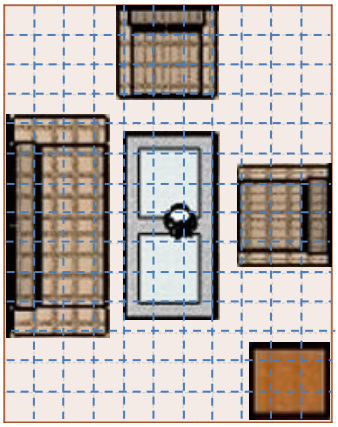
Learning Goals

1. The students are able to determine the area of a floor using the multiplication strategy and apply area of formula to find the area of a floor.
2. The students are able to grasp the need of a square as unit of measurement
   2.1. The students are able to estimate the area of an irregular figures
   2.2. Students are able to estimate and compare the area of two irregular figures with different size of unit of measurement.
   2.3. Students can make paper grid by themselves to estimate the area of an irregular figure.
   2.4. Students understand that the smaller unit of measurement, the more accurate its estimation.

The teaching and learning activities

1st session (Group)

After students explore the unit of measurements, covering floor and structuring array and understand the area formula of rectangle, student will explore the use of unit of measurement to measure areas of irregular figures. Here the teacher relates to the tiled floor of a living room with furniture to let students deepen the use of multiplication strategy in measuring area. Then students will use the unit of measurement to estimate the area of irregular figures and later on will make use grid paper.

The activity	The role of the teacher
Determining the area of a living room	The teacher begins with relating the tiled floor with the tiled living room. The teacher asks students what furniture in their living room. Then the teacher poses a question whether they can measure the area of their living room or not. The teacher distributes the worksheet 7. Ask students whether they understand the problem on worksheet 8 or not. *"Could you tell me what do you about the problem?"* After the students understand the problem, let them work on the worksheet 7.
Students draw lines to trace the tile from the visible lines of the tiles. Then they will count the tiles one by one or by using a multiplication strategy 	The teacher just let students do with the strategies they use. If they have difficulties ask or suggest to use any tool to help *Do you need something for help? A ruler or straightedge maybe useful.* If students try to count one by one, pose a question: *Do you have a faster way to count? Do you still remember what you learned in previous meeting?* If students use multiplication strategy, ask the students *how long the length and the width of the floor? Can you use the formula that you have in previous meeting?* *Always remind students the standard unit of measurement, is it cm or cm^2?* After student finish the worksheet, the teacher tell students that they will discuss it later.

2nd session (Individual)

The students will explore the use of unit of measurement to solve the problems in meeting 1 related to irregular rice fields. Student will estimate the area of the rice fields and leave by using unit of measurement. They are expected to make use the dots and make the grid and estimate the area of the rice fields.

The activity	The role of the teacher
Comparing area of irregular rice field with unit of measurement.	The teacher reminds students to the problem of comparing irregular rice fields. The teacher will ask: *Would you be able to solve this problem now?* The teacher distributes the worksheet 8 to each group.
Students will connect the dots with a straightedge or a ruler. And estimate the	If the students still count the dots, suggest students to connect the dots with a ruler.

square units fit the leaves.	*You may use a ruler to connect the dots.* Let students to solve the problem, some assistance are needed if students have difficulties counting the square units. *"Do you have another way to count the square units"*
Students will make their own grid paper and put the leaves on it and count the number of squares units and estimate the area.	The teacher can ask: *How do you find the area of the carpet from the tiles? How many tiles do you think that are covered by the carpet?* The teacher may remind students of the reallotment activity, *you may reshape it to make you easier to estimate.* After student finish the worksheet, the teacher tell students that they will discuss it later.

3rd session (Individual)

Students will explore to use unit of measurement to estimate area of irregular figures and compare their areas. Students will solve the same problem in the 1st meeting of comparing leaves. Students will make their grid paper with different sizes, for instance 2 cm x 2 cm and 1 cm x 1 cm. Students will understand that the smaller the unit of measurements, the more accurate their estimation.

The activity	The role of the teacher
Comparing area of leaves	The teacher reminds students to the problem of comparing leaves. The teacher will ask: *Would you be able to solve this problem now?* The teacher distributes the worksheet 9 to each group.
Students will draw a grid paper and estimate the area of each leaf.	If students draw a grid paper with a big size, 2 cm x 2 cm, suggest them to try a smaller size, for instance 1 cm x 1 cm. Then ask them whether the result is still same or not. *Will the result be different if you make a smaller grid paper? Which one estimates better?*
Students will do reallotment and estimate the area of each leaves.	If students have difficulties estimating the area since there are some non-full square units, the teacher may suggest to reallot parts of non-full square unit of the leaf.

Classroom Discussion The chosen group or students will present their work.	The teacher will orchestrate a class discussion of students' work on worksheet 7, 8 and 9. The teacher will not give the correct answer but just lead the discussion in the right track. The teacher may ask students who do not present the questions: *"Do you know what they have just explained?"* *"Could you tell me what they explain in your words?" "Do you agree?, why and why not?"* After the discussion, the teacher and the students will conclude together what they learned today. **The main points of conclusion :** We can find the area of a rectangular floor by multiplying the number of tiles in the edges of the floor. We can use a paper grid to estimate an area of a figure. The smaller the square units, the better it estimate area of a figure

Teacher Guide
5th Lesson
BUILDING AND GLASSES

Duration of lesson
2 x 40 minutes
Material
Worksheets of lesson
Learning Goals
1. Students are able to reshape parallelogram and triangle into a rectangle.
2. Students are able to derive the area formulas of parallelogram and triangle from the area formula of rectangle.

The teaching and learning activities
1st session (Group)
Students will explore the relation between a rectangle and a parallelogram. Students will reshape the parallelogram into a rectangle and see the relation to determine the area formula of a parallelogram. The teacher begins with asking students where they can find parallelogram. The teacher shows a building with parallelogram shape, and asks students whether they can determine how many glasses to cover the side of the buildings.

The activity	The role of the teacher
Comparing areas of a rectangle and a parallelogram	The teacher asks where students find parallelogram in their surroundings. The teacher will show a building with a parallelogram shape and ask : What is the height of this building? Can you

The activity	The role of the teacher
	determine how many glasses to cover that side of building? The teacher distributes the worksheet 10 to each group.
Students may count one by one the square units	If students count one by one, ask: *"Do you have a faster way to count the square units?* *Do you still remember how to find an area of a rectangular floor?* If students have difficulties in counting the number of square units in the parallelogram, suggest student to reshape into another figure. *Maybe, you can reshape it into another figure.* Or remind their previous activities. After students find that the rectangle and the parallelogram have the same area. Ask: *If they have the same base, height, do you think they have the same area? Can you use the area formula for rectangle?*
Determining the areas of parallelograms.	After some minutes and students have finished the 1st problem, the teacher then asks to work on the next problem. The teacher may suggest, *Maybe, you can try to use the formula and prove it by reshaping.*
Students may reshape the parallelogram into a rectangle and use a multiplication strategy. Students may just use the formula of rectangle	If students reshape the parallelogram into a rectangle and use multiplication strategy or area formula for rectangle, the teacher asks: *Can you say that the area formula of a parallelogram is same with the formula of rectangle? So, what is the general area formula of parallelogram?* If students only use the formula, the teacher may ask: *How can you use the area formula of a rectangle? Why does it work? Can you tell me the relation between the rectangle and the parallelogram? Can you generalize the area formula of parallelogram?*

2nd session (Group)

Students will explore the relation of a rectangle and a triangle. Students will reshape a triangle into a rectangle to find its area. Students will understand why the area formula of triangle is 1/2 (base x height) that is a half of the formula of a rectangle.

The activity	The role of the teacher
Determining areas of triangles	The teacher asks students where they can find a triangular shape. The teacher reminds students about a unique building, in previous

	problem, a parallelogram building. The teacher shows a picture of building with triangular shape. The students are asked whether they can find the area of glasses to cover the side of the building. *Could you find the area of glasses to cover the side of the building?*
Students may count one by one the square units	If students count one by one and have difficulties, ask: *"Maybe, you can reshape it into another figure"* After student reshape the triangle into a rectangle, and still count one by one the square units, ask: *Do you have a faster way to count them? Do you still remember the area formula of rectangle?* *What is the formula now?* *See the base of your triangle and the base of the rectangle. What can you conclude?*
Determining the areas of shaded areas. The students will count one by one the square units. The students will use the formula of parallelogram and rectangle and divide by two.	If students count one by one the square unit, suggest them: *What do you think of the area in a whole figure?* *What do you think the area of the shaded part? What is the relationship with the parallelogram and the rectangle?* If students use the formula of parallelogram and rectangle, ask *So, what do you think of the area of a triangle?*
Classroom Discussion The chosen group or students will present their work.	The teacher will orchestrate a class discussion of students' work on worksheet 10, 11 and 12. The teacher will not give the correct answer but just lead the discussion in the right track. The teacher may ask students who do not present the questions: *"Do you know what they have just explained?","Could you tell me what they explain in your words?" "Do you agree?, why and why not?"* After the discussion, the teacher and the students will conclude together what they learned today. **The main points of conclusion :** The area formula of parallelogram can be derived from a rectangle, the area formula of parallelogram is *base x height*. The area formula of triangle can be derived from a rectangle or parallelogram; the area formula of triangle is *½ x base x height*.

Teacher Guide
6th Lesson
BUILDING AND GLASSES

Duration of lesson
2 x 40 minutes
Material
Worksheets of lesson
Learning Goals
1. Students are able to reshape trapezoid, rhombus, kite and into a rectangle.
2. Students are able to derive the area formulas of quadrilaterals from the area formula of rectangle and triangle.

The teaching and learning activities
1st session (Group)
Before students begin the lesson, the teacher poses a question Students will explore to reshape a trapezoid into a rectangle to determine the area of a trapezoid. Afterward students will find the area of trapezoids using the area formula of a triangle. Remind and refresh students with the distributive law of multiplication. The teacher begins with asking about the buildings they have seen in the previous meeting and tell students they will do the same again.

