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Research Article

LOTS to HOTS: How do mathematics teachers improve students' higher-order thinking skills in the class?

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ABSTRACT

This study explored how mathematics teachers improve students' thinking skills from low to higher order thinking skills (HOTS) during class. This study used a qualitative descriptive research design. The research subjects involved were mathematics teachers from one of the high schools in Malang City, East Java, Indonesia. Data were collected through a process of initial observation in schools, the results of preparing lesson plans, classroom assessments by teachers, and semi-structured interviews. The results of the research were analyzed using models, namely data reduction, data presentation, and concluding. Data focused on lesson plans based on a scientific approach and HOTS-based assessments: analyzing, evaluating, and creating. The teachers' class assessments were analyzed and classified into the HOTS cognitive level using the Anderson & Krathwohls' Taxonomy indicators. The findings of this study indicate that teachers arranged the class with a scientific approach setting and provided HOTS-based class assessments to students to improve students thinking skills. But on the other hand, teachers experienced obstacles, that are students who are still passive when the scientific method was applied and the learning took a lot of time. Another obstacle related to the HOTS-based assessment is that teachers had difficulty when compiling HOTS-based assessment because it required a lot of time and thinking skill. Students also had difficulty in solving HOTS-based questions due to low reading interest and diverse student abilities.

Keywords: assessments class; mathematics; scientific approach; higher order thinking skills; HOTS;

1. INTRODUCTION

Mathematics is one of the branches of science that is important to be studied by all ages, but it was found that many students do not know the relevance and usefulness of mathematics in their daily (Gijsbers et al., 2020). Mathematics is a subject that can be used to improve students' high-level abilities or is known as Higher Order Thinking Skills (HOTS) (Nessel & Graham, 2006). Some experts say that students at all levels of education need to be good thinkers, namely thinking at a higher level (Schulz & Fitzpatrick, 2016). In the 21st century, students need to improve their thinking skills to become higher-order thinking skills. This is because the 21st century provides complex and challenging competitiveness. Higher-order thinking skills are needed by students so that they can solve the problems of everyday life (Handayani et al., 2020). These skills can certainly obtain through constructivism learning where students are placed at the center of the learning process (student-centered), namely, students find and form an understanding of concepts independently and control their learning process (Castaño Muñoz et al., 2013; Madhuri et al., 2012).

In Indonesia, the government has made a paradigm shift to constructivism learning which is expected to produce innovative creative, and productive human resources (Retnawati et al., 2016). The Indonesian government establishes an education system that uses scientific-based, problem-based, and project-based learning so that students become active in constructing their own understanding (Kemendikbud, 2014). Scientific learning is a learning process that builds knowledge through scientific methods and adopts the steps of scientists, namely observing, questioning, analyzing, reasoning, and communicating (Retnawati, 2016; Wieman, 2007). The results of the study proved that scientific-based learning has positive potential to improve students' learning skills (Spernes & Afdal, 2021). The results of other studies supported that the scientific approach applied by mathematics teachers can improve student achievement in understanding mathematics which is an abstract science (Maharani et al., 2020). Thus, learning mathematics in the classroom needs to be developed into a scientific-based learning process. In addition to scientific-based learning, the teachers' step to improve students' thinking skills is to arrange a HOTS-based class assessment (Sa'dijah et al., 2021).

Higher Order Thinking Skills (HOTS) are abilities that include analyzing, evaluating, and creating (Anderson et al., 2001). These abilities are the result of the revision of the top three abilities of Bloom Taxonomy by Anderson and Krathwohl, namely analysis, synthesis, and evaluation (Bloom, 1956). Improvement of thinking skills to higher-order levels is an important goal for education and Indonesia is no exception. However, the reality is that the higher-order thinking skills of students in Indonesia are not maximized. This is evidenced by research that Indonesian students are still struggling to achieve better rankings in the Trends in International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA) (Fenanlampir et al., 2019). An important role of education in learning and teaching is to transfer knowledge content and facilitate HOTS among students (Gupta & Mishra, 2021). One of the efforts to increase students' HOTS is through classroom assessments given by the teacher. Assessment is a series of data collection processes to obtain, analyze, and interpret what students know and can do (Sa'dijah et al., 2015).

