E-ISSN : 2621-4768
Journal Riset Pendidikan Matematika Jakarta
Volume 3, No. 1, Februari 2021, pp. 36-47

JRPMJ

An Instructional Design Process for Developing Students Higher Order Thinking Skills in Number Patterns

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Abstract

Higher order thinking skills in learning are the application of thinking processes for complex situations and of course have many variables. Every student can think, but most students need encouragement and guidance for higher order thinking processes. The research used a qualitative approach, namely literature review. This study aims to explain the outline of activities planned for designing learning on number pattern class VIII material, the development of learning objectives, expected results, and practice questions that require the use of high order skills. Several efforts must be made to improve students' higher order thinking skills in mathematics, namely: (1) involving students in non-routine problem-solving activities; (2) facilitating students to develop their ability to analyze and evaluate (critical thinking) and creative ability (creative thinking); and (3) encourage students to construct their own knowledge, so that learning becomes meaningful for students.

Keywords: Instructional Design, Higher Order Thinking Skills, Number Patterns, Brookhart Aspect

Abstrak

Keterampilan berpikir tingkat tinggi dalam pembelajaran merupakan penerapan proses berpikir untuk situasi yang kompleks dan tentunya memiliki banyak variabel. Setiap siswa dapat berpikir, tetapi kebanyakan siswa membutuhkan dorongan dan bimbingan untuk proses berpikir tingkat tinggi. Penelitian menggunakan pendekatan kualitatif yaitu studi pustaka. Penelitian ini bertujuan untuk menjelaskan secara garis besar kegiatan yang direncanakan untuk merancang pembelajaran pada materi pola bilangan kelas VIII, pengembangan tujuan pembelajaran, hasil yang diharapkan, dan soal latihan yang membutuhkan penggunaan keterampilan tingkat tinggi. Beberapa upaya yang harus dilakukan untuk meningkatkan keterampilan berpikir tingkat tinggi siswa dalam matematika, yaitu: (1) melibatkan siswa dalam kegiatan pemecahan masalah non rutin; (2) memfasilitasi siswa untuk mengembangkan kemampuan menganalisis dan mengevaluasi (berpikir kritis) dan kemampuan kreatif (berpikir kreatif); dan (3) mendorong siswa untuk mengkonstruksi pengetahuannya sendiri, sehingga pembelajaran menjadi bermakna bagi siswa.

Kata kunci: Desain Instruksional, Keterampilan Berpikir Tingkat Tinggi, Pola Angka, Aspek Brookhart

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Email Address: muizghifari47@gmail.com
Received 18 Februari 2021, Accepted 24 Februari 2021, Published 28 Februari 2021

INTRODUCTION

Human resource is one of the important roles in competition in the era of globalization and modernization. Education is the key to building human resources. Indonesian legislation also regulates the National Education System, namely, number 20 of 2003 which states that national education functions to develop the ability and development of dignified national character and civilization in the context of educating the nation's life. One of the efforts to achieve this goal is through learning mathematics.

Based on Permendikbud number 68 of 2013, it is stated that the basic competencies of junior high school mathematics subjects that are expected to be possessed are to show a logical, critical, analytical, consistent and thorough attitude, responsible, responsive, and not easily give up. To achieve

this goal, learning mathematics in the classroom needs to be developed in various aspects of skills, one of which is higher order thinking skills. This is also in line with the opinion of Yen & Halili (2015) that higher order thinking skills are skills that are needed by every individual in an educational environment.

Thomas & Thorne (2009) stated that higher order thinking requires students to do something about facts, namely understanding them, concluding them, connecting them with facts in new ways and applying them to find solutions to problems. Abosalem (2016) further explains that high order thinking will occur when students acquire new knowledge and store it in memory, then this knowledge correlates with previous knowledge to achieve certain goals. In other words, higher order thinking skills occur when learners get new information, organize, and relate it to existing knowledge and then pass on that information to reach solutions to problems. Thinking skills were crucial because it was one of the content to be achieved in the learning process in addition to other skills such as communication skills, social skills, and skills in globalized social life (Lestari & Napitupulu, 2020).

The PISA (Program for International Student Assessment) research conducted by the OECD (Organization for Economic Cooperation and Development) PISA not only provides information on international benchmarks but also information about the weaknesses and strengths of students and the factors that influence them. 2018 also showed the weak abilities of students in Indonesia, especially in the field of mathematics studies. Indonesia is ranked 70th out of 78 participating countries that are members of PISA. Indonesia's score is still far below the average, namely 396 out of 489.