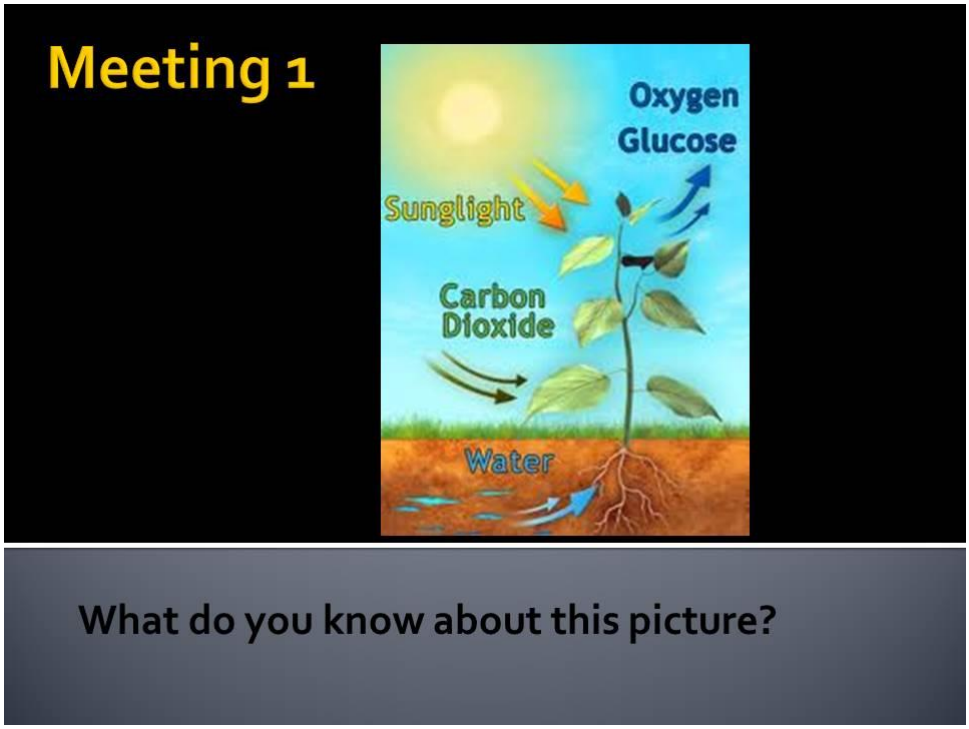
The activity	The role of the teacher
Determining areas of trapezoid	The teacher asks students where they can find a trapezoid shape. The teacher reminds students about a unique building, in previous problem, a parallelogram building. The students are asked whether they can find the area of glasses to cover the side of the building. *Could you find the area of glasses to cover the building?*
Students may count one by one the square units	If students if students count one by one and have difficulties, ask: After student reshape the triangle into a rectangle, and still count one by one the square units, ask: *Do you have a faster way to count them?* *Do you still remember the area formula of rectangle?* *What is the formula now?* *See the base of your trapezoid and the base of the rectangle. What can you conclude?*

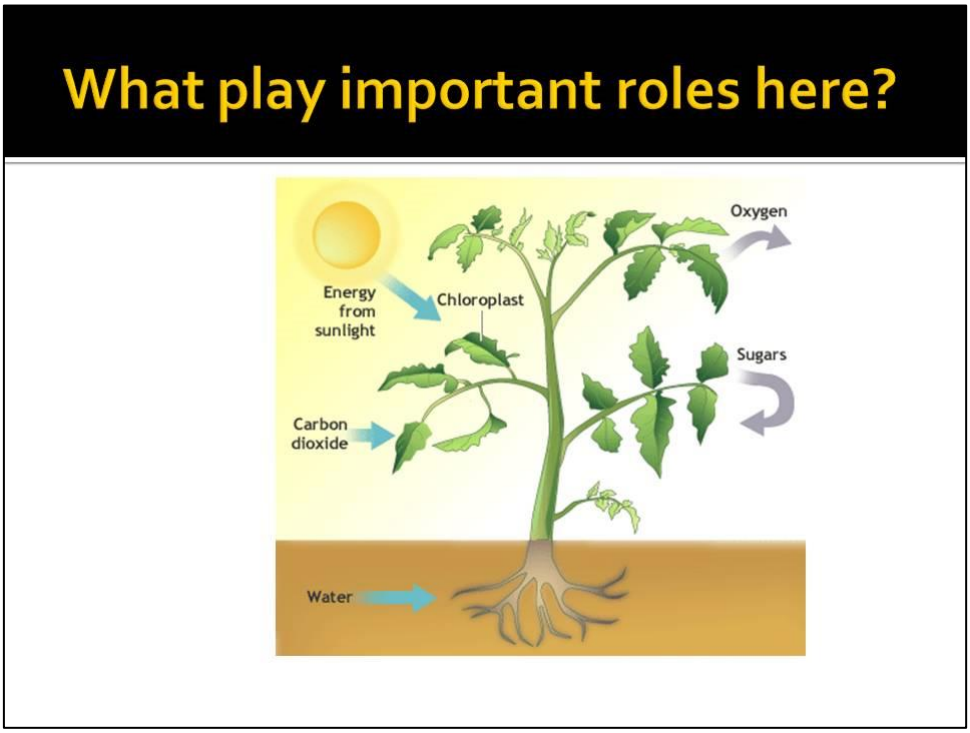
Determining the area of a trapezoid Students will find the area of the triangles in the trapezoid. The sum areas of triangles are the area of the trapezoid. Since students know the area formula of triangle, students will add the area formulas	Ask students to see what figures inside the trapezoid. How to determine the area of the trapezoid with the figures. If students sum the area of the triangles, ask: *Is it allowed to do it? Is the sum areas is equal to the area of the trapezoid, why?* If students sum the area formula of triangles, remind students with the distributive law of multiplication. Ask: *can you simplify the formula?* Ask students to relate the formula with the parallel sides and the height of the trapezoid. When students get this formula : $$A = \frac{1}{2}(a_1 + a_2)t$$ Ask: *what is the a1 and a2 in the trapezoid?*
Finding the area of a kite and a rhombus Students will reshape the kite and the rhombus into a rectangle and use the area formula of rectangle.	The teacher may suggest students to remember what they did to the parallelogram. After students have reshaped the kite and rhombus into a rectangle, ask them to use the area formula of rectangle. The teacher should ask: *What is the relation between the lengths of the base and height of the rectangle with the lengths of the diagonals?* *Can you conclude what the area formula of kite and rhombus is?*
Classroom Discussion The chosen group or students will present their work.	The teacher will orchestrate a class discussion of students' work on worksheet11 and 12. The teacher will not give the correct answer but just lead the discussion in the right track. The teacher may ask students who do not present the questions: *"Do you know what they have just explained?"* *"Could you tell me what they explain in your words?""Do you agree?, why and why not?"* After the discussion, the teacher and the students will conclude together what they learned today. **The main points of conclusion :** The area formula of trapezoid can be derived from a rectangle, the area formula of parallelogram is *½ x (sum of the length of parallel sides x height)*. It can be derived also from the area formula of triangle. The area formula of rhombus and kite can be derived from a rectangle, the area formula of rhombus and kite is *(length of diagonal 1 x length of diagonal 2)*

APPENDIX F

POWER POINT

Meeting 1





Rice Fields

Meeting 3

Meeting 3


Meeting 3 SDN 3 Danaraja
Map
Photos
© 2013 Google
Image © 2014 DigitalGlobe
© 2013 AfriGIS (Pty) Ltd
Google earth

Meeting 5


Meeting 5
What do you know about this building?

Unique buildings

What is the shape of sides of these buildings?

Unique buildings

What is the shape of sides of these buildings?

APPENDIX G

HYPOTHETICAL LEARNING TRAJECTORY

Table 1. The overview of the activity and the hypothesis of the learning process in lesson 1

Activity	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
Comparing leaves	Students are able to compare two leaves with their own strategies. Students grasp the idea that an irregular shape has an area. Students understand that area is region inside the boundary.	The students will try to compare the leaves by: • Use their superficial judgment by just looking at two leaves and say one leaf is larger than another because it looks bigger or wider or the leaves are almost the same • Trace one leaf and place it over another one to see the non- overlapping areas • Overlap one leaf to another one and cut parts of non-overlapping area and paste them to non- overlapping area of another leaf.	After the teacher distributes the worksheet 1 to each group then ask students whether they understand the problem on the worksheet or not.*"Could you tell me what the problem is?"* If students answer based on the superficial judgment or use their perception, the teacher may ask students how they can be confident about their argument by asking: *"How do you know it?" "How do you prove it?"" How do you convince others?"*

Activity	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
			If students have difficulties, then the teacher asks students if they have the leaves on their hands, what they will do. *"What will you do if you have those leaves in your hands?"* Ask students what they can do from the leaves on the worksheet. If students reply that they need something to cut, then provide the materials. Otherwise, just provide the materials.
Comparing rice fields	Students are able to compare two irregular figures by overlapping, cutting and pasting. Students grasp the concept of	The students will use the same strategies like in comparing leaves. • Use their superficial judgment by just looking at two rice fields and say one rice field is larger than another one because it looks longer or almost the same. • Trace one rice field and place it over another	The teacher may ask students about plants that produce food for human to the rice field. *Tell me plants that produce food for human!* The teacher asks students what they know about the shape of

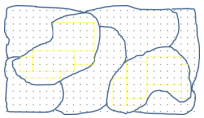
Activity	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
	conservation of area	one to see the non- overlapping areas • Overlap one rice field to another one and cut parts of non-overlapping area and paste them to non- overlapping area of another rice field.	rice fields. *What do you know about the shape of rice fields?* The teacher asks students whether the area of the rice fields changes or not when they cut and paste the rice fields.*What happens to the leaf after you cut and paste?*
Comparing dotted rice fields	Students are able to compare two with their own strategies. Students understand that area is region inside the boundary. They will grasp the idea of unit measurement but not too much focused on this meeting.	Students may count one by one the dots in each rice field and compared them. Student will make rectangles to count the dots efficiently as shown below:  or they will make a bigger rectangle covering the rice field and use the multiplication strategy to count the dots and then subtracting the result with the outsider dots.  Students combine tracing and counting strategies and count only the dots in the non-overlapping parts.	If students count the dots one by one, ask them to count the dots in a faster way. *Do you another faster way to count the dots?* If students have difficulties, ask them to do cut and overlap. *Can you cut and overlap the rice fields?*

Table 2. The overview of the activity and the hypothesis of the learning process in lesson 2