Furthermore, assessment is important in the learning process because assessment serves as a tool for teachers to place students into certain groups, improve teaching methods, measure students' attitudes, and mental and material readiness, provide guidance in class and provide information to teachers for improving education (Reynolds et al.,2010) and making decisions about the sustainability and evaluation of student learning processes (Johnson et al., 2008). This is in line with Pearce, et al. that mathematics assessment must require students to have mathematical literacy skills because these abilities are important to improve problem-solving skills for students (Pearce et al., 2011). Brookhart said that assessment is said to assess higher order thinking skills if students do the following things: 1) analyze, evaluate, and create 2) reason logically, 3) think critically, 4) make decisions, 5) solve problems, and 6) creative thinking (Brookhart, 2010). This is also supported by similar research that critical thinking is the first step for students to think creatively which is classified as HOTS (Susilowati & Sumaji, 2020). However, previous studies have shown that teachers have difficulties on how to teach HOTS and developing HOTS-based assessments (FitzPatrick & Schulz, 2010; Schulz & Fitzpatrick, 2016; Widiatsih et al., 2020). On the other hand, teachers should familiarize students with solving mathematical problems through an assessment in the form of a mathematical numeracy test that can use four approaches, namely assessment of validity, reliability, level of difficulty, and discrimination power (Annisavitri et al., 2020). Teachers should actively introduce and apply various forms of representation assessments such as assessments in the form of problem-solving that help each student understand concepts and solve mathematical problems effectively (Hidajat et al., 2019). Therefore, teachers need to teach and improve students' higher-order thinking skills through classroom assessments.

Currently, there is no research answer to this research question and examines how the steps of mathematics teachers to improve students' abilities from lower-order thinking skills (LOTS) to higher-order thinking skills (HOTS) during the learning process in the classroom through scientific learning coupled with HOTS-based assessments. Most of the research that has been carried out is only related to teachers' understanding of HOTS-based assessments (Retnawati et al., 2018; Schulz & Fitzpatrick, 2016), assessment development in the context of HOTS (Dhewa Kusuma et al., 2017; Gradini & Noviani, 2022; Tanjung et al., 2020), and instructional design for HOTS-based assessments (Apino & Retnawati, 2017). Similar research that is relevant, namely the analysis of the design of the implementation of learning plans for mathematics teachers based on Higher Order Thinking Skills, showed that the preparation of class assessments is still at a low level (Kartika et al., 2019). In line with Retnawatis' research that teachers have difficulty in implementing scientific-based learning, especially in the "Questioning" section (Retnawati, 2016). Other findings also report that teachers who do not have digital literacy skills will have difficulty developing HOTS-based assessments (Widana, 2020). Similar research also found that teachers faced difficulties when implementing a scientific approach, especially promoting students to ask questions and analyze (Madina & Kardena, 2021). The scientific approach supported by HOTS-based classroom assessment from the teacher is believed to be able to improve students' abilities and achievements. Based on the explanation above, research that explores the preparation of HOTS-based assessments and scientific learning by mathematics teachers is important and needs to be done.

2. RESEARCH METHOD

This study explored the preparation of HOTS-based assessments coupled with scientific learning by mathematics teachers so that researchers used descriptive qualitative research methods because qualitative research provides designs that answer research problems through exploration and development of a detailed understanding of a phenomenon (Creswell, 2012). The location of research was carried out in one of the A-accredited high schools located in Malang City, East Java Province, Indonesia. The subjects involved in this study were seven teachers with the following criteria: 1) had teaching experience of more than 15 years, 2) used a scientific approach, and 3) were able to compile HOTS-based assessments. The research instruments used include: 1) human instruments, namely researchers directly acted as research instruments because only researchers can adapt to conditions and situations when conducting research and in-depth interviews with research subjects (Suwendra, 2018), 2) observation sheet for surveying the initial use of the learning and assessment approach by the teacher, 3) a semi-structured interview sheet contains complete and detailed questions made by the researcher, 4) higher order thinking indicators based on Anderson & Krathwohl's Taxonomy (Anderson et al., 2001) (Anderson et al. 2001) and 5) validation sheets. The following indicators of higher order thinking skills based on Anderson & Krathwohls' Taxonomy used by researchers are presented in **Table 1**.

