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The instruments of higher order thinking skills

S Ahmad[1], R C I Prahmana[2], A K Kenedi[1], Y Helsa[1], Y Arianil[1], M Zainil[1]

[1]Universitas Negeri Padang, Jl. Prof. Dr. Hamka Air Tawar, Padang, Indonesia
[2]Universitas Ahmad Dahlan, Jl. Pramuka Kav. 5, Pandeyan, Yogyakarta, Indonesia

E-mail: syafriahmad95@yahoo.co.id

Abstract. This research developed the standard of instrument for measuring the High Order Thinking Skill (HOTS) ability of PGSD students. The research method used is development research with eight steps namely theoretical studies, operational definition, designation construct, dimensions and indicators, the preparation of the lattice, the preparation of grain, an analysis of legibility and Social desirability, field trials, and data analysis. In accordance with the type of data to be obtained in this study, the research instrument using validation sheet, implementation observation, and questionnaire. The results show that the instruments are valid and feasible to be used by expert and have been tested on PGSD students with 60% of PGSD students with low categorization.

1. Introduction

Mathematics learning is one of the main subjects that need special attention in Indonesia [1]. It is because mathematics is a basic knowledge needed by learners to support the success of their learning process in pursuing higher education [2-3]. Mathematics is one of the tools or tools in scientific thinking necessary to develop critical, logical and, and systematic thinking skills in learners [4]. It aims to learners can analyze a problem, take the right conclusions and use systematic thinking.

NCTM (National Council of Teachers of Mathematics) recommended four principles of mathematics, namely mathematics as problem solving, mathematics as reasoning, mathematics as communication, and mathematics as a relationship [5]. It can be concluded that the learning of mathematics should be given to the learners so that they can solve a problem, think logically, analytically, systematically, critically, creatively, able to communicate correctly (communicative) and can cooperate as well.

The improvement of mathematics learning achievement needs to get serious attention in every education level. Mathematics is a subject taught in every level and type of education, according to the level of need of each level and type of education [6-8]. However, at this time there are still many found mathematics achievement in schools at the levels of elementary, middle, high school / vocational school and even university level is still low, not least in for pre-service primary school teacher (PGSD).

Mastery of mathematics by PGSD students becomes an obligation that must be implemented in the management of reason and decision making in the era of increasingly fierce and competitive competition. But in fact, the math still considered subject is unpopular or even most hated by most students [9]. It becomes the duty of the lecturer as a teacher to correct the assumption to change into a positive assumption.

Negative side on mathematics learning also occurs in the course of high grade Mathematics Learning is also experienced by PGSD students. Mathematics is considered a difficult and scary course. The assumption has an impact on the results of the lectures are always less satisfactory, even though they are prospective teachers in primary schools who will teach the concept of mathematics in elementary. This fact if left

unabated then PGSD graduates will be difficult to compete with graduates from universities or even other countries. It is more worrying that one day our graduates become spectators in their own country because of the inability of our graduates to be competitors in their own country.

Based on the observations data conducted by researchers in the department of PGSD, the assessment of learning achievement is conducted by lecturers only based on the test scores. Assessment of student achievement that is only based on the value of the test causes the lecturer lacks precisely understand what has been achieved and what is needed by students in learning mathematics. It is because the mastery of the mathematics material measured in the test generally does not measure the thinking skills of the students.

Several researchers already documented their research about students' mathematics thinking ability [10-14]. Based on their studies, we can conclude that the thinking ability of high-level PGSD students is still low. Human thinking skills can be classified into two, namely the low level thinking skills / lower order thinking skills (LOTS) and high-level thinking skills or higher order thinking skills (HOTS). Additionally Higher order thinking skills include critical, logical, reflective, metacognitive, and creative thinking. They are activated when individuals encounter unfamiliar problems, uncertainties, questions, or dilemmas [15].

Higher order thinking skills is an important aspect in teaching and learning especially at higher education institutions. Thinking skills practices are part of the generic skills that should be infused in all technical subjects. Students with higher order thinking skills are able to learn improve their performance and reduce their weaknesses [16]. Therefore student's HOTS ability who studies mathematics needs to know, so it can be arranged qualified mathematics learning. Newman and Wehlage [17] states that HOT requires students to manipulate information and ideas that transform their meaning and implications, such as when students combine facts and ideas in order to synthesize, generalize, explain, hypnotize, or arrive at some conclusion or interpretation.