Activity Lesson 2	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
Determining the rice field to make a fair deal. Grasp the idea of perimeter. Comparing the perimeter before and after the reshaping	Students are able to choose which rice field to fairly exchange the farmer's rice field by comparing the area. Students are able to differentiate between area and perimeter. Students understand that reshaping will preserve the area not the perimeter. Students are able to differentiate between area and perimeter.	Some students may choose one of the options and maybe more than one. Students only judge superficially based on their visual. They will say that it is fair because the farmer will get a longer rice field or it is not fair because the shape is different. Students will choose rice field which has the same perimeter as the farmer's rice field by using the string. Students will choose the rectangular rice fields because it is regular and common. Students will choose the rice field which has the same area by reshaping the farmer's rice field. Students will compare the lengths	Ask students to convince their arguments *"Tell me the reason why you think so?"* *"Can you convince others?"* *"Maybe the materials can help you"* If students choose the rice field with the same perimeter, just let them to do so and this group will present in the classroom discussion. If students cut and paste the farmer's rice field to fit the optional rice field, ask students *"Why do you do that", What is your goal by doing that?* If students choose only the rectangular rice fields, ask: *Why do you choose them? Do they have the same area?*

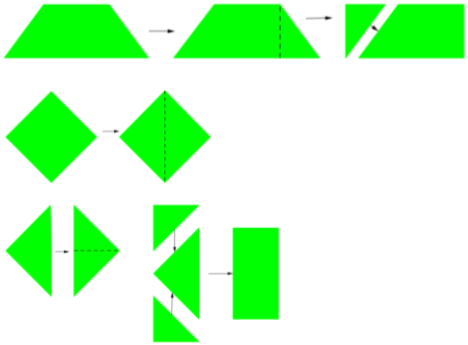
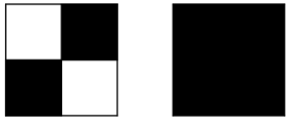
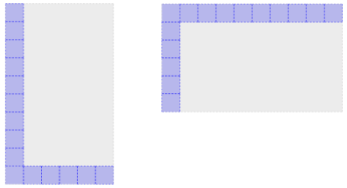
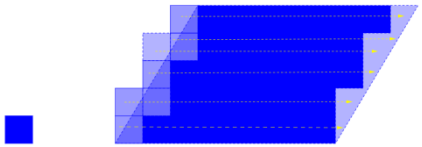
Activity Lesson 2	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
		of sting to measure the perimeter of each rice field. Students will use the string to measure the perimeter before and after reshaping and compare them	After students finish worksheet 6, tell students that they will discuss their work later. The teacher may ask students what is the difference between area and perimeter.
Reshaping quadrilaterals into a rectangular.	Students are able to do cut and paste to reshape figures into a rectangle.	Students may do trial and error. As students are able to do reshaping in previous activity, this geometrical figures are easier to reshape. 	Ask students how they reshape it. *What did you do first? Did you do trial and error? Or do you have your way to reshape them?* Ask also: *If you reshape, what will remain the same and what will not? What do you know about area and perimeter?* *If you reshape, do you think it will help you to find the area after reshaping? Why?*

Table 3. The overview of the activity and the hypothesis of the learning process in lesson 3

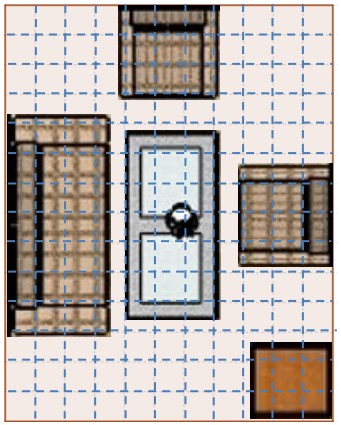
Activity Lesson 3	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
Comparing tiled floors	Students are able to compare two floors with different tiles as their unit measurements. Students understand the need of the same square unit to compare area.	Students will count the number of tiles on each floor either one by one or using multiplication strategy. Students will compare the number of tiles from the floors and says that floor A is bigger since it has more tiles or some students will say that floor B is bigger since it has a bigger tile. Students will take one tile of each floor and compare them.  Students may realize that the tile on floor B is for time as big as the tile on floor A. 	Do not provide materials like scissors or tools to cut. Let students use their strategies to compare the floors. If they found that the floors has the same size. Ask: *What did you do see them having the same area?* If students count the tiles *How do you find the number of tiles in each floor?* Make a discussion if there is an answer that they judge the floor based on the number of tiles.

Activity Lesson 3	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
Tiling / structuring array	Students are able to compare floors by the number of square units cover them. Students are able to use their cut and paste strategy to tile the parallelogram floor.	Students will easily tile rectangle floors by putting some tiles on the edges of the floors and use multiplication strategy to count the tiles as follows:  Or they continue to tile fully the floor by using a ruler and count the tiles.Students will tile with possible position of full tile unit and cut the remaining parts then paste then to  the untilled parts. Students may reshape the floor into a rectangle and then tile it. Students may do trial and error.	The teacher prepares the material such as straightedges if students need them. The teacher will not provide the tools to cut. The teacher needs to ask students: *What do you do to cover the floors?* When students have difficulties in covering the parallelogram floor, suggest: *You may modify the tiles.*

Activity Lesson 3	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
Determining area of rectangular floors	Students are able to use multiplication strategy. Students understand how the formula *length x width* or *base x height works.*	Students will tile all the surface of the floor and count one by one the tiles. After students get the number of the tiles (60 tiles), they will multiply it by 625 cm^2 since each tile has an area of 625 cm^2. Therefore, the area of the floor is 37500 cm^2. Students will only tile the edges of the floors and multiply the number of tiles on the vertical edge with the number of tiles in horizontal edge. After students get the number of the tiles, they will multiply it by 625 cm^2 since each tile has an area of 625 cm^2. Students will only tile the edges of the first floor and measure the length of the vertical and the horizontal edges. They will get the length of the	Ask: *What do you do to cover the floors?* Or suggest: *You may use pencil to draw your tiles.* If students only draw or tile only some parts on the edges of the floor, ask: *Can you determine the number of the tiles by tiling some parts? Why?* When students cover all the floors by tiles, ask them how they count the number of the tiles? *How do you count the number of the tiles?* If they count one by one, ask do you have a faster way to count them? *What is the area of the floors?*

Activity Lesson 3	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
		horizontal and vertical edges are 250 cm and 150 respectively. Therefore, they will find the area of the floor is 37500 cm^2. On the second floor, the lengths of the horizontal and vertical edges are 250 cm and 150 cm. Its area is equal to the first floor.	*How many centimeter squares?* Remind students of the standard measurement units. *Is the unit is centimeter or centimeter squares?* *If the edges of the floor are called base and height, what can you conclude?* Tell students that they will discuss their work after.
Determining area of rectangles by applying area formula	Students are able to apply area formula for rectangles.	Students will multiply the length of the base and height of each rectangle to get its area.	The teacher may ask how this way works. *How does it work? Can you conclude what the area formula of rectangles is?*

Table 4. The overview of the activity and the hypothesis of the learning process in lesson 4

Activity Lesson 4	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
Estimating an area of a covered floor.	The students are able to determine the area of a floor using the multiplication strategy and apply area of formula to find the area of a floor.	Students draw lines to trace the tile from the visible lines of the tiles. Then they will count the tiles one by one or by using a multiplication strategy. 	The teacher just let students do with the strategies they use. If they have difficulties ask or suggest to use any tool to help *Do you need something for help? A ruler or straightedge maybe useful.* If students try to count one by one, pose a question: *Do you have a faster way to count? Do you still remember what you learned in previous meeting?* If students use multiplication strategy, ask the students how long the length and the width of the floor are? *Can you use the formula that you have in previous meeting?* Always remind students the standard unit of measurement, is it cm or cm^2?

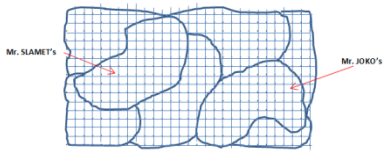
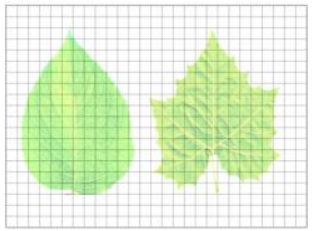
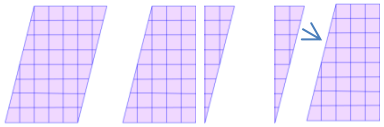
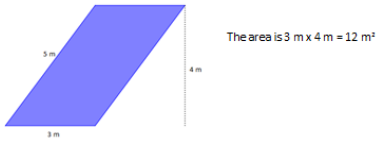
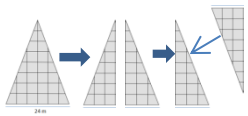
Activity Lesson 4	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
Comparing dotted rice fields and comparing leaves	Students are able to estimate the area of the dotted rice field by using square units. Students grasp the use of grid paper to estimate the area of irregular shape and combine it with the cut-paste strategy.	Students will connect the dots with a straightedge or a ruler. And estimate the square units fit the rice fields.   Students will make their own grid paper and put the leaves on it and count the number of squares and compare them	If the students still count the dots, suggest students to connect the dots with a ruler. Let students to solve the problem, some assistance are needed if students have difficulties counting the square units. *"Do you have another way to count the square units".*The teacher may remind students of the reallotment activity, *you may reshape it to make you easier to estimate.*

Table 5. The overview of the activity and the hypothesis of the learning process in lesson 5

Activity Lesson 5	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
Comparing area of sides of two buildings with rectangular and parallelogram shape	Students are able to determine the area of a parallelogram by reshaping and derive the area formula from a rectangle.	Students will count the full square units and combine the not fully square units with other not fully square units in order to get full square units. Then students will count the square unit one by one or using multiplication strategy. Students may reshape the figures into a rectangle and count the square units one by one or using multiplication strategy. 	The teacher will show a building with a parallelogram shape and ask : *What is the height of this building? Can you determine how many glasses to cover that side of building?* The teacher distributes the worksheet 12 to each group. If students if students count one by one, ask: *"Do you have a faster way to count the square units?* *Do you still remember the formula to find an area of a rectangle?* If students have difficulties in counting the number of square units in the parallelogram, suggest student to reshape into another figure. *Maybe, you can reshape it into*