Furthermore, the research stages included the preparation stage, implementation stage, and data analysis stage. In the preparation stage, the researcher determined the location, subject, and time of the study, and arranged the research instrument. At the implementation stage, the researcher conducted observations at school and collected data in the form of assessments made by the mathematics teacher and given by the teacher to the students, then followed by interviews with the selected research subjects to support and complete the data. The last stage is data analysis where the researcher reduced the data obtained in schools by analyzing teachers' assessments qualitatively based on higher order thinking skills indicators Anderson & Krathwohl (2001) and then presented data reports.

Furthermore, the researcher analyzed the data obtained using techniques, namely 1) data reduction, 2) data presentation and 3) concluding (Miles et al., 2018). Data reduction means the process of summarizing, choosing the main data, focusing on the data that are important, and looking for themes and patterns. Reduction of data needed to be done because the data that researchers get from mathematics teachers will be quite a lot. Thus, the data that will be focused on by researchers are teachers who used a scientific approach and developed HOTS-based assessments (analyzing, evaluating, and creating). After reducing the data, the next step is for the researcher to present the data in the form of descriptive text. The final step in data analysis is concluding. Concluding or known as continuous verification during the research process.

Table 1. Indicators of HOTS based on Anderson & Krathwohls' Taxonomy

Cognitive Levels	Descriptions	Aspects
Analyzing	Cognitive processes break down knowledge into its constituent parts and determine how these parts relate to one another.	Differentiating, organizing, and attributing.
Evaluating	Cognitive processes make judgments based on certain criteria and standards.	Checking and Critiquing.
Creating	Cognitive processes rearrange elements into new ideas or structures	Generating, planning, and producing.

3. RESULTS AND DISCUSSION

3.1 Results

The results of the study and interviews with research subjects showed that there were two main findings related to the steps taken by the mathematics teacher to improve students' higher order thinking skills in the classroom, namely: 1) classroom learning with a scientific approach and 2) teachers' HOTS based assessments which included analyzing, evaluating, and creating. The following describes each of the findings in this study in detail.

a. Class Learning Process with Scientific Approach

The curriculum currently being implemented in Indonesia emphasizes the student-centered learning process, namely scientific-based learning that adopts the scientific method including 1) Observing, 2) Questioning, 3) Analyzing, 4) Reasoning and 5) Communicating. Learning in the classroom based on a scientific approach is expected to increase student activity in constructing their understanding. The research subjects said that they prepared a lesson plan with a scientific approach. The following is an example of preparing a lesson plan with a scientific approach, which is presented in **Figure 1**.

C. Materi
- Barisan dan Deret Aritmetika
- Barisan dan Deret Geometri
- Pertumbuhan, Peluruhan, Bunga Majemuk, dan Anuitas

D. Pendekatan, Model, dan Metode Pembelajaran
Pendekatan : Pendekatan Saintifik (*Scientific*)
Model : Diskusi Kelas (Pertemuan ke-1 & 2)
Cooperative Learning (Pertemuan ke-3)
Metode : *Think-Pair-Share* (TPS), *Jigsaw*, diskusi, penugasan

E. Media/Alat dan Bahan Pembelajaran
LCD, *Whiteboard*/Papan Tulis

F. Sumber Belajar
Buku Matematika (Wajib) Kelas XI Semester 2: Penerbit Intan Pariwara

Translate Version:
C. Subject
- Arithmetic squences and series
- Geometric squences and series
- Gowth, decay, compound interest, and annuities

D. Learning Approach, Model, and Method
Approach : Scientific Approach
Model : Class Disscussion (1st and 2nd Meet)
Cooperative Learning (3rd Meet)
Method : Think-Pair-Share (TPS), jigsaw, discussion, and assigments

