Higher order thinking skills (HOTS) first middle school of class viii students in completing the problem of polyhedron

Ma’rufi, M Ilyas and R F Pasandaran
Universitas Cokroaminoto Palopo
Email: marufi.ilyas@gmail.com

Abstract. The development of mathematics learning now has undergone changes in a contemporary manner. This drastic change focuses on developing the way mathematics works in a case, not just seeing mathematics as a procedure and we know it as HOTS (Higher Order Thinking Skills). This research aims to detect HOTS students in solving problems in building flat side spaces. The instrument is presented in the form of a HOTS problem that contains several indicators, namely: building complex thinking, there are no clear algorithms to solve it, difficult to predict, using approaches that are different from existing problems or with examples that have been given. The results of data analysis show that HOTS can be translated into several capabilities, namely; (1) explore information, (2) arrange conjectures, (3) logical reasoning, (4) structure problem solving, (5) communicate mathematically, and (6) connecting mathematical ideas.

1. Introduction
Mathematics and the way it is taught are dynamic ideas and are always interesting to discuss. Various reformations aimed at improving mathematics education have been widely carried out. Starting from curriculum reconstruction, the application of innovative learning models through various approaches, to the creation of information technology-based learning media. These efforts are a reasonable reaction carried out by the actors and practitioners of mathematics education given that students' learning needs and curriculum demands are also increasing.

Philosophically, mathematics must be seen as deep and reflective. Reflective thinking about mathematics contains several things such as mathematical material, objects taught, instructors, learning facilities, and a conducive learning environment. These things must be seen simultaneously, not partially so that they can build an in-depth understanding of mathematics and the way to teach it. This concept is the forerunner to the emergence of Pedagogical Content Knowledge (PCK).

The existence of PCK has begun to shift classical and traditional forms of learning. PCK allows each teacher to design innovative learning scenarios, have distinctive characteristics, and of course based on student learning needs. One important aspect in PCK is how far a teacher understands his/her learners or knowledge of students (KS). Knowledge about students includes ways that teachers use to know their students' knowledge, how to diagnose potential problems that may arise, as well as how to solve them. In other terms, this process can be categorized as teacher metacognition of students. The ability of teachers to understand students' thinking processes allows a dynamic learning, considering that each student has different abilities and has the potential to cause different problems. This challenge is so interesting to explore more deeply to project all the actions that teachers can take in dealing with cases of classroom learning.
Furthermore, a shift in perspective on mathematics also occurs among students. Students view mathematics as limited to a tool or "mathematics as a tool". This view is relative, depending on the how deep one's understanding in addressing mathematics both theoretically and practically. Such a view or assumption is not wrong at all and also does not have to be discarded at all. The thing to realize is placement. If in learning a teacher tends to think of mathematics as a tool, it is not impossible that the child will believe that "result is the most important thing" or "the important thing is memorizing the formula". Even though it is more than that, mathematics is an art of high-level thinking based on the law of logic that emphasizes rationality and agreement.

Thinking is a mental process that takes place continuously. The process in this case is to acquire knowledge and manipulate knowledge through activities of remembering, analyzing, understanding, judging, reasoning, imagining, and speaking. These thinking skills can have the opportunity to develop students' high-thinking skills, if they are designed with the right strategy. [5] explained that high-level thinking skills were more likely to use logic rather than remembering and memorizing formulas, thus mastering concepts would be total and allowing students to solve more complex mathematical problems. [1] described that the problems of HOT (Higher Order Thinking) are problems with a solution which is not only to use formulas directly, to create complex problems, to have many solutions, to require interpretations and to require hard effort in linking decisions. This is a challenge for teachers to create learning oriented to higher order thinking skills.

2. Literature Review
Content analysis on HOT issues has a positive impact on teachers. On the one hand, the teacher has insight in identifying the level of analysis (C4), evaluation (C5), and creating (C6), then integrating it into a mathematical problem. On the other hand, this also requires the creativity of the teacher to choose the context in accordance with the learning material. The selection of the right material context will stimulate students' reasoning power in the process of problem solving. Stimulus in learning can be done through questions, limited guidance, or constructivist commands. [6] described that emphasizes that in the assessment of mathematical literacy, the context is important, because it brings the students’ mindset to recall the concepts they have learned, connect with problems, then formulate a suitable solution.