Activity Lesson 5	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
			another figure. After students find that the rectangle and the parallelogram have the same area. Ask: *If they have the same base, height, do you think they have the same area? Can you use the area formula for rectangle?*
Determining areas of parallelograms	Students are able to use the formula of rectangle to find the areas of parallelograms.	Students will reshape the parallelograms into a rectangle and apply the area formula of rectangle. Students will use directly the area formula of rectangle to find the areas of parallelograms.  	After some minutes and students have finished the 1st problem, the teacher then asks to work on the next problem. The teacher may suggest, *Maybe, you can try to use the formula and prove it by reshaping.* If students reshape the parallelogram into a rectangle and use multiplication strategy or area formula for rectangle, the teacher asks: *Can you say that the area formula of a parallelogram is same with the*

Activity Lesson 5	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
			formula of rectangle? So, what is the general area formula of parallelogram? If students only use the formula, the teacher may ask: *How can you use the area formula of a rectangle? Why does it work? Can you tell me the relation between the rectangle and the parallelogram? Can you generalize the area formula of parallelogram?*
Determining areas of triangles	Students are able to derive the area formula of triangle	Students may count one by one the square units Students may reshape the triangles into a rectangle and apply area formula of rectangle 	The teacher asks students where they can find a triangular shape. The teacher reminds students about a unique building, in previous problem, a parallelogram building. The teacher shows a picture of building with triangular shape. The students are asked whether they can find the area of glasses to cover the side of the building. *Could you find*

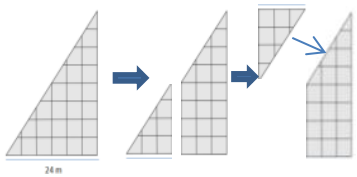
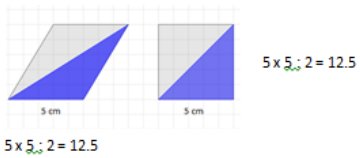
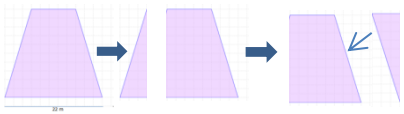
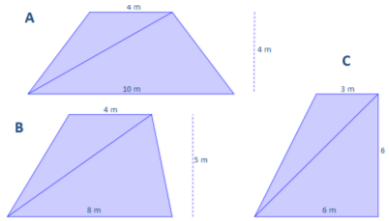
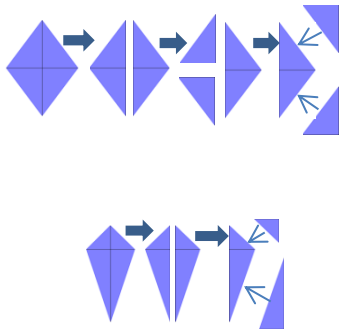
Activity Lesson 5	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
			*the area of glasses to cover the building* If students if students count one by one and have difficulties, ask: *"Maybe, can you reshape it into another figure?* After student reshape the triangle into a rectangle, and still count one by one the square units, ask: *Do you have a faster way to count them? Do you still remember the area formula of rectangle?* *What is the formula now?*
Determining the areas of shaded areas.	Students understand that the area formula of triangle is half of the are formula of rectangle (*1/2 x base x height*)	The students will count one by one the square units. The students will use the formula of parallelogram and rectangle and divide by two. 	If students count one by one the square unit, suggest them: *What do you think the area of the shaded part? What is the relationship with the parallelogram and the rectangle?* If students use the formula of parallelogram and rectangle, ask *So, what do you think the area of a triangle?*

Table 6. The overview of the activity and the hypothesis of the learning process in lesson 6

Activity Lesson 6	Learning Goal	Conjectured of Students' thinking	Guidance for teacher
Determining areas of isosceles trapezoid	Students are able to use the formula of rectangle to find the areas of trapezoid.	Students may count one by one the square units Students will reshape the trapezoid and use the area formula of rectangle 	The teacher shows a picture of building with trapezoid shape. The students are asked whether they can find the area of glasses to cover the side of the building. If students if students count one by one and have difficulties, ask: *"What did you do to the parallelogram in previous meeting? Can you do it to the trapezoid?* After student reshape the triangle into a rectangle, and still count one by one the square units, ask: *Do you have a faster way to count them? Do you still remember the area formula of rectangle? What is the formula now?*

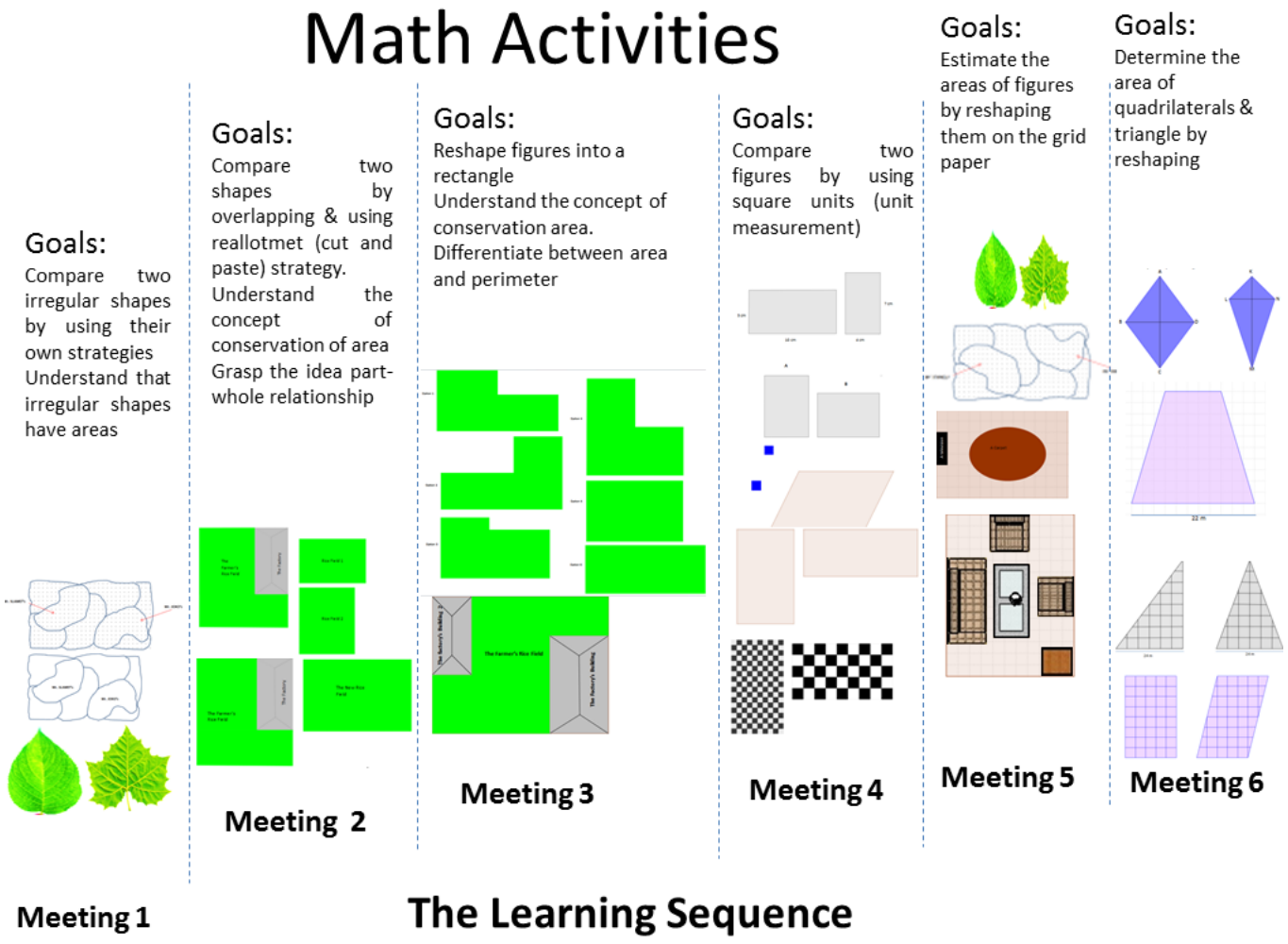
			See the base of your trapezoid and the base of the rectangle *What can you conclude?* If students reshape the trapezoid and use the area formula of a rectangle, ask: *How do you find the area? If you use any formula, what is the formula?* Ask also the height of the trapezoid, *what is the height of the trapezoid?*
Determining areas of trapezoids	Students are able to use the formula of triangle to find the areas of trapezoid and derive area formula of trapezoid.	Students will add the area of the triangles inside the trapezoid. Students will simplify the sum area formulas of triangles to derive the area of trapezoid 	Ask students to see what figures inside the trapezoid. How to determine the area of the trapezoid with the figures. If students sum the area of the triangles, ask: *Is it allowed to do it? Is the sum areas is equal to the area of the trapezoid, why?* If students sum the area formula of triangles, remind students with the distributive law of multiplication.

			Ask: *can you simplify the formula?* Ask students to relate the formula with the parallel sides and the height of the trapezoid. When students get this formula : $A = \frac{1}{2}(a_1 + a_2)t$ Ask: *what is the a1 and a2 in the trapezoid?*
Finding the area of a kite and a rhombus	Students are able to derive the formula of kite and rhombus by reshaping into a rectangle	Students will reshape the kite and the rhombus into a rectangle and use the area formula of rectangle. 	After students have reshaped the kite and rhombus into a rectangle, ask them to use the area formula of rectangle. The teacher should ask: *What is the relation between the lengths of the base and height of the rectangle with the lengths of the diagonals?* *Can you conclude what the area formula of kite and rhombus is?*