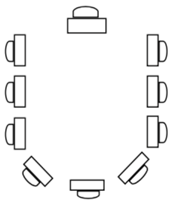
E. Media/ Learning Tools and Materials
LCD, Whiteboard

F. Learning Resources
Mathematics Book Eleventh Class Semester 2: Intan Pariwara Publisher

Figure 1. Lesson Plan based scientific approach

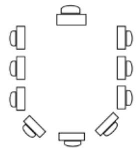
The preparation of the lesson plans in **Figure 1**. shows that the teacher used a scientific approach to the content of arithmetic sequences and series, geometric sequences series as well as the application of Arithmetic and Geometric sequences and series including growth, decay, compound interest, and annuities. Then, the teacher arranged a class setting with a learning model, that is the class discussion for meetings one and two, while for the third meeting, the teacher used a cooperative learning model that allows students to interact with each other and learn actively. In addition, the cooperative learning model also trains students to solve problems and various tasks through collaboration, exploration, and sharing ideas in a group. The teachers said that with the discussion and cooperative learning, students were expected to actively exchange ideas and solve problems and assignments given by the teacher in groups. Cooperative learning teaches students to work in small groups, then discuss, complain to each other, and help each other to learn the subject until in the end each student acquires new knowledge and understands the subject taught by the teacher. Furthermore, the teacher organizes the class using the Think-Pair-Share (TPS) method, Jigsaw, discussions, and assignments in scientific approach-based learning. The TPS method directs students first to think independently of a problem given by the teacher (think), then discuss it in pairs with other students (pairs) and finally share their ideas in a larger group discussion (share). Meanwhile, the jigsaw method teaches students to have the responsibility of teaching the subject they get to their group. Furthermore, the teachers convey the learning objectives and also arrange the class setting into scientific learning with a discussion model as shown in **Figure 2**.

Kegiatan Inti (± 140 menit)
Fase 1: Menyampaikan tujuan dan mengatur setting
1. Guru meminta siswa untuk mengatur tempat duduk menggunakan model bentuk U, agar siswa dapat berhadap-hadapan atau bertatap muka.



2. Guru menginformasikan kepada siswa bahwa pada pembelajaran hari ini, guru bersama siswa akan mengingat dan membahas kembali tentang barisan dan deret Aritmetika dan Geometri. Kemudian guru akan memberikan sebuah permasalahan barisan Aritmetika dan Geometri terkait masalah nyata kepada siswa dan siswa diminta untuk menyelesaikan masalah tersebut dengan berdiskusi.
3. Guru memotivasi siswa untuk berpartisipasi, misal dengan memberitahukan bahwa guru akan mengawasi diskusi dan mencatat siapa yang berpartisipasi dan yang tidak berpartisipasi.

Translate Version:
Core Activities (± 140 minutes)
Phase 1: Communicating goals and setting classroom
1. The teacher asks students to arrange their seats using a U-shaped model so that students can face to face.



2. The teacher informs the students that in today's lesson, the teacher and students will remember and discuss again about Arithmetic and Geometry sequences and series. Then the teacher will give an Arithmetic and Geometry sequence problem related to real problems to students and students are asked to solve the problem by discussing.
3. The teacher motivates students to participate, for example by informing that the teacher will supervise the discussion and note who participates and who does not participate.

Figure 2. Class Setting with Discussion U-shape Model

Figure 2. shows that the teacher conveys the learning objectives to the students and arranges the class setting in the core activity in 140 minutes. The teacher used a scientific approach so that the learning model used is a "U" shape discussion, meaning that students are asked to arrange seats in the class like the letter "U". This is done by the teacher so that all students and teachers face each other when discussing. First, the teacher conveys the learning objectives at the first meeting, that is solving contextual problems related to everyday problems about arithmetic and geometric sequences and series. The problem is expected to be solved by students by way of discussion. Furthermore, the teacher also said that students must actively participate in questions and answers, exchanging ideas and opinions. Scientific-based learning with a discussion model is also supervised by the teacher directly and the teacher makes observations by noting students who are actively participating and those who are not actively participating as an attitude assessment in mathematics.