HOTS important role in learning Mathematics is also shown by research conducted by Rooney [18] which uses inquiry learning model-based learning to improve student`s HOTS ability. Furthermore it is said that in the action research done, the researchers measure the students' HOTS ability based on the mathematics assigned by the students. HOTS that aims to make students solve problems is a matter that is needed by students, so that when students graduate from a level of education then students are ready in facing greater challenges [19]. HOTS also stressed that teaching students how to think is a very critical effort to be taken seriously in preparing the students to become a Better future workers and problem solver [20].

HOTS consist of two components namely critical and creative thinking skills [16]. When students apply both skills it means students apply HOTS. The same was stated by Rosnawati [21] who stated that the ability of critical thinking and creative thinking are two important components of HOTS. Furthermore, in the planning of University North Carolina State in order to develop students' HOTS ability, it also uses only two variables, namely critical thinking skills and creative thinking skills. Others argue that HOTS is sufficiently measured using critical thinking skills [22].

Based on several studies that have been done, it appears that there is no standard instrument developed specifically to measure of HOTS ability of PGSD students on learning Mathematics Education. The instruments are intended specifically for measuring of HOTS ability of PGSD students. The results of these measurements can be used to conduct a comprehensive evaluation of PGSD students' thinking skills in high school mathematics learning.

As a variable, HOTS is a latent variable that cannot be measured directly as a physical variable. In order to measure the characteristics of latent variables, it takes a manifest variable commensurate with the latent variable requiring a standard instrument [23]. The main problem is how lecturers can have raw instances about HOTS and able to perform measurements properly and correctly.

On the other hand, the limited knowledge and time of the lecturers of mathematics in developing valid and reliable instruments for measuring HOTS become the obstacles less attention to the achievement of the basic goals of mathematics lessons. Therefore it is necessary to develop HOTS instrument in High class Mathematics learning in the Department of PGSD.

2. Method
This research was carried out in the Department of PGSD UPP I FIP UNP, i.e., even semester students amounted to 30 people enrolled in the learning year 2017/2018. This research is development research using eight steps namely development of theoretical studies, development of operational definition,

designation construct, dimensions and indicators, the preparation of the lattice, the preparation of grain, an analysis of legibility and Social desirability, field trials, as well as data analysis. In accordance with the type of data to be obtained in this study, the research instrument using validation sheet, implementation observation, and questionnaire.

3. Result and discussion

The results of the higher order thinking skills instrument development in learning high class mathematics in the PGSD majors are described in the following steps:

1. Theoretical Review.

Theoretical study in this study aims to develop the conceptual definition of HOTS instrument compiler variables. This theoretical assessment get the sense that HOTS is a broader thinking skills, not just to remember, understand, and the ability to apply a concept but also the ability to think for analyzing a concept, evaluate and even to create a concept.

2. Operational Definition Development.

The next step is to develop operational definitions of HOTS instrument compiler variables. The development and determination of operational definitions of HOTS is based on the conceptual definition that has been obtained that is the ability to analyze a concept, evaluate and even create a concept. After the researchers collide from various opinions of experts then for the operational definition of HOTS is composed of critical thinking skills and creative thinking skills which will then be developed into indicators.

3. Determination of Constructs, Dimensions, and Indicators.

The determination of collisions, dimensions and indicators is based on the withdrawal of operational definitions. The operational definition of HOTS is contracted into critical thinking ability and creative thinking ability.

The dimensions of critical thinking skills are all things that can make a person think critically namely the use of the concept, the use of the principle, the prediction of the impact, problem solving, and decision making. Therefore, after the researchers analyzed the dimensions of critical thinking, the indicator of critical thinking is to have the basic skills, provide an explanation, concluded the assumptions required, questioned the concept, analyze concepts, to synthesize the relationships between concepts, determine the result of the assumption, using the concept is good and balanced , find the source of the problem, guess the cause of the problem, gather the information in solving the problem, find some alternative solutions, choose the best alternative / solution, and evaluate the decision that has been taken.