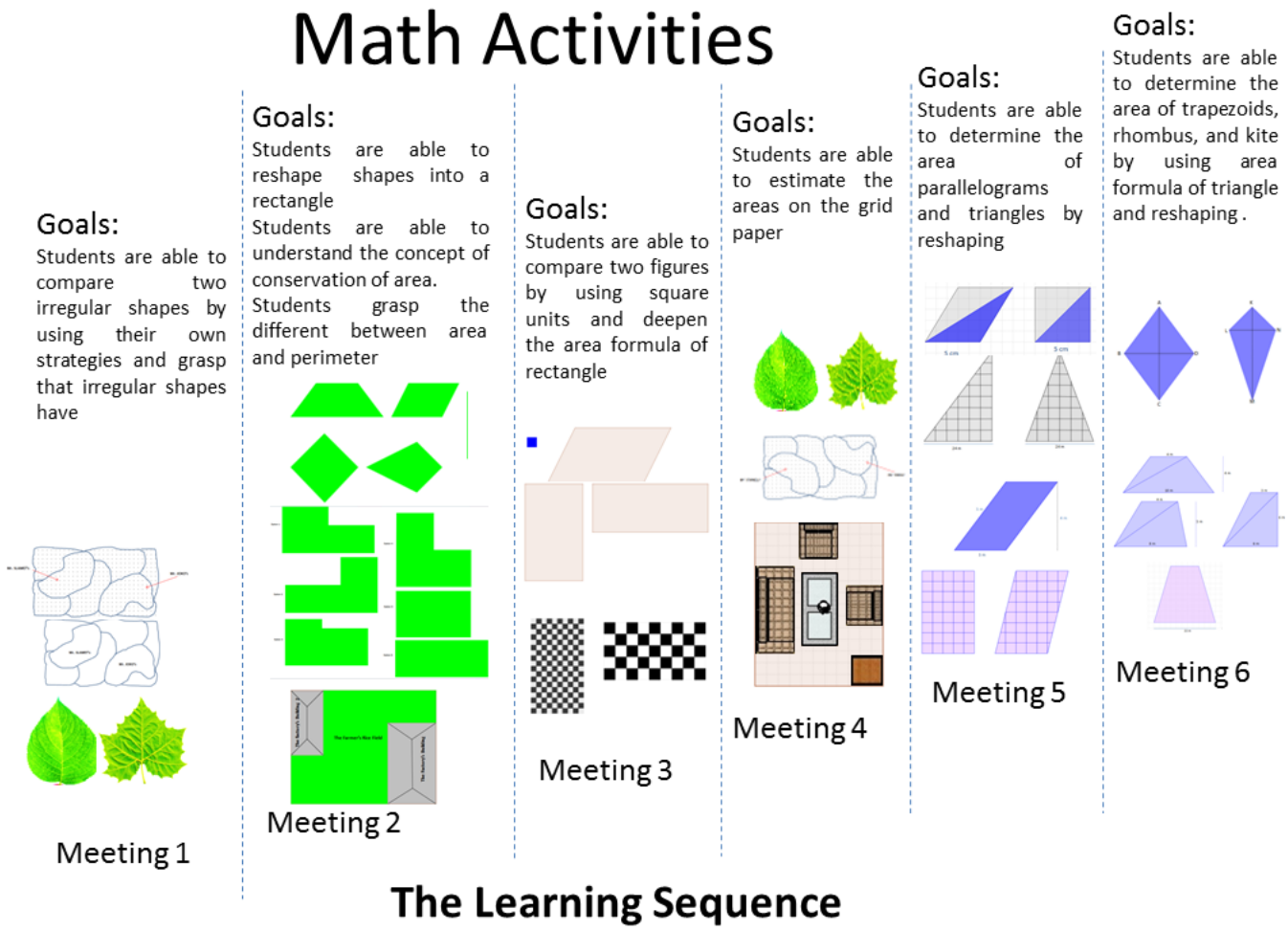
APPENDIX H

INSTRUCTIONAL ACTIVITIES AND LOCAL INTRUCTIONAL THEORY

Learning Activities Cycle 1



Learning Activities Cycle 2



APPENDIX I

Rencana Pelaksanaan Pembelajaran (RPP)

Sekolah : SMP PUSRI Palembang

Mata Pelajaran : Matematika

Kelas/Semester : VII /2 (genap)

Alokasi Waktu : 12 x 40 menit (6 pertemuan)

A. Kompetensi Inti

1. Menghargai dan menghayati ajaran agama yang dianutnya.
2. Menghargai dan menghayati perilaku jujur, disiplin, tanggungjawab, peduli (toleransi, gotong royong), santun, percaya diri, dalam berinteraksi secara efektif dengan lingkungan sosial dan alam dalam jangkauan pergaulan dan keberadaannya.
3. Memahami dan menerapkan pengetahuan (faktual, konseptual, dan prosedural) berdasarkan rasa ingin tahunya tentang ilmu pengetahuan, teknologi, seni, budaya terkait fenomena dan kejadian tampak mata.
4. Mengolah, menyaji, dan menalar dalam ranah konkret (menggunakan, mengurai, merangkai, memodifikasi, dan membuat) dan ranah abstrak (menulis, membaca, menghitung, menggambar, dan mengarang) sesuai dengan yang dipelajari di sekolah dan sumber lain yang sama dalam sudut pandang/teori.

B. Kompetensi Dasar

1. Menunjukkan sikap logis, kritis, analitik, konsisten dan teliti, bertanggung jawab, responssif,dan tidak mudah menyerah dalam memecahkan masalah.
2. Memiliki rasa ingin tahu, percaya diri, dan ketertarikan diri pada matematika serta memiliki rasa percaya pada daya serta kegunaan matematika, yang terbentuk melalui pengalaman belajar
3. Mengidentifikas sifat-sifat bangun datar dan menggunakannya untuk menentukan keliling dan luas.
4. Menyelesaikan permasalahan nyata yang terkait penerapan sifat-sifat persegi panjang, persegi, trapesium, jajar genjang,belah ketupat dan layang-layang.

C. Indikator

1. Menemukan strategi menumpuk, memotong dan menempel
2. Menemukan konsep konservasi luas

3. Menemukan konsep unit satuan luas
4. Menyelesaikan persoalan memperkirakan luas suatu bentuk
5. Menyelesaikan persoalan luas segi empat dan segitiga dengan metode pengubahan bentuk serta dapat menemukan rumus luas bangun tersebut

D. Tujuan Pembelajaran

Pertemuan Pertama

1. Siswa mampu menemukan startegi menumpuk, memotong dan menempel untuk membandingkan luas
2. Siswa mampu memahami pengertian luas
3. Siswa mampu memahami konsep konservasi luas

Pertemuan Kedua

1. Siswa mampu membandingkan luas dengan strategi menumpuk, memotong dan menempel
2. Siswa mampu memahami konsep konservasi luas
3. Siswa mampu membedakan luas dan keliling
4. Siswa mampu mengubah bentuk segi empat menjadi persegi panjang

Pertemuan Ketiga

1. Siswa mampu membandingkan luas dengan unit satuan luas yang sama
2. Siswa mampu memahami bagaimana menghitung luas persegi panjang
3. Siswa mampu menentukan luas segi empat dengan unit satuan luas
4. Siswa mampu menentukan rumus luas persegi panjang

Pertemuan Keempat

1. Siswa mampu menggunakan rumus luas persegi panjang untuk menyelesaikan masalah kontektual
2. Siswa mampu menaksir luas bentuk dengan menggunakan unit satuan luas
3. Siswa dapat membandingkan luas dua bentuk dengan unit satuan luas

Pertemuan Kelima

1. Siswa mampu mengubah jajar genjang menjadi persegi panjang untuk mengukur luasnya
2. Siswa mampu menemukan rumus luas jajar genjang dengan cara mencari hubungan jajar genjang dengan persegi panjang yang dibentuk.
3. Siswa mampu mengubah segitiga menjadi persegi panjang untuk mengukur luasnya dan mampu menemukan rumus luas segitiga dengan mencari hubungan segitiga dengan jajar genjang atau persegi panjang

Pertemuan Keenam

1. Siswa mampu mengubah trapesium menjadi persegi panjang untuk mengukur luasnya
2. Siswa mampu menggunakan rumus segitiga untuk menemukan rumus luas trapezium
3. Siswa mampu mengubah laying-layang dan belah ketupat menjadi persegi panjang untuk mengukur luas dan menemukan rumus luas bangun tersebut.

E. Materi Pembelajaran

Segi Empat dan Segitiga

F. Model, Pendekatan, dan Metode Pembelajaran

Model : Pembelajaran Kooperatif

Pendekatan : Pendekatan ilmiah dan PMRI

Metode Pembelajaran : Diskusi, tanya jawab dan presentasi

G. Sumber Belajar

1. Lembar Aktivitas Siswa

H. Langkah-langkah aktivitas pembelajaran

Pertemuan Pertama (Aktivitas 1 dan Aktifitas 2)

Alokasi waktu : 2 × 40 Menit

Kegiatan	Aktivitas Pembelajaran	Waktu
Pendahuluan	a. Guru dan siswa memberikan salam pembuka yang diikuti kegiatan berdo'a bersama sesuai dengan agama dan kepercayaan masing-masing. b. Guru memberikan apersepsi dengan menanyakan tentang fotosintesis. c. Guru memberikan motivasi kepada siswa *Permasalahan-permasalahan pada kehidupan sehari-hari tidak terlepas dari matematika, contohnya adalah membandingkan luas daun untuk menentukan banyaknya sinar matahari*	5 Menit

	yang diserap daun saat fotosintesis. d. Guru menjelaskan tujuan pembelajaran kepada siswa. *Tujuan pembelajaran pada hari ini adalah untuk menemukan strategi membandingkan luas* e. Guru menginformasikan kegiatan pembelajaran yang akan dilaksanakan *Kegiatan pembelajaran pada hari ini adalah diskusi secara berkelompok, presentasi kelompok dan diskusi kelas. Pembagian kelompok telah diatur oleh guru.*	
Kegiatan Inti	a. Meminta siswa untuk duduk secara berkelompok dengan anggota yang telah ditentukan. **Mengamati** b. Guru memberikan LAS 1 dan 2 serta lembar jawaban pada setiap kelompok dan meminta siswa untuk memahami permasalahan pada LAS tersebut. **Menanya** c. Siswa dan guru melakukan tanya jawab mengenai pemahaman siswa terhadap permasalahan di LAS *Apa yang diminta oleh soal?* *Apa yang diketahui?* **Mengumpulkan Informasi/Eksperimen** d. Siswa diminta untuk menganalisis berbagai macam cara yang dapat digunakan dalam menyelesaikan permasalahan yang diberikan pada LAS 1 dan 2. e. Siswa menuliskan jawaban dari permasalahan	5 Menit 5 Menit 5 Menit

	yang diberikan pada LAS 1 dan 2 di kertas yang telah disediakan. *Silahkan tuliskan langkah penyelesaian di kertas yang telah disediakan.* **Mengasosiasikan/Mengolah Informasi** f. Guru berperan sebagai fasilitator selama proses pembelajaran berlangsung dengan memberikan pertanyaan-pertanyaan mengenai jawaban yang ditulis siswa dan memberikan bimbingan apabila siswa menemui kesulitan. • *Langkah apa yang akan kalian lakukan terlebih dahulu?* • *Daun yang mendapatkan sinar matahari adalah daun yang bagaimana?* • *Apa yang bisa kamu lakukan dengan alat yang disediakan?* • *Kalau misalkan daunnya kamu pegang, apa yang akan kamu lakukan?* • *Apa yang kamu lakukan pada sawah tersebut? Apakah kamu bisa melakukan hal sama seperti pada daun tadi?* **Mengkomunikasikan** g. Perwakilan kelompok diminta untuk mempresentasikan jawabannya di depan kelas. h. Kelompok lain diminta untuk memberikan komentar mengenai jawaban yang telah dipresentasikan temannya. i. Melaksanakan diskusi kelas yang dipimpin langsung oleh guru **(Mengasosiasikan/ Mengolah Informasi)** • *Secara garis besar apa saja langkah penyelesaian yang dapat digunakan?*	10 Menit 15 Menit 15 Menit