After the data collection process, the researchers conducted in-depth interviews with the teachers. Most of the teachers said that learning with a scientific approach was useful for training students' activeness in learning. However, teachers often experienced problems when implementing scientific-based learning with a cooperative learning model. The obstacle experienced by the teacher is the limited time duration and the students are not active to ask questions. The teachers said that the time allocated was not enough to teach subjects with a scientific approach that applied the scientists' method. Furthermore, the teachers also explained that most students would be passive when promoted to ask questions about the problems given by the teacher.

This is supported by the statements of the teachers as follows:

"…scientific based learning takes a relatively long time, yes, I am often afraid not finished when teaching the subjects." **(Teacher 3)**

"..most students must be passive when promoted to ask questions in the let's questioning section .." **(Teacher 7).**

b. HOTS-based Classroom Assessments

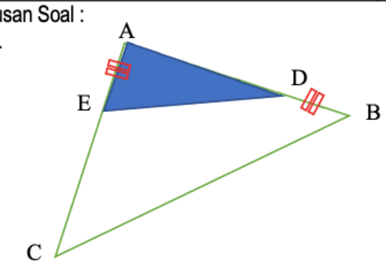
Assessment is an important and inseparable aspect of the teaching and learning process. Assessment is defined as a series of processes that measure student achievement regarding students' understanding, thinking, and behavior. The current curriculum in Indonesia emphasizes assessments that assess logical thinking skills, problem-solving, reasoning, evaluative, analytical, critical thinking, creativity, collaboration, and innovation where all of these abilities are included in the HOTS. Therefore, teachers are required to have the ability to compose HOTS-based classroom assessments. Before preparing the assessment, the teachers first understand the basic competencies of the curriculum used. Then, the teachers formulate indicators along with the cognitive level of their class assessment. The teachers arrange a HOTS-based assessment in the form of essay questions. As can be seen in Table 2, that is the results of the formulation of indicators and cognitive levels of teacher assessments are classified as HOTS. The following are examples of formulating indicators based on basic competencies and determining cognitive levels from teacher assessments, which are presented in **Table 2.**

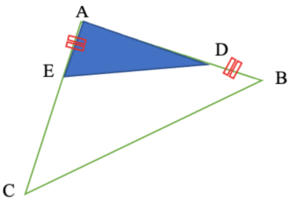
Table 2 shows that the teacher formulates three assessment indicators based on one basic competency item. In the derivative application, the basic competencies used by the teacher are at the cognitive level of HOTS: analyzing because students are asked to analyze the relationship between the first derivative of the function with its optimal value (maximum or minimum value) and the monotony and gradient of the tangent to the curve. Next, the teacher must arrange an assessment at least at analyzing level. Therefore, the teacher formulated three assessment indicators targeted at the cognitive levels of C4 (analyzing), C5 (Evaluating), and C6 (Creating). The teacher said that if the basic competence targets the cognitive level of analysis, then their assessment must assess the cognitive level of analysis and can be at the cognitive level above the analysis level, but the assessment should not target the cognitive level below the basic competence. For example, basic competency is at Analyzing level (C3) but teachers' assessments only assess student understanding or C2 (understanding). The teachers' assessment indicator that assesses students' abilities at the analyzing level is that students can determine the maximum area of a quadrilateral in the isosceles right triangle, and there is a small right triangle in the isosceles right triangle. The indicator is at the analyzing level because the indicator targets students to use their reasoning skills to determine the area of a rectangle when they are in a certain triangle related to derivative applications. Students must break their knowledge and then determine how the relationship between the derivative applications, the area of a rectangle, and the area of a triangle to solve the assessment. Furthermore, the class assessment indicators prepared by the teacher are also at the cognitive level HOTS: Evaluating, that is students can determine the correct statement related to the minimum point if students are given an equation of the curve, two points at the curve, and the maximum turning point of the curve. The assessment indicator is at the evaluating level because the indicator targets students to compare and prove whether every statement given is true or false. Furthermore, teachers are also able to formulate assessment indicators at the highest cognitive level, namely creating. The assessment indicator is students can make various equations of tangents to curves if students are presented with: 1) the equation of a curve, 2) the point through which the curve passes, and 3) the equation of the tangent line parallel to the slope of the curve. The indicator is included in the creating category because students are creatively asked to formulate an equation if given certain conditions so that the curve equations of students will differ from one another.