This shows that the ability of Indonesian students is still low. Arifin (2018) concluded, scientific literacy of Indonesian students still low. Science processes, content and applications and maths still doesn't match up hope. There is still a lot of memorization material who are buried and are in the realm *short term memory. Thinking ability* still just tend to remember (recall), restate, or refer without processing (recite).

According to Heong, et al. (2011) suggest that higher order thinking skills can be taught and learned, and all learners have the right to learn and apply this thinking to solve problems. This shows that higher order thinking skills are important and wise for students to solve problems in their learning process, thus enabling students' competitive thinking systems, developing their intelligence and helping students avoid mistakes in thinking (Heong, et al., 2011).

Students will have intelligence in analyzing the environment, analyzing reading, even in social interactions using higher order thinking skills. In addition, students will be able to integrate information, and generalize their knowledge to other things. Higher order thinking skills become an asset for students in facing a much more complex life in the future. Teaching higher order thinking skills from an early age will have a positive impact in the future. HOTS will enable students to construct or compile appropriate and effective arguments to make rational decisions or solutions.

Patterns provide the basis for Mathematical thinking. According to Vogel (2005), analyzing and describing patterns and their properties is one of the goals of mathematics. Mulligan (2002) says

that almost all mathematics is based on patterns and structures. Therefore, many mathematicians claim that mathematics is a "science of patterns" (Resnik, 1997; Tikekar, 2009).

Furthermore, Radford (2006) explains that when a person faces a problem of generalization patterns, he will try to solve the problem of pattern generalization by using different strategies. The strategies used can be divided into naive induction and generalization. Naive induction is a generalization of patterns based on trial and error. Furthermore, generalizations consist of arithmetic generalizations and algebraic generalizations. Algebraic generalizations consist of factual, contextual, and symbolic generalizations. The factual type of generalization is the general type based on known facts. Contextual generalization is a type of generalization based on the context of the problem and is limited to a specific object.

From the description above, it can be seen how important it is to have higher order thinking skills. Efforts can be made to develop higher order thinking skills, for example in the implementation of learning, as well as by developing practice questions that require the use of high order skills in number pattern material.

METHOD

This article was written using the literature review method. The literature used consists of journal articles related to the topic of discussion. Most of the journals used are publications of the last 10 years and books. The study in the article focuses more on making learning designs for higher order thinking skills for number pattern material.

DISCUSSION

Before the actual development of each learning activity, conducting a needs analysis is one of the most important activities in designing learning. According to Nasrulloh & Ismail (2017) this is in accordance with the design objectives developed to help solve the learning needs of students and the teaching needs of teachers whose interactions are manifested in the learning process. Although in theory this is logical in practice, there are many obstacles that may occur and this must be taken into account when developing teaching. According to Mager (in Brown & Green, 2011) that performance analysis aims to assess and overcome differences between what learners know and what they need to learn to achieve the goals set.

An outline of the activities planned for designing learning on the eighth grade number pattern material is shown below:

1. Before discussing number patterns ask the prerequisite material:
    a. Algebra
    b. Integer Operations
    c. Power Numbers and Roots.
    d. Two-dimentional figure.

2. Ask for patterns around (such as flowers, walnuts and beaded necklaces)
3. Observing patterns in a sequence.
4. State various sequences of numbers.
5. Introduces the equation of an object configuration.
6. Determine the next term of a number sequence, after which evaluate it by discussion.
7. Generalizing the sequence pattern of numbers into an equation after which evaluates it with discussion.
8. Indicate the learning resources available for the topic. Such as material references in the form of books, instructional videos, learning media, and teaching aids.
9. Distribute student activity sheets, both for groups and individuals. Student activity sheets are used to apply concepts using creative problems, and make decisions that require many answers and or many ways to solve problems.
10. Provide questions or feedback from students to other students regarding other students' presentations.
11. Summarize what has been learned during the lesson.
12. Reflect on activities that have been learned.
13. Giving homework with different questions, this is done to determine the level of higher-order thinking skills.
14. Deliver the topic rater for the next day's lesson.