	• *Luas itu bagian yang mana?* • *Apakah setelah dipotong-potong tadi luasnya berubah? Apakah ada yang dibuang?* • *Strategi menumpuk dapat kita gunakan untuk membandingkan luas*	15 Menit
Penutup	a. Siswa diminta untuk memberikan kesimpulan dari pembelajaran pada hari ini. *Permasalahan yang diberikan dapat diselesaikan dengan cara : menumpuk, memotong dan menempel* b. Guru menanyakan respon siswa mengenai kegiatan pembelajaran yang telah berlangsung. c. Siswa diminta untuk memahami kembali di rumah pelajaran yang telah dibahas pada hari ini.	5 Menit

<u>Pertemuan Kedua (Aktivitas 3 dan Aktivitas 4</u>)

Alokasi waktu : 2 × 40 Menit

Kegiatan	Aktivitas Pembelajaran	Waktu
Pendahuluan	a. Guru dan siswa memberikan salam pembuka yang diikuti kegiatan berdo'a bersama sesuai dengan agama dan kepercayaan masing-masing. b. Guru memberikan apersepsi dengan menanyakan kemampuan prasyarat kepada siswa yaitu pengetahuan yang sudah dipelajari pada pertemuan sebelumnya. *Pada pertemuan sebelumnya kita dapat membandingkan luas dengan cara menumpuk dan menempel. Apakah saat dipotong dan*	5 Menit

	ditempel luasnya berubah? Apa yang berubah? c. Guru memberikan motivasi kepada siswa *Selain untuk membandingkan luas daun, kita juga bisa menggunakannya untuk mnyelesaikan permasalahan traksaksi yang adil suatu bidang tanah.* d. Guru menjelaskan tujuan pembelajaran kepada siswa *Tujuan pembelajaran pada hari ini adalah menemukan konsep konservasi luas, bahwa suatu bentuk saat dipotong dan ditempel kembali luasnya tetap tetapi kelilingnya berubah. Siswa dapat mengubah bentuk segi empat menjadi persegi panjang* e. Guru menginformasikan kegiatan pembelajaran yang akan dilaksanakan *Kegiatan pembelajaran yang akan dilaksanakan yaitu diskusi secara berkelompok, presentasi kelompok dan diskusi kelas. Pembagian kelompok sama dengan pertemuan sebelumnya.*	
Kegiatan Inti	a. Meminta siswa untuk duduk secara berkelompok dengan anggota kelompok sama seperti pertemuan sebelumnya. **Mengamati** b. Guru memberikan LAS 3 dan 4 serta lembar jawaban pada setiap kelompok dan meminta siswa untuk mengamati sawah-sawah pada LAS tersebut. **Menanya** c. Siswa dan guru melakukan tanya jawab mengenai bagaimanakah suatu transaki	5 Menit 5 Menit 5 Menit

	diakatakan adil. . *Transaksi yang adil adalah jika sawah pengganti pak tani memliki luas yang sama denga sawah pak tani. Untuk mengetahui manakah sawah yang cocok, maka harus dibuktikan dengan menumpuk, memotong dan menempel sawah tersebut.* *Jika sawah pengganti pas bisa menutupi sawah pak tani maka sawah tersebut adlah sawah yang cocok dan adil jika melakukan transaksi. Apabila tidak pas (ada sisa atau kurang) maka sawah tersebut tidak adil saat dilakukan transaksi.* *Jika kamu mengelilingi sawah tersebut, manakah yang memiliki jejak terpendek? Apakah sawah pak tani atau sawah yang kamu pilih?* **Mengumpulkan Informasi/Eksperimen** d. Siswa diminta untuk menganalisis cara yang dapat digunakan dalam menyelesaikan permasalahan yang diberikan pada LAS 3 dan 4. e. Siswa diminta menuliskan jawaban dari permasalahan yang diberikan pada LAS di kertas yang telah disediakan. *Silahkan tuliskan langkah penyelesaian di kertas yang telah disediakan. Siswa diberikan kebebasan untuk menuliskan objek sesuai dengan keinginan seperti menggunakan simbol, huruf atau kata.* **Mengasosiasikan/Mengolah Informasi** f. Guru berperan sebagai fasilitator selama proses	10 Menit 15 Menit

	pembelajaran berlangsung dengan memberikan pertanyaan-pertanyaan kepada siswa mengenai jawaban yang mereka tulis dan memberikan bimbingan kepada siswa yang menemukan kesulitan dalam menyelesaikan LAS 3 dan 4. • *Apa yang akan kalian cari?* • *Bagaimana menentukannya?* • *Apakah bisa melakukan menumpuk dan menempel seperti pada daun?* • *Gunakan alat-alat yang sudah disediakan.* **Mengkomunikasikan** g. Setiap kelompok diminta untuk mempresentasikan jawabannya di depan kelas. h. Kelompok lain diminta untuk memberikan komentar mengenai jawaban yang telah dipresentasikan temannya. i. Melaksanakan diskusi kelas yang dipimpin langsung oleh guru **(Mengasosiasikan/ Mengolah Informasi)** • *Secara garis besar apa saja langkah penyelesaian yang dapat digunakan?* • *Pada pertemuan ini kita telah menemukan cara menumpuk, memotong dan menempel untuk menentukan sawah yang adil untuk mengganti sawah pak tani. Apa yang terjadi saat kalian potong-potong dan tempel?* • *Untuk menentukan sawah yang luasnya sama, kita dapat membandingkan luas sawah tersebut dengan cara menumpuk, memotong dan menempel. Jika dipotong dan ditempel, tanpa ada bagian yang terbuang, maka apanya yang tetap? Apanya yang berubah?*	15 Menit 15 Menit

Penutup	a. Siswa diminta untuk memberikan kesimpulan dari pembelajaran pada hari ini. • *Sawah yang adil adalah sawah yang memiliki luas yang sama* • *Jika dipotong dan ditempel tanpa ada yang dibuang maka luasnya tetap tetapi bentuk dan kelilingnya berubah* b. Guru menanyakan respon siswa mengenai kegiatan pembelajaran yang telah berlangsung. c. Siswa diminta untuk memahami kembali di rumah pelajaran yang telah dibahas pada hari ini.	5 Menit

<u>Pertemuan Ketiga (Aktivitas 5 dan Aktivitas 6)</u>

Alokasi waktu : 2 × 40 Menit

Kegiatan	Aktivitas Pembelajaran	Waktu
Pendahuluan	a. Guru dan siswa memberikan salam pembuka yang diikuti kegiatan berdo'a bersama sesuai dengan agama dan kepercayaan masing-masing. b. Guru memberikan apersepsi dengan menanyakan kemampuan prasyarat kepada siswa yaitu mengenai lantai dan ubin yang ada di kelas. *Untuk menbandingkan luas, tanpa memomotong dan menempel, kita bisa membandingkan luas lantai dengan jumlah ubinnya.* c. Guru memberikan motivasi kepada siswa. *Lantai tersebut akan dibandingkan mana yang lebih luas. Bagaimana menurut pendapat kamu?*	5 Menit

	d. Guru menjelaskan tujuan pembelajaran kepada siswa. *Tujuan pembelajaran pada hari ini yaitu siswa mampu membandingkan luas dengan unit satuan yang sama. Luas persegi pajang dapat diukur dengan mencari banyaknya ubin untuk menutupi lantai dan menggunakan perkalian panjang dan lebar lantai tersebut.* e. Guru menginformasikan kegiatan pembelajaran yang akan dilaksanakan. *Kegiatan pembelajaran pada hari ini adalah diskusi secara berkelompok, presentasi kelompok, diskusi kelas dan bekerja secara individu. Pembagian kelompok sama dengan pertemuan sebelumnya.*	
Kegiatan Inti	a. Meminta siswa untuk duduk secara berkelompok dengan anggota kelompok sama seperti pertemuan sebelumnya. **Mengamati** b. Guru memberikan LAS 5 dan 6 yang berisi permasalahan baru serta meminta siswa untuk mengamatinya. **Menanya** c. Guru menanyakan kepada siswa mengenai pengetahuannya tentang unit satuan luas. *Unit satuan luas adalah unit yang berbentuk persegi yang biasanya berukuran 1x1. Ubin bisa kita sebut sebagai unit satuan luas dan dapat kita gunakan untuk mengukur luas ubin.* **Mengumpulkan Informasi/Eksperimen** d. Setiap kelompok diminta untuk memikirkan strategi yang dapat digunakan dari	5 Menit 3 Menit 7 Menit

	permasalahan yang terdapat pada LAS 5 dan 6 dan menuliskan jawaban di tempat yang telah disediakan. e. Guru berperan sebagai fasilitator selama proses pembelajaran berlangsung dengan memberikan pertanyaan-pertanyaan mengenai jawaban yang ditulis siswa dan memberikan bimbingan apabila siswa menemui kesulitan. • *Apakah ubinnya berukuran sama?* • *Apakah bisa kita tentukan luas dengan menggunakan luas ubin?* • *Apakah ada cara lain untuk mengukur luas ubin?* • *Apa yang dapat kita simpulkan?* f. Setiap kelompok diminta untuk mempresentasikan jawabannya di depan kelas dan kelompok lain diminta untuk memberikan tanggapan **(mengkomunikasikan)**. g. Melakukan diskusi kelas yang dipimpin oleh guru • *Luas ubin dapat dicari dengan luas ubin.* • *Untuk membandingkan luas dapat menggunakan unit satuan luas yang sama* • *Luas persegi panjang (lantai) dapat diukur dengan cara menghitung jumlah ubin dikalikan dengan luas satu ubin atau dengan mengukur panjang dan lebar lantai dengan menggunakan ukuran ubin.* **Mengasosiasikan/Mengolah Informasi** h. Siswa diminta untuk menganalisis penerapan proses perkalian untuk menghitung jumlah ubin. Siswa diminta untuk memahami sifat komutatif perkalian.	15 Menit 10 Menit 5 Menit 25 Menit

	i. Guru berperan sebagai fasilitator selama proses pembelajaran berlangsung dengan memberikan bimbingan kepada siswa yang menemukan kesulitan dalam menyelesaikan soal. **Mengkomunikasikan** j. Beberapa orang siswa diminta untuk mempresentasikan jawabannya di depan kelas. k. Siswa lain diminta untuk memberikan komentar mengenai jawaban yang telah dipresentasikan temannya.	25 Menit 15 Menit
Penutup	a. Siswa diminta untuk memberikan kesimpulan dari pembelajaran pada hari ini yaitu *1) Membandingkan luas dapat dilakukan dengan menggunakan unit satuan luas yang sama.* *2) Luas persegi panjang dapat ditentukan dengan menggunakan perkalian panjang dan lebar* b. Guru menanyakan respon siswa mengenai kegiatan pembelajaran yang telah berlangsung. c. Siswa diminta untuk memahami kembali di rumah pelajaran yang telah dibahas pada hari ini.	5 Menit