The teacher as the facilitator for students has a very important role in achieving this particular mission. Professional skills and teacher pedagogy in designing learning can be elaborated in the form of knowledge of subject matter including; the ability to understand the relation of concepts, the ability to demonstrate procedural knowledge, and the ability to design frameworks/concept maps to make students easier to learn conceptual sequences. Teacher's knowledge should be presented into mature, structured and systematic learning planning [2]. Teachers must consider the use of an accommodative learning approach, in accordance with the background of the students' condition, the level of students’ thinking, and should potentially build a conducive learning environment.

The implementation of cooperative learning is a prevalent alternative. Special methods are needed to build HOTS. If it is referred to the implementation of the 2013 Curriculum, the scientific approach can be regarded as the solution, even though it is not the only one. The stages of scientific learning include: (1) stating the problem; (2) collecting information; (3) developing hypotheses (hypotheses are interpretations of information collected by scientists); (4) conducting experiments to test the accuracy of the hypothesis; (5) recording and analyzing data that has been collected; and (6) withdrawing conclusions. The learning steps through the scientific approach consist of observing, asking, gathering information, reasoning, communicating and creating [10].

Referring to the facts described above, this article aims to describe students' high-level thinking processes from the point of view of problem solving and the design of teacher learning strategies that can build students' high thinking skill level.

3. Research Methods
This research is a qualitative case study on learning the Surface Area of Cubes and Cuboid in Bua 2 High School from February to March 2019. The research data are in the form of statements and arguments derived from observations and field notes. The main instrument of research was the researchers themselves, as collectors, processors, and interpreters of data, assisted by additional instruments in the form of student worksheets, field notes, teacher activity observation sheets, student activities, and learning transcripts.

The instrument was developed through several stages namely; (1) Preliminary analysis is done by analyzing curriculum, learning objectives and student needs, (2) Student analysis is done by digging information about students' initial abilities about teaching material, (3) Material analysis is done by recognizing the concepts of teaching materials and their relationships, (4) Selection of the format is done by selecting the appropriate initial format, (5) The initial design is done by compiling the draft instrument based on its components, (6) Preparation of the design is done by describing each component of each instrument based on indicators, and (7) expert validation, is carried out by submitting a complete draft instrument to be validated internally by experts, (8) Revised instrument, (9) Revised instrument is ready to use.

Data was obtained through learning observation, by recording all learning activities from the beginning of the class to the end. After the data had been collected, they were than validated through triangulation method. Triangulation was performed by looking at the compatibility of data from each research instrument. The data collected were reviewed to see their consistency. Once they had fulfilled that condition, they were categorized to be valid, and can be continued with the data analysis process. Data analysis was performed using Miles and Huberman techniques (Data Collection, Data Reduction, Data Display, Data Verification) interactively and continuously to obtain patterned data forms.

4. Finding and Discussion
There are many mathematical learning models/approaches that have the potential to build HOTS. However, among those abundant options, the teacher must take the right choice. Some aspects can be considered such as we should prioritize cognitive psychology rather than behavioristic ones. Learning must be arranged to allow students actively building their knowledge independently through a number of discovery activities. Scientific activity reflects changes in learning behavior, but the main motive for driving change is mental symptoms (thinking). A person's thinking skills are mainly obtained through education while genetics plays the minor role. In the contrary, intelligence is dominantly controlled by genetic, while the rest is by education [4].

Thinking is a mental activity that occurs through the development of ideas and concepts within a person. The development of ideas and concepts takes place through the interaction between the parts of information stored in the cognitive structures that have been previously existed, so that a new more complete knowledge is formed. The relationship between the parts of knowledge and the object in mind will be formed through the process of assimilation and accommodation. Both of these processes allow everyone to integrate information in their cognitive schemes, even creating a new scheme that can produce new ideas or concepts that are more complex.

The following are the HOTS forms of students in solving the problem of cubes and cuboids.
Students solve this problem through the stages of problem solving as follows.