According to Brown & Green (2011), it shows that learning outcomes usually have a broad statement of knowledge that is expected and achieved through pengaranjan, while goals are measurable actions that occur with the aim of achieving broader results.

The following learning objectives were developed in discussing the number pattern material. Whether students can demonstrate and apply this knowledge by using several measures, namely :

1. Students are able to mention number patterns in everyday life.
2. Students are able to state the reasons for mentioning the type of sequence pattern.
3. Students well convey the equations of an object configuration.
4. Students can make a pattern for the next term using algebra for the sequence pattern;
5. Students can generalize a number pattern well and its explanation using arguments and assumptions
6. Students are looking for a variety of additional information on number pattern material (for example: newspapers, printed and electronic news)
7. Students can provide arguments that provide information in order to provide clarity during reflection.
8. students can apply number patterns into everyday life.

The learning outcomes for each of the expected objectives after teaching are as follows:

1. Students can explain the types of sequence patterns;

2. Students can determine the next syllable pattern from a sequence of numbers;
3. Students can generalize number patterns to equations using algebra; and
4. Students can connect the concept of number patterns with real life situations.

This attainable ability will be the result of a subset of the learning objectives mentioned. It should be noted that teaching must follow a sequence from the simpler to the more complex, it can even be concrete to abstract. In line with Zayyadi (2017) Mathematics learning should follow pedagogical principles, namely learning begins from concrete to abstract, simple to complex, and from easy to difficult. Mathematics learning should be adapted to the unique concepts and development of students' thinking as well as the essential nature of the material and its use in everyday life.

Saido, et al. (2015) stated that the strategy that can be used to improve students' higher order thinking skills is through problem solving activities. This is a demand for mathematics teachers to have skills in providing problems that can develop students' higher order thinking skills. The following is an example of using problem-oriented problems in mathematics and some aspects of Brookhart (2010), namely1) Analysis, evaluation, creation; 2) Logical reasoning (*logical reasoning*); 3) Decision and critical thinking, 4) Problem solving, 5) Creativity and creative thinking.

According to Widiatsih et al. (2020) there are still many teachers who still do not understand and master how to compose questions, the characteristics of HOTS questions and how to make ordinary questions into HOTS questions. It is important to train teachers to develop questions that are included in HOTS. The following is an example of creating a problem:

Problem 1

1. Class / Semester : VIII / I
   Topics : Patterns and Sequences
   Basic competencies :
   4.1 Solving problems related to number patterns and configuration sequences.
   Problem Indicators : Given the row of seats in a stadium (see Figure 1) consisting of 7 rows and ticket prices:
   a. determines the number of seats available, if the number of seats is known in the first four rows, where the difference in the number of seats between two consecutive rows is different

b. determine the ticket price for a particular line, if it is known the desired total income from the sale of all tickets.

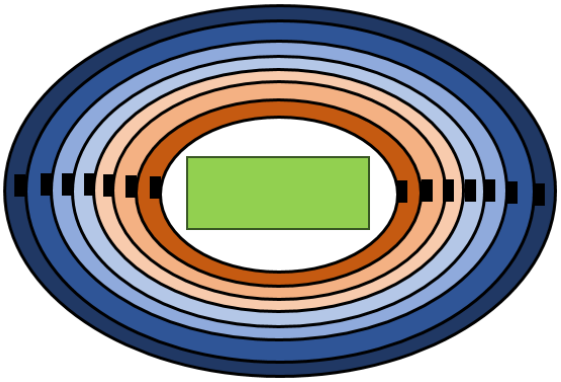


Figure 1. Row of seats in a stadium

HOTS indicators: Brookhart (2010) Levels of decision making and critical thinking.

Indicator	About HOTS
All stadium seat capacities	Expressed in tabular form (critical thinking)
Is it true that most home ticket advantage prices	Statement through ticket correctness questions (making decisions)
two consecutive rows are different, assuming all spectator seats are filled	Statement in statement (Critical thinking)

TABLE 1. Question indicator number 1

Question:

Look at the picture below! The friendly match committee held a fundraising for humanitarian programs. The proceeds from the sale of the soccer games will be donated for malnutrition and research for the Ebola virus vaccine. The committee chose Muiz Ghifari Stadium as the venue for the match, where the audience seats are oval in shape consisting of seven rows. The number of spectators in each row forms a certain pattern.

a. If in the first row there are 2500 seats, the second row is 3500 seats, the third row is 5000 seats, the fourth row is 7000 seats, and so on. Determine the total number of seats at Muiz Ghifari Stadium. Write down the completion steps.

b. If the first line ticket price is the most expensive and the difference in ticket prices between two adjacent rows is Rp.10,000.00, assuming all spectator seats are fully occupied, the committee will receive an income of Rp.2,170,000,000.00. Is it true that the cheapest ticket price is IDR 25,000? (If wrong, what is the cheapest ticket price?)