Table 2. Formulation of Indicators and The Cognitive levels of Classroom Assessments

Subject: The Derivative Application			
Basic Competency	Indicators	The Cognitive Levels	No.
Analyzing the relationship between the first derivative of the function with the maximum value, minimum value, and the monotony of the function interval, as well as the slope of the tangent to the curve.	Given the equation of a curve and two points, namely the point through to the curve passes and the maximum turning point of the curve. Students are asked to determine the correct statement relating to the minimum turning point of the curve.	C5	1
	Given the equation of a curve and the point through which the curve passes and the equation of the line parallel to the tangent of the curve. Students are asked to make various equations of the tangents to the curve.	C6	2
	Given an isosceles right triangle, and a small right triangle inside an isosceles right triangle. Students are asked to determine the maximum area of the quadrilateral in the triangle.	C4	3

After the teacher formulates the indicators and cognitive level of the classroom assessments, then the teacher arranges the assessment according to the content and cognitive level of indicators. The teacher said that compiling assessments, especially those at the HOTS cognitive level was a challenge for teachers. Teachers must be able to align the cognitive level of their class assessments with the indicators they have formulated. If the indicator is at the analyzing level, so the teacher must formulate a class assessment that assesses students' analytical skills and may not assess the lower order thinking skills such as remembering, understanding, and applying. The following is an example of a teachers' class assessment at the cognitive analyzing level, which is presented in **Figure 3**.

Kompetensi Dasar 3.9 Menganalisis keberkaitanan turunan pertama fungsi dengan nilai maksimum, nilai minimum, dan selang kemonotonan fungsi, serta kemiringan garis singgung kurva	Nomor Soal : 3	Level Kognitif : C4
Materi Aplikasi Turunan	Rumusan Soal : 1.  Perhatikan gambar di atas. Segitiga ABC siku-siku sama kaki. Panjang $AE = BD = 2$. Tentukan luas minimum segiempat BCED	
Indikator Diberikan suatu bangun segitiga siku-siku sama kaki, dan segitiga siku-siku kecil di dalam segitiga siku-siku sama kaki. Siswa diminta untuk menentukan luas maksimum dari segiempat yang ada di dalam segitiga tersebut		

<table>
<tr><td>Translate Version:
Basic Competency
3.9. Analyze the relationship between the first derivative of the function with the maximum value, minimum value, and the monotony of the function interval, as well as the slope of the tangent to the curve.</td><td>No: 2</td><td>Cognitive Level: C4</td></tr>
<tr><td>Subject
The Derivative Application</td><td colspan="2" rowspan="2">Question formulation:


Look at the picture above. Triangle ABC is an isosceles right triangle. Length AE=BD=2. Find the minimum area of the quadrilateral BCED.</td></tr>
<tr><td>Indicator
Given an isosceles right triangle, and a small right triangle inside an isosceles right triangle. Students are asked to determine the maximum area of the quadrilateral in the triangle.</td></tr>
</table>

Figure 3. Class Assessment at Cognitive Level: Analyzing

The teacher arranges a HOTS-based class assessment with a cognitive level: Analyzing as shown in Figure 2, where students are presented with an isosceles triangle ABCD, then in the triangle, there is a small blue triangle that is triangle ABD and the two right triangles at point A. Then the student is given the condition that the side length AE=BD=2 cm. Students are asked to determine the minimum area of the quadrilateral BCED in the isosceles right triangle ABC. The assessment makes students analyze before calculating the minimum area of the BCED quadrilateral. Students must analyze the relationship between the concepts of triangles, quadrilaterals, and the application of derivative functions with a minimum area. Then students connect the parts of the concept that are relevant for solving the assessment questions. Therefore, the class assessment in Figure 2 is categorized as HOTS at the analyzing level because the assessment can assess students' skills to organize, that is students can determine how the parts are relevant or function with each other and attribute, that is students can determine the point of view from the problem. If students cannot break down their knowledge related to each concept and connect them, then students are not necessarily able to solve the assessment questions given by the teacher. But on the other hand, teachers also said that they had problems when giving HOTS-based assessments to students.