**Figure 1. Problems with Cubes and Cuboid**

Students can write important things into three information categories and have not made a connection between the information. This stage is a process of analytical thinking (C4). Analytical thinking allows students to disassemble / detail a general information into small information. The information is then used in preparing the problem solving plan / strategy as follows.

**Figure 2. Stages of Understanding Problems**

Student worksheets (LKS) designed by the teacher assisted them to determine problem solving strategies. Through instructions in the LKS, students were asked to use the concept of cube and cuboid surface area. Students wrote the formula for the second surface area to build the space, then they were asked to determine the elements of the cube and the cuboid needed to calculate the second surface area to build the space as follows.

**Figure 3. Stages of Arranging a Plan**
This process guides students to gather as much information as possible to build a working hypothesis. The work hypothesis refers to the process of constructing conjectures about relevant information and those that are not relevant to the problem. It seemed that students wrote diagonals, vertices, plane side, angle and so on. In the end they would choose important things to compile a calculation algorithm. Through this process, students were guided to synthesize information before carrying out further calculations.

Students determined the area of the second object then added them together. This result is not immediately justified by the teacher. Next was the stage of exchange of opinions / discussions. These results received comments from other student groups. According to them, this process was wrong because there were various top of cuboid that were covered in cubes. So the surface area of the cuboid must be reduced by the area covered by the cube base and the surface area of the cube was calculated by the formula $5r^2$ because there was one cube plane that intersects with the cuboid. The discussion process allows students to correct each other's answers / ideas. This indicates the occurrence of the evaluation process (C5) and creates new ideas (C7) within the scope of peer assessment. Peer assessment guarantees authentic / process evaluation in the classroom, so that the assessment is not only seen as scoring or grading through a series of tests, but also must be an integral part of learning [8]. The results of the detailed assessment and formulation of new ideas are presented as follows.
Figure 6. Results of Student Discussions

Based on the results of continuous observations, researchers succeeded in identifying student learning needs when completing non-routine/HOT questions, including: (a) requiring a problem solving strategy, (b) requiring guidance when experiencing difficulties/failures, (c) requiring guidance for linking several ideas and applications, (d) requiring reflection strategies. The four aspects are described in the table below!

Table 1. Strategy Design Analysis

| No | Student Learning Needs                              | Teacher Strategy / Stimulus                                      |
|----|-----------------------------------------------------|-----------------------------------------------------------------|
| 1  | Need a problem solving strategy                     | **Encourage students so they can:**                             |
|    |                                                     | a. Identify all information needed for problem solving (C2)     |
|    |                                                     | b. Describe the type of knowledge to be used (C2)               |
|    |                                                     | c. Write a detailed problem solving strategy plan (C2)          |
|    |                                                     | d. Explain problem solving strategies (C4)                      |
| 2  | Need guidance when experiencing difficulties / failures | **Encourage students so they can:**                             |
|    |                                                     | a. Represent concepts into diagrams, graphs, tables, sentences and images (C4) |
|    |                                                     | b. Design several hypotheses / conjectures (C4)                 |
|    |                                                     | c. Compare concepts arranged by each group (C5)                 |
| 3  | Need guidance to associate some ideas and applications | **Encourage students so they can:**                             |
|    |                                                     | a. Design your own example / problem according to the composition of a recognized concept (C6) |
|    |                                                     | b. Discuss group findings (C2)                                  |
| 4  | Need a reflection strategy                          | **Encourage students so they can:**                             |
|    |                                                     | a. Describe the reasons underlying the correct                  |
The research data presented in the table above was taken from observation. Observation conducted on learning activities showed many effective ideas that can be applied to improve the practice of learning carried out by teachers who focus on solving various learning problems, taking the context of learning and experience of other teachers, and providing support to teachers in peer relations [3].

In addition to observation, the preparation stage also determined the results of this study. The preparations included compiling learning tools which were syllabus, lesson plans, student activity sheets (LKS), student books, and HOTS-based teacher books. It is also necessary to prepare research instruments used to retrieve data. The research instruments included observation sheets of learning activities, student response questionnaires, and test of learning outcomes if deemed necessary.