Pertemuan Keempat (Aktivitas 7, Aktivitas 8 dan Aktivitas 9)

Alokasi waktu : 2 × 40 Menit

Kegiatan	Aktivitas Pembelajaran	Waktu
Pendahuluan	a. Guru dan siswa memberikan salam pembuka yang diikuti kegiatan berdo'a bersama sesuai dengan agama dan kepercayaan masing-masing. b. Guru memberikan apersepsi dengan menanyakan kemampuan prasyarat kepada siswa yaitu mengenai lantai dan ubin yang ada di kelas. Untuk membandingkan luas, tanpa memomotong dan menempel, kita bisa membandingkan luas lantai dengan jumlah ubinnya. c. Guru memberikan motivasi kepada siswa. Lantai tersebut akan dibandingkan mana yang lebih luas. Bagaimana menurut pendapat kamu? Jika ubin atau unit bisa digunakan untuk menghitung luas lantai, apakah bisa digunakan untuk benda lain? Bagaimana caranya? d. Guru menjelaskan tujuan pembelajaran kepada siswa. Tujuan pembelajaran pada hari ini yaitu siswa mampu membandingkan luas dengan unit satuan yang sama. Luas persegi pajang dapat diukur dengan mencari banyaknya ubin untuk menutupi lantai dan menggunakan perkalian panjang dan lebar lantai tersebut. Unit satuan luas bisa digunakan untuk mengukur dan membandingkan luas.	5 Menit

	e. Guru menginformasikan kegiatan pembelajaran yang akan dilaksanakan. Kegiatan pembelajaran pada hari ini adalah diskusi secara berkelompok, presentasi kelompok, diskusi kelas dan bekerja secara individu. Pembagian kelompok sama dengan pertemuan sebelumnya.	
Kegiatan Inti	l. Meminta siswa untuk duduk secara berkelompok dengan anggota kelompok sama seperti pertemuan sebelumnya. **Mengamati** f. Guru memberikan LAS 7, 8, dan 9 yang berisi permasalahan baru serta meminta siswa untuk mengamatinya. **Menanya** g. Guru menanyakan kepada siswa mengenai pengetahuannya tentang unit satuan luas. *Unit satuan luas adalah unit yang berbentuk persegi yang biasanya berukuran 1x1. Ubin bisa kita sebut sebagai unit satuan luas dan dapat kita gunakan untuk mengukur luas lantai dan bentuk lainnya.* **Mengumpulkan Informasi/Eksperimen** h. Setiap kelompok diminta untuk memikirkan model matematika dari permasalahan yang terdapat pada LAS 7, 8 dan 9 dan menuliskan jawaban di tempat yang telah disediakan. i. Guru berperan sebagai fasilitator selama proses pembelajaran berlangsung dengan memberikan pertanyaan-pertanyaan mengenai jawaban yang ditulis siswa dan memberikan bimbingan apabila siswa menemui kesulitan. • *Bagaimana mengukur luas lantai?* • *Apakah rumus persegi panjang bisa*	5 Menit 3 Menit 7 Menit 15 Menit

	digunakan? • *Apakah unit atau ubin kita bisa pakai untuk mengukur luas bentuk lain?* • *Apa yang dapat kita simpulkan?* j. Beberapa kelompok diminta untuk mempresentasikan jawabannya di depan kelas dan kelompok lain diminta untuk memberikan tanggapan **(mengkomunikasikan)**. k. Melakukan diskusi kelas yang dipimpin oleh guru • *Luas lantai dapat dicari dengan luas ubin atau dengan menggunakan rumus persegi panjang dengan mengalikan lebar dan panjang lantai.* • *Untuk mengukur dan membandingkan luas dapat menggunakan unit satuan luas yang sama* **Mengasosiasikan/Mengolah Informasi** l. Siswa diminta untuk menganalisis penerapan proses pembuatan unit satuan luas dengan kotak persegi yang mereka buat sendiri. Siswa diminta untuk memahami kenapa saat menggabungkan kotak persegi yang tidak utuh untuk menjadi utuh diperbolehkan. m. Guru berperan sebagai fasilitator selama proses pembelajaran berlangsung dengan memberikan bimbingan kepada siswa yang menemukan kesulitan dalam menyelesaikan soal. **Mengkomunikasikan** n. Beberapa orang siswa diminta untuk mempresentasikan jawabannya di depan kelas. Siswa lain diminta untuk memberikan komentar mengenai jawaban yang telah dipresentasikan temannya.	10 Menit 5 Menit 25 Menit 25 Menit

		15 Menit
Penutup	a. Siswa diminta untuk memberikan kesimpulan dari pembelajaran pada hari ini yaitu *1) Luas persegi panjang adalah panjang dikali lebar* *2) Suatu bangun atau bentuk dapat diukur luasnya dengan menggunakan unit satuan luas* b. Guru menanyakan respon siswa mengenai kegiatan pembelajaran yang telah berlangsung.	5 Menit

Pertemuan Kelima (Aktivitas 10, Aktivitas 11 dan Aktivitas 12)

Alokasi waktu : 2 × 40 Menit

Kegiatan	Aktivitas Pembelajaran	Waktu
Pendahuluan	a. Guru dan siswa memberikan salam pembuka yang diikuti kegiatan berdo'a bersama sesuai dengan agama dan kepercayaan masing-masing. b. Guru memberikan apersepsi dengan menanyakan kemampuan prasyarat kepada siswa yaitu mengenai gedung yang unik bentuknya. Untuk mengukur dan membandingkan luas, dapat menggunakan unit satuan luas, kalau kemarin ubin, sekarang gelas kaca. c. Guru memberikan motivasi kepada siswa. Gedung tersebut akan dibandingkan luas sisi gedung yang ditutupi gelas kaca. Bagaimana menurut pendapat kamu? Bagaimana caranya? d. Guru menjelaskan tujuan pembelajaran kepada siswa.	5 Menit

	Tujuan pembelajaran pada hari ini yaitu siswa mampu mengukur luas persegi panjang dan jajar genjang. Siswa mampu mengukur luas jajar genjang serta menemukan rumus luasnya. Siswa mampu megukur luas segitiga dan mampu menemukan luasnya. e. Guru menginformasikan kegiatan pembelajaran yang akan dilaksanakan. Kegiatan pembelajaran pada hari ini adalah diskusi secara berkelompok, presentasi kelompok, diskusi kelas dan bekerja secara individu. Pembagian kelompok sama dengan pertemuan sebelumnya.	
Kegiatan Inti	m. Meminta siswa untuk duduk secara berkelompok dengan anggota kelompok sama seperti pertemuan sebelumnya. **Mengamati** f. Guru memberikan LAS 10, 11 dan 12 yang berisi permasalahan pada jajar genjang dan segitiga **Menanya** g. Guru menanyakan kepada siswa mengenai pengetahuannya tentang pengubahan bentuk dan hubungan antara jajar genjang/ persegi panjang dengan segitiga. *Apakah luas jajar genjang sama dengan luas persegi panjang yang dibentuk? Apakah rumus persegi panjang dapat kita gunakan untuk mengukur luas jajar genjang? Apakah hubungan segitiga dengan bangun jajar genjang atau persegi panjang?* **Mengumpulkan Informasi/Eksperimen** h. Setiap kelompok diminta untuk memikirkan	5 Menit 3 Menit 7 Menit 15 Menit

	model matematika dari permasalahan yang terdapat pada LAS 10, 11 dan 12 dan menuliskan jawaban di tempat yang telah disediakan. i. Guru berperan sebagai fasilitator selama proses pembelajaran berlangsung dengan memberikan pertanyaan-pertanyaan mengenai jawaban yang ditulis siswa dan memberikan bimbingan apabila siswa menemui kesulitan. • *Bagaimana rumus persegi panjang? Mana alasnya sekarang? Mana tingginya sekarang? Apa hubungannya dengan panjang dan lebar?* • *Apakah saat dirubah menjadi persegi panjang luasnya berubah? Kenapa?* • *Apakah hubungan dari segitiga dengan jajar genjang?* • *Apa yang dapat kita simpulkan?* j. Beberapa kelompok diminta untuk mempresentasikan jawabannya di depan kelas dan kelompok lain diminta untuk memberikan tanggapan **(mengkomunikasikan)**. k. Melakukan diskusi kelas yang dipimpin oleh guru • *Luas jajar genjang dapat dicari dengan apa? Saat dirubah bentuk apakah luasnya sama?* • *Luas segitiga dapat diukur dengan mengubah menjadi persegi panjang, apa hubungan panjang dan lebar persegi panjang dengan alas dan tinggi segitiga?* **Mengasosiasikan/Mengolah Informasi** l. Siswa diminta untuk menganalisis perubahan	10 Menit 5 Menit 25 Menit

	bentuk jajar genjang menjadi persegi panjang dan mencari hubungan alas dan tinggi jajar genjang dengan panjang dan lebar persegi pnajang yang dihasilkan. m. Guru berperan sebagai fasilitator selama proses pembelajaran berlangsung dengan memberikan bimbingan kepada siswa yang menemukan kesulitan dalam menyelesaikan soal. **Mengkomunikasikan** n. Beberapa orang siswa diminta untuk mempresentasikan jawabannya di depan kelas. Siswa lain diminta untuk memberikan komentar mengenai jawaban yang telah dipresentasikan temannya.	25 Menit 15 Menit
Penutup	a. Siswa diminta untuk memberikan kesimpulan dari pembelajaran pada hari ini yaitu *1) Luas jajar genjang dapat diukur dan dicari rumusnya dengan mengubahnya menjadi persegi panjang.* *2) Luas segitiga dapat diukur dengan cara mengubah bentuknya menjadi persegi panjang atau melihat segitiga sebagai separoh dari jajar genjang* b. Guru menanyakan respon siswa mengenai kegiatan pembelajaran yang telah berlangsung.	5 Menit