The teacher said that when compiling HOTS-based assessment questions was not easy, it required time and thinking skills. Therefore, not all teachers can develop HOTS-based assessments. Another obstacle faced by teachers is the relatively large number of students and diverse abilities. This obstacle is exacerbated by the fact that now students' reading interest is low and they often forget the knowledge that has been previously learned. This is supported by the results of interviews conducted by researchers with research subjects as follows:

"...not all teachers can make HOTS-based questions because they are difficult." **(Teacher 1)**

"Even though now technology is advanced, students should use it to learn, but in reality, they are lazy to read..." **(Teacher 5)**

"… students' abilities vary…. classes are heterogeneous and students abilities are different one to another" **(Teacher 3)**

"I asked why they couldn't solve my questions, apparently they forgot the previous lesson..." **(Teacher 2).**

3.2 Discussion

Many factors affect the achievement of students' higher-order thinking skills, there are internal factors and external factors (Tambunan, 2019). One of the internal factors that influence the achievement of students' HOTS in mathematics is the interest and motivation of students in learning. On the other hand, internal factors that build students' HOTS include the performance of mathematics teachers in compiling assessments that assess students' understanding, mathematical communication, creativity, problem-solving, and reasoning (Moodley, 2013; Murtafiah et al., 2020; Tambunan & Naibaho, 2019) and implementation of the learning approach used by teachers (Cakir, 2008; Schmidt et al., 2009; Tyas et al., 2019; Vygotsky, 2012). This study showed that the teacher arranges the learning setting in the classroom using a scientific approach. The teacher also applies discussion and cooperative learning models in the form of think-pair-share and jigsaw so that students are trained to collaborate in small groups. This is supported by research that highlights the application of collaborative learning models such as three-step interviews and think-pair-share with a scientific approach that can improve student achievement better than the classical approach (Maharani et al., 2020). Furthermore, the results of this study are supported by research that states collaborative learning in the form of group discussions has many benefits and results in higher learning achievement, greater productivity, close cooperative relationships, mutual commitment, and training of students' social competence (Laal & Ghodsi, 2012).

Similar research also shows that cooperative learning can motivate students to take responsibility independently so that they can solve problems and improve their cognitive abilities (Slavin, 2015). However, the application of the scientific approach to the learning model of discussion and cooperative learning in the classroom encountered problems. This is supported by research that states teachers have difficulty managing time and motivating students to be more active when learning with the scientific approach (Retnawati, 2016). Other research highlights that teachers do not easy to apply learning with a scientific approach, especially cooperative learning as a learning model in the classroom because the time provided is not enough and the teacher is not comfortable just monitoring students (Buchs et al., 2017). Therefore, the learning approach used by the teacher when teaching in the classroom is an important factor in improving students' abilities and achievements. Apart from the learning approach, another factor that can improve students' higher-order thinking skills is a teachers' class assessment.

Assessment is an important aspect to complement teacher learning practices in the classroom (Pegg, 2003). Furthermore, mathematics assessment should require students to have high-level skills because these skills are important to improve their problem-solving abilities (Pearce et al., 2011). Therefore, the results of this study indicated that teachers apply HOTS-based assessments including assessments that assess analyzing, evaluating, and creating skills to improve students' thinking skills at a high level. This is supported by research that highlights teachers are required to use HOTS aspects in the teaching process and assessment process (Braaten & Windschitl, 2011). Similar research by Preus states that assessment in the form of open-ended questions, problem-solving tasks, and discussions are assignments to encourage higher-order thinking skills (Preus, 2018). This is in line with Novita and Putra, assessments in the form of problems that resemble PISA questions have better potential to support students' thinking skills at a high level, especially creative thinking skills (Novita & Putra, 2016). Furthermore, HOTS-based assessments taught by teachers in class can be in the form of 1) giving problems, 2) asking for problem-solving, 3) asking for solution checks, 4) asking for new ideas either in the form of contextual or non-contextual problem solving (Sa'dijah et al., 2021).