Related to the learning content, Table 1 shows that in each stimulus there was a level C2 or understanding the problem. By understanding a concept students can know, explain, describe, compare, differentiate, classify, give examples and not examples, conclude and re-express an object with their own language by realizing the processes through it [11]. Mathematical concepts is important to be taught meaningfully. Meaning means that students must understand mathematical concepts in order to be able to solve questions and be able to apply the learning in the real world and be able to develop other abilities which are the goals of mathematics learning.

This shows that understanding is the main key to HOTS learning. Understanding the correct concept of a problem, allows students to explore the next problems with a more complicated level of thinking. Understanding in this case leads more to relational understanding or non-procedural thinking. This is characterized as the ability of students to search for and explore mathematical patterns/structures and the underlying relationships, the ability to use available facts, formulate problem solving pathways, the ability to make mathematical ideas meaningfully, the ability to think and reason flexibly through constructing conjectures, generalization, and justifying, and the ability to determine that a result of problem solving is reasonable or logical. This result recommends an idea for teachers to place conceptual understanding as a top priority in learning. Concepts must be maximized to students, before they further experience more complicated mathematical processes.

Problem solving is a human activity that combines concepts and rules that have been obtained previously, and not as a generic skill. This is the weakness of students. Impressions are hard to come by when they cannot associate initial knowledge and transform the concept into new problems faced. The teacher must carefully look at this as a case that must be solved. Teachers must provide assistance by providing learning media such as worksheets. Through worksheets, students have the opportunity to be deeply involved in learning. their activities include: being able to study information, identify types of initial knowledge, write down problem solving plans, and interpret their findings in writing. The worksheets certainly must be arranged with clear and constructivist instructions.

The use of worksheets provides several advantages such as: (a) activating students in the teaching and learning process, (b) helping students in developing concepts, (c) training students to find and develop teaching and learning processes, (d) helping teachers in compiling lessons, (e) as a guideline for teachers and students in carrying out the learning process, (f) helping students obtain notes on the material learned through learning activities, (g) helping students to add information about concepts learned through systematic learning activities [7]. Table 2 is the expected learning strategies and student activities.

HOTS-based mathematics learning must also build student writing skills. Writing allows students to build relevant data sources. This data source allows them to plan systematic problem solving. Writing is one form of mathematical communication that becomes a central force for students in: (a)
formulating mathematical concepts and strategies, (b) becoming the capital of success for students in mathematical exploration and investigation, (c) a place for students to communicate with their friends to obtain information, share their thoughts and findings [9].

| No | Teacher Strategy / Stimulus | Student Activities |
|----|-----------------------------|--------------------|
| 1  | Encouraging students so they can;  
   a. Identify all information needed for problem solving (C2) | Students can:  
   a. Examine the quadruple rectangular material.  
   b. Write down the properties, arguments, or formulas that apply.  
   c. Write down the dimensions of cubes and cuboids.  
   d. Write down the formula for the surface area of cubes and cuboids. |
|    | b. Describe the type of knowledge that will be used (C2) | a. Determine prerequisite material such as:  
   b. Review these materials |
|    | c. Write down the problem solving strategy plan in detail (C2) | Design problem solving flowcharts involving prerequisite materials. |
|    | d. Explain problem solving strategies (C4) | Describe problem flowcharts that involve prerequisite material, both orally and in writing. |
| 2  | Encouraging students so they can;  
   a. Make representations of concepts into pictures, diagrams, graphs, tables and sentences (C4) | Students can:  
   Make images that match the problem. |
|    | b. Design several hypotheses / conjectures (C4) | a. Discuss several plans / alternative problem solving in each group.  
   b. Write down the results of the discussion. |
|    | c. Compare the arrangement of concepts produced in groups (C5) | Compare findings from one group to another. |
| 3  | Encouraging students so they can;  
   a. Design your own example / problem according to the composition of the recognized concept (C6) | Submit similar problems with similar content. |
|    | b. Discuss findings in groups (C2) | Discuss the resolution of problems submitted in groups. |
| 4  | Encouraging students so they can;  
   a. Describe the reasons underlying the correct solution (C4) | Write down the theorems underlying the steps. |
|    | b. Design conclusions (C6) | Write down the correct answers followed by steps of systematic problem solving. |
| No | Teacher Strategy / Stimulus | Student Activities |
|----|-----------------------------|--------------------|
| c. | Determine the degree of truth of the conclusions produced (C5) | Assess the results of peer problem solving in each group. |