Discussion:

Line : 1 2 3 4 5 6 7

Chairs : 2500____3500____5000____7000___9500____12500____16000

Difference : 1000 1500 2000 2500 3000 3500

(a) Total capacity = 2500 + 3500 + 5000 +7000 + 9500 + 12500 + 16000

= 56,000 seats

(b) For example: Cheapest ticket = (in thousands)x

$$16000x + 12500(x + 10) + 9500\,(x + 20) + 7000\,(x + 30) + 5000\,(x + 40) + 3500\,(x + 50) + 2500\,(x + 60) = 2.170.000$$

$$56.000x + 1.050.000 = 2.170.00$$

$$56.000x = 2.170.000 - 1.050.000$$

$$56.000x = 1.120.000$$

$$x = \frac{1.120.000}{56.000}$$

$$x = 20$$

So, the statement that the cheapest ticket price is IDR 25,000.00 is wrong, but the correct one is IDR 20,000.00 for the cheapest ticket price.

Problem 2.

2. Class / Semester : VIII / I

Topics : Patterns and Sequences

Basic competencies :

4.1 Solving problems related to number patterns and configuration sequences.

Indicator : Given the data around the land and the first distance of the seat:

a. Find the pattern, if you know the circumference, the first distance of the chair, keep the distance and the seat must not be directly at the back of the chair in front of it.
b. Determine the number of benches required, if known as (a).

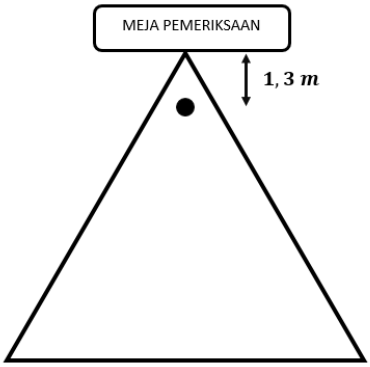
HOTS indicators: Brookhart (2010) Levels of making decisions and critical thinking, doing creativity and thinking creatively.

Indicator	About HOTS
The number of rows and seats	Expressed explicitly (taking decisions)
Front and rear seat distance	Stated explicitly (critical thinking)
The seat must not be directly behind the seat in front of it. With assumption.	Statement in implicit (doing creativity)
If following according to health protocol (June) keeping the distance specified for the left and right distances, the pattern of the ranks.	Seeking information (doing creative thinking)

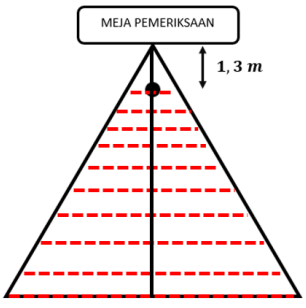
TABLE 2. Question indicator number 2

Question 2:

Look at the picture on the side! One day at the company Ghifari Corp. there is a PCR examination for its employees. The PCR was carried out in the company's open land in the form of an equilateral triangle with a circumference of 60 meters. If following the health protocol (June 2020) keep the distance that has been set for the distance left and right. If there is left-right distance then it must be the same. The seat must not be directly behind the seat in front of it, with the distance from the seat in front of it in accordance with the distance of the first row from the PCR examination table. What sequence patterns did you find? How many chairs do you need?



Discussion:



Assumption :

1. First row, remaining distance left and right 1 meter
2. Based on the health protocol information in June 2020 it is 1 meter.

$$a = \frac{60}{3} = 20$$

So, the sides of the triangle are 20 m

$$T = \frac{1}{2}a\sqrt{3}$$

$T = \frac{1}{2}20\sqrt{3}$

$T = 10\sqrt{3}$

That means there are 10 lines with each row spaced $1\sqrt{3}\ m$

a = 2 m

First row 1 seat

Note the Figure on the side for the first and second row seats.