<u>Pertemuan Keenam (Aktivitas 13 dan Aktivitas 14</u>)

Alokasi waktu : 2 × 40 Menit

Kegiatan	Aktivitas Pembelajaran	Waktu
Pendahuluan	a. Guru dan siswa memberikan salam pembuka yang diikuti kegiatan berdo'a bersama sesuai dengan agama dan kepercayaan masing-	5 Menit

	masing. b. Guru memberikan apersepsi dengan menanyakan kemampuan prasyarat kepada siswa yaitu mengenai gedung yang unik bentuknya pada pertemuan sebelumnya. Pada pertemuan sebelumnya, untuk mengukur luas sisi gedung dapat menggunakan gelas kaca yang menutupinya. c. Guru memberikan motivasi kepada siswa. Gedung unik tersebut akan dicari luas sisi gedung yang ditutupi gelas kaca. Bagaimana menurut pendapat kamu? Bagaimana caranya? d. Guru menjelaskan tujuan pembelajaran kepada siswa. Tujuan pembelajaran pada hari ini yaitu siswa mampu mengukur luas trapesium serta menemukan rumus luasnya. Siswa mampu megukur luas layang-layang dan belah ketupat serta mampu menemukan luasnya. e. Guru menginformasikan kegiatan pembelajaran yang akan dilaksanakan. Kegiatan pembelajaran pada hari ini adalah diskusi secara berkelompok, presentasi kelompok, diskusi kelas dan bekerja secara individu. Pembagian kelompok sama dengan pertemuan sebelumnya.	
Kegiatan Inti	n. Meminta siswa untuk duduk secara berkelompok dengan anggota kelompok sama seperti pertemuan sebelumnya. **Mengamati** f. Guru memberikan LAS 13 dan 14 yang berisi permasalahan pada trapesium dan layang-layang serta belah ketupat	5 Menit 3 Menit

	Menanya g. Guru menanyakan kepada siswa mengenai pengetahuannya tentang pengubahan bentuk dan hubungan antara trapezium dengan segitiga *Apa sajakah bangun yang ada di trapesium tersebut? Apakah jumlah luas dua segitiga tersebut sama dengan luas satu trapesium? Apakah rumus segitiga dapat kita gunakan untuk mengukur luas trapesium? Apakah hubungan segitiga dengan trapesium?* *Apakah hubungan layang-layang, belah ketupat dengan persegi panjang yang dibentuk? Apakah kamu bisa menemukan hubungan diagonal dengan sisi persegi panjang?* **Mengumpulkan Informasi/Eksperimen** h. Setiap kelompok diminta untuk memikirkan model matematika dari permasalahan yang terdapat pada LAS 13, dan 14 dan menuliskan jawaban di tempat yang telah disediakan. i. Guru berperan sebagai fasilitator selama proses pembelajaran berlangsung dengan memberikan pertanyaan-pertanyaan mengenai jawaban yang ditulis siswa dan memberikan bimbingan apabila siswa menemui kesulitan. • *Bagaimana rumus segitiga? Apakah jumlah luas segitiga itu bisa kamu sederhanakan?* • *Apakah saat dirubah menjadi persegi panjang luasnya berubah? Kenapa?* • *Apa hubungan diagonal-diagonal laying laying maupun belah ketupat dengan*	7 Menit 15 Menit 10 Menit 5 Menit

	panjang dan lebar persegi panjang yang terbentuk? • *Apa yang dapat kita simpulkan?* j. Beberapa kelompok diminta untuk mempresentasikan jawabannya di depan kelas dan kelompok lain diminta untuk memberikan tanggapan **(mengkomunikasikan)**. k. Melakukan diskusi kelas yang dipimpin oleh guru • *Luas trapesium dapat dicari dengan apa? Bisakah dicari dengan luas segitiga di dalam trapesium?* • *Luas laying-layang dan belah ketupat dapat diukur dengan mengubah menjadi persegi panjang, apa hubungan panjang dan lebar persegi panjang dengan diagonal-diagonal laying-layang dan belah ketupat* **Mengasosiasikan/Mengolah Informasi** l. Siswa diminta untuk menganalisis bangun yang ada di dalam trapezium dan mencari luas segitiga-segitiga dalam trapezium dengan luas trapezium tersebut. m. Guru berperan sebagai fasilitator selama proses pembelajaran berlangsung dengan memberikan bimbingan kepada siswa yang menemukan kesulitan dalam menyelesaikan soal. **Mengkomunikasikan** n. Beberapa orang siswa diminta untuk mempresentasikan jawabannya di depan kelas. Siswa lain diminta untuk memberikan komentar mengenai jawaban yang telah dipresentasikan temannya.	25 Menit 25 Menit 15 Menit
Penutup	a. Siswa diminta untuk memberikan kesimpulan dari pembelajaran pada hari ini yaitu *1) Luas trapezium dapat diukur dan dicari rumusnya dengan menggunakan luas segitiga yang ada di dalam trapesium* *2) Luas laying-layang dan belah ketupat*	5 Menit

	dapat diukur dengan cara mengubah bentuknya menjadi persegi panjang b. Guru menanyakan respon siswa mengenai kegiatan pembelajaran yang telah berlangsung.	

I. Teknik Penilaian

Teknik penilaian difokuskan pada penilaian proses selama pembelajaran.

a. Ranah afektif

Penilaian ranah afektif dilakukan dengan observasi. Observasi yang dilakukan terbagi atas dua bagian yaitu sikap spiritual dan sikap sosial. Berikut lembar observasi sikap spiritual dan sikap sosial siswa.

Lembar Observasi Sikap Spritual

Kelas : ……

Hari, tanggal : …….

Materi : …….

No	Nama	Sikap					Keterangan
		1	2	3	4	5	

Pernyataan Sikap :

1. Berdoa sebelum dan sesudah melakukan sesuatu
2. Mengucapkan rasa syukur atas karunia Tuhan
3. Memberi salam sebelum dan sesudah menyampaikan pendapat/presentasi
4. Mengungkapakan kekaguman secara lisan maupun tulisan terhadap Tuhan saat melihat kebesaran Tuhan
5. Merasakan keberadaan dan kebesaran Tuhan saat mempelajari ilmu pengetahuan

Rubrik Penilaian :

4 = selalu, apabila selalu melakukan sesuai pernyataan

Lembar Observasi Sikap Sosial

Kelas : …….

Hari, tanggal : …….

Materi : …….

No	Nama Peserta Didik	Sikap							Keterangan
		Jujur	Disiplin	Tanggung Jawab	Toleransi	Gotong Royong	Santun	Percaya Diri	

Rubrik Penilaian :

4 = apabila selalu konsisten menunjukkan sikap sesuai aspek sikap

3 = apabila sering konsisten menunjukkan sikap sesuai aspek sikap dan

Petunjuk Penskoran :

Skor akhir menggunakan skala 1 sampai 4

Perhitungan skor akhir menggunakan rumus :

$$\frac{\text{Skor diperoleh}}{\text{Skor Maksimal}} \text{ x } 4 = \text{skor akhir}$$

Perolehan nilai

Sangat Baik : apabila memperoleh skor : 3,33 < skor ≤ 4,00
Baik : apabila memperoleh skor : 2,33 < skor ≤ 3,33
Cukup : apabila memperoleh skor : 1,33 < skor ≤ 2,33
Kurang : apabila memperoleh skor : skor ≤ 1,33

b. Ranah psikomotorik

Penilaian ranah psikomotorik dilakukan dengan observasi. Berikut lembar observasi keterampilan kelompok.

Lembar Observasi Keterampilan Kelompok

Kelas : …….

Hari, tanggal : …….

Materi : …….

No	Kelompok	Indikator			Keterangan
		1	2	3	

Indikator :

1. Deskripsi pengamatan
2. Mencoba menyelesaikan permasalahan
3. Mempresentasikan hasil diskusi

Rubrik Penskoran

Skor yang digunakan dengan skala 1 sampai 3. Berikut tabel rubrik penskorannya.

No	Indikator	Rubrik
1.	Deskripsi pengamatan	3. Memperoleh deskripsi hasil pengamatan *secara lengkap*. 2. Memperoleh deskripsi hasil pengamatan *kurang lengkap*. 1. *Tidak memperoleh* deskripsi hasil pengamatan.
2.	Mencoba menyelesaikan permasalahan	3. Mampu menyelesaikan *semua* permasalahan dengan benar. 2. Mampu menyelesaikan *sebagian* permasalahan dengan benar 1. *Tidak mampu* menyelesaikan permasalahan dengan benar.
3.	Mempresentasikan hasil diskusi	3. Mampu mempresentasikan hasil dikusi dengan benar, bahasa mudah dimengerti dan penuh percaya diri. 2. Mampu mempresentasikan hasil praktik dengan benar, bahasa mudah dimengerti, dan disampaikan kurang percaya diri.

No	Indikator	Rubrik
		1. Mampu mempresentasikan hasil praktik dengan benar, bahasa sulit dimengerti, dan disampaikan tidak percaya diri.

Kriteria Penilaian:

$$\text{Nilai} = \frac{\text{Jumlah Skor yang Diperoleh}}{\text{Skor Maksimum}} \text{ X } 100$$

c. Ranah kognitif

Penilaian ranah kognitif dilakukan dengan pemberian *pre-test*, soal latihan dan *post-test*.

Palembang, Maret 2014

Guru Kelas

Fauziyah, S.Pd.
NIS :120.07

Peneliti

Wahid Yunianto, S.Si.

Mengetahui,

Kepala Sekolah

Dra. Trisna Sundari