5. Conclusion

Students' higher-order thinking skills must be built through effective learning planning by the teacher. This can be achieved if the teacher can carefully identify the way students think and work correctly. Teachers must limit themselves in taking the teaching role. The dominance of learning activities must be in students. Therefore, students must always be encouraged to be able to compile the information needed in problem solving. It also allows students to distinguish the types of mathematical knowledge they need. They can diagnose problem solving strategy plans through a combination of mathematical knowledge in the form of factual, conceptual, procedural or relational knowledge appropriately. Diagnoses made by students can also encourage them to represent each of their ideas in a simpler display of concepts. The representations they make can be done verbally or in writing so as to develop their mathematical communication power. One form of their communication is through discussion in class. The right discussion is expected to be able to explain every reason they put forward so that they can determine their own degree of truth of a problem solving.

On the other hand, building learning that involves higher-order thinking skills is also strongly supported by appropriate learning tools. In this study, student worksheets (LKS) were chosen as learning aids which were considered effective for building students' high-level thinking skills. The worksheet is developed through defining the material and concepts, designing the design, testing and revision. The worksheets that were developed combined two aspects of higher-order thinking namely understanding and problem solving. Two mental activities that occur in one learning activity. Understanding allows students to build initial ideas deductively, so that in the aspect of problem solving they can use and manipulate ideas that are already there to make a solution plan.

References

[1] Badjeber R and Purwaningrum J P 2018 Pengembangan Higher Order thinking Skills dalam pembelajaran matematika di SMP Guru Tua: Jurnal Pendidikan dan Pembelajaran 1 36-43
[2] Kartika D R and Pasandaran R F 2016 Analisis kemampuan guru dalam menanamkan konsep limit fungsi Jurnal Pedagogy 1 57-65
[3] Mahmudi A 2009 Mengembangkan kompetensi guru melalui lesson study Forum Kependidikan 28 4
[4] Mahmudi A 2015 Pendekatan sains di dalam pembelajaran matematika Jurnal Pendidikan Matematika FMIPA UNY 5
[5] Nurina D L and Retnawati H 2015 Keefektifan pembelajaran menggunakan pendekatan Problem Posing dan Pendekatan Open Ended ditinjau dari HOTS Phytagoras: Jurnal Pendidikan Matematika 10 129-36
[6] Pasandaran R F 2018 Taksonomi SOLO (Structure Of Observed Learning Outcomes) sebagai asesmen autentik untuk membangun kemampuan literasi mahasiswa dalam mengidentifikasi grafik fungsi trigonometri Proximal: Jurnal Matematika dan Pendidikan Matematika 1 88-105
[7] Pasandaran R F, Kartika D R and Masni E D 2017 Pengembangan Lembar Kerja Mahasiswa (LKM) pada pembuktian dalil-dalil segitiga Prosidig Seminar Nasional 2
[8] Purnomo Y W 2014 Asessment based learning: Sebuah tinjauan untuk meningkatkan motivasi belajar dan pemahaman matematis Sigma Journal 6 22-33
[9] Umar W 2012 Membangun kemampuan komunikasi matematis dalam pembelajaran matematika Infinity: Jurnal Ilmiah Program Studi Pendidikan Matematika STKIP Siliwangi 1 1-9
[10] Wibowo A 2017 Pengaruh pendekatan pembelajaran matematika realistik dan saintifik terhadap prestasi belajar, kemampuan penalaran matematis dan minat belajar *Jurnal Riset Pendidikan Matematika* 4 1-10

[11] Widyastriti N S and Pujiastuti P 2014 Pengaruh Pendidikan Matematika Realistik Indonesia Terhadap pemahaman konsep dan berpikir logis siswa *Jurnal Prisma Edukasia* 2 4-6