Because the second row is 1 meter from the front, the height is

$t = 1\sqrt{3} + 1\sqrt{3} = 2\sqrt{3}$

Looks for the side, for the second row setting distance.

$t = \frac{1}{2}a\sqrt{3}$

$2\sqrt{3} = \frac{1}{2}a\sqrt{3}$

$a = 4$ m

Second row 4 seats

Because the second row is 1 meter from the front, the height is

$t = 2\sqrt{3} + 1\sqrt{3} = 3\sqrt{3}$

Looks for the side, for the second row setting distance.

$t = \frac{1}{2}a\sqrt{3}$

$3\sqrt{3} = \frac{1}{2}a\sqrt{3}$

$a = 6$ m

Third row 7 seats

Because the second row is 1 meter from the front, the height is

$t = 3\sqrt{3} + 1\sqrt{3} = 4\sqrt{3}$

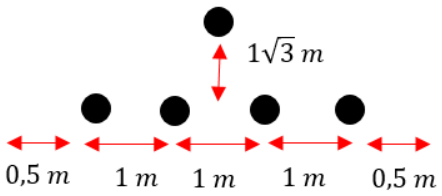
Looks for the side, for the second row setting distance.

$t = \frac{1}{2}a\sqrt{3}$

$4\sqrt{3} = \frac{1}{2}a\sqrt{3}$

$a = 8$ m

Fourth row 8 seats



Because the second row is 1 meter from the front, the height is $t = 4\sqrt{3} + 1\sqrt{3} = 5\sqrt{3}$

Looks for the side, for the second row setting distance.

$t = \frac{1}{2}a\sqrt{3}$

$5\sqrt{3} = \frac{1}{2}a\sqrt{3}$, $a = 10$

The fifth row seats 10

Because the second row is 1 meter from the front, the height is $t = 5\sqrt{3} + 1\sqrt{3} = 6\sqrt{3}$

Looks for the side, for the second row setting distance.

$t = \frac{1}{2}a\sqrt{3}$

$6\sqrt{3} = \frac{1}{2}a\sqrt{3}$, $a = 12$

The sixth row is 13 couriers

a = 14 m then the seventh row 15 seats

a = 16 m, the eighth row is 16 seats

a = 18 m then the ninth row is 19 seats

a = 20 m, the tenth row is 22 seats

Sequence pattern,

1, 4, 7, 8, 10, 13, 15, 16, 19, 22

1) The formation pattern jumped 2.

2) Place chairs = 1 + 4 + 7 + 8 + 10 + 13 + 15 + 16 + 19 + 22 = 115

So, the number of seats that must be prepared is 115 seats.

The assessment of students' answers uses researchers who refer to the modified scoring rubric from Pahdi et al. (2020) as follows.

Score	Description
4	Correct answer with complete clear and precise solutions steps or strategies
3	Correct answer with partial clear and precise solutions steps or strategies / incorrect answer with complete clear and precise solutions steps or strategies
2	Correct answer without solutions steps or strategies
1	Incorrect answer with complete solutions steps or strategies
0	Incorrect answer without complete solutions steps or strategies / no answers without complete solutions steps or strategies

TABLE 3. Rubric for Scoring Students' Answers

Brown & Green (2011) describes the problem of the importance of sequencing the order of learning activities and shows a framework. Planning and implementation cannot be separated when faced with

complex problems. In addition, there is a risk that formalizing mathematics education is too strong and thus hinders learners from finding their own creative ways to solve problems (Franke & Ruwisch 2010).

CONCLUSION

Based on the results and discussion, it can be concluded that higher order thinking skills in learning mathematics are very important. Because it aims to develop students' abilities in analyzing, evaluating, and being creative, so that students have critical power and creativity that can be used to solve problems in everyday life. Some of the efforts that must be made to increase students' HOTS in mathematics are: (1) involving students in non-routine problem-solving activities; (2) facilitating students to develop analysis and evaluation skills (critical thinking) and creative abilities (creative thinking); and (3) encourage students to construct their own knowledge, so that learning becomes meaningful for students.

Based on this research, it is suggested that teachers apply the learning design that has been developed in this study in mathematics learning. To ensure that the learning design can be implemented properly, the teacher should provide various non-routine problems that are close to everyday life and train students' ability to ask “why” and “how”. To help create problem-oriented HOTS, the teacher can adapt and modify the questions from this study.

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