This is in line with research that highlights assessment in the form of contextual problems can support the development of students in mathematical thinking on the condition that teachers must actively involve students to solve the problem (Widjaja, 2013). On the one hand, teachers also encounter obstacles when implementing HOTS-based assessments in the classroom. Teachers feel that they find it difficult to compile assessments that assess students' thinking skills and students also have difficulty completing HOTS-based assessments. This is in line with Abkary and Purnawans' research which highlights that the challenges faced by teachers when making HOTS-based assessments are divided into 2 aspects, namely: 1) not all teachers understand the concept of HOTS-based assessments, and 2) students have different abilities, backgrounds, and characteristics in one class (Abkary & Purnawarman, 2020). Similar research also found that teachers' understanding and skills in implementing HOTS-based assessments were still low (Istiyono, 2018). In addition, another factor comes from the ability of students that they cannot solve HOTS-based problems because the problem is outside the context of the problems they usually encounter in class (Abdullah et al., 2015) (Abdullah, Abidin, and Ali 2015).

4. CONCLUSION

The results showed two main findings related to how mathematics teachers improve students' higher-order thinking skills. The first finding is teachers increase students' HOTS through classroom learning with a scientific approach. The teacher applies a scientific approach in the form of discussion and cooperative learning models. Classroom learning with discussion and cooperative learning models can help students improve their understanding, knowledge, and abilities when they work in small groups. In this small group, they can exchange ideas and help each other learn about the subject. However, the teacher found obstacles when implementing classroom learning with a scientific approach, especially during the discussion process. Students were still passive and needed more motivation to ask questions related to the problems given by the teacher. Another obstacle faced by teachers is the limited allocation of learning time in class so teachers often do not apply all scientific methods. The next finding is that teachers improve students' higher-order thinking skills through the HOTS-based assessments given to students in class. The arrangement of the HOTS-based assessment begins with the formulation of assessment indicators based on the basic competencies, then the teacher determines the cognitive level of these indicators. The teacher prepares HOTS-based assessment indicators including assessments that assess students' ability to analyze, evaluate, and create. Then, the teacher makes assessment questions whose cognitive level is in line with the cognitive level of the indicator. However, on the other hand, teachers encountered obstacles when compiling HOTS-based assessments. These obstacles include the HOTS-based assessment is seen as difficult to arrange by teachers and difficult to apply for students. The low reading interest of students and also the number of students in class and their diverse abilities are also obstacles for teachers in implementing HOTS-based assessments in the classroom. Based on the results of the explanation above, the researchers give suggestions for further similar research, that is to explore further how teachers improve students' higher-order thinking skills other than through scientific learning and HOTS-based assessments because both of them still have obstacles. Therefore, other steps are needed from teachers to maximize students' higher-level thinking skills.

Based on the results of the description and analysis of data in this study, then presented some conclusions as follows: 1) Approach to realistic mathematics learning by developing learning devices meet valid criteria. The average value of total validity of RPP, LKS and Test Ability Mathematics Connection (TKKM) is 4.5. 2) Increasing the ability of mathematical connections of students using learning devices based on the realistic mathematical approach that has been developed is seen at the pretest of 0.38 while in the posttest is 0.71 which means the "medium" category. 3) Learning tools based on realistic mathematical approaches developed meet the effective criteria. Effective criteria are reviewed from: (a) The ability mathematical connection of students in the class meets the criteria above the KKM with a percentage of 85%; (b) Student activities in all aspects observed meet active criteria; (c) Teacher activities in managing learning are in the well-implemented category and (d) Students' positive responses reach 92.15% of the components of the device and learning activities.

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AUTHOR'S CONTRIBUTIONS

The authors discussed the results and contributed to from the start to final manuscript.

CONFLICT OF INTEREST

There are no conflicts of interest declared by the authors.

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