The dimension of the ability to think creatively is anything that can make people think creatively. After the analysis of the researchers as for the dimensions of creative thinking is to work on the limits of competence, try new things, divergent mindset (spread) and imaginative mindset. for indicators of creative thinking is to reject the standard technique, optimizing knowledge, high motivation and contains, broad interests, orientation fore/optimistic, like the challenge/new ideas, to think freely, not rigid, develop concepts, modifying concepts, approaches trial and error, have original ideas, and have new ideas.

4. Grid Arrangement

Preparation of the lattice is held after the establishment of the constructs, dimensions and indicators. The HOTS instrument grille can be seen in the following Table 1.

Table 1. The HOTS instrument grille

Dimensions	Indicator	Number
Concept Utilization	1. Have basic skills	1,2
	2. Provide an explanation	3.4
	3. Summing up the necessary assumptions	5
Principle Utilization	1. Questioning the concept	6,7
	2. Analyze the concept	8,9
	3. Synthesizing relationships between concepts	10,11

Predicted Impact	1. Determine the consequences of the assumption	12,13
	2. Assumptions	14,15
	3. Using the concept well and balanced	16,17
Solution to problem	1. Find the source of the problem	18, 19
	2. Suspect the cause of the problem	20, 21
	3. Gathering information in solving problems	22, 23
Decision-making	1. Find some alternative solutions	24, 25
	2. Choosing the best alternative / solution	26, 27
	3. Evaluate the decisions that have been taken	28, 29
Working limited competence	1. Refuse standard techniques	30, 31
	2. Optimizing knowledge	32, 33
	3. High motivation and contents	34, 35
Try new things	1. Broad interest	36, 37
	2. Future orientation / optimism	38,
	3. Love new challenges / ideas	39, 40
Divergent mindset (spread)	1. Think freely, not rigidly	41,
	2. Develop a concept	42, 43
	3. Modify the concept	44,
Imaginative Mindset	1. Approaching trial and error	45, 46
	2. Have original ideas	47, 48
	3. Have new ideas	49, 50
	AMOUNT	

5. Preparation of Items

The preparation of the instrument item is based on the planned grid. The examples of HOTS instruments that have been made are:

    a. Examples of critical Thinking with the dimensions of concept utilization with indicators summarizing assumptions required.

      "If the circumference of the equilateral triangle wakes up, circle, and square are equal. Determine the largest flat wake. Explain your reasons!"

      The reason for this represent the critical thinking with the dimension of concept utilization with the indicator conclude the assumption needed is in this matter the students are asked to think critically by utilizing the concept of geometry wake flat then from the concept student can conclude assumption of a fact.

    b. Examples of creative thinking with the dimension of trying new things with indicators like challenges with new ideas. Andi gives a problem to Lusi. As for the case as follows:

      $1 + 4 = 4$

      $2 + 5 = 12$

      $3 + 6 = 21$

      $8 + 11 = ?$

      Help the search for answers above using mathematics.

      The reason for this represents the problem of creative thinking with the dimension of trying new things with indicators like the challenge with new ideas is that students are required to be able to think creatively about new things with the problem students will feel energized to find new ideas and think creatively.

6. An analysis of legibility And Social desirability.

Analysis of legibility is done by a pre-trial in the form of qualitative evaluation conducted by expert judgment. Expert assessment is conducted to test whether the items that have been compiled meet the rules of the Indonesian language is good and true, and whether the items already reflect the measured indicators or dimensions or not. It also carried out an examination of whether the items are arranged still have a Social desirability. The implementation of the validation is done several times by the expert. In the execution there are several HOTS instruments commented explain in Table 2.

Table 2. Advice from experts for prototyping and decision 1ˢᵗ revision

Comment	Revision Decision
1. The language used is good and correct some letters are missing	1. Inspect and repair instruments is ketinggaln letters.
2. There are some questions that do not reflect HOTS such as numbers: 1,2,3,4,6,7,12,13,14,15,16,17,18,21,22,23, 26,29,30,34,35,36,38,41,42,44,45,46,48,49,50.	2. Fixed issues that did not comply with HOTS
3. The question is not biased from the indicator set.	

Examples of problems that do not conform to the HOTS Indicators are as follows:
a. "A rectangular photo placed on a cardboard measuring 45 cm x 30 cm. To the right, top and bottom of the photo there are 7 cm of cardboard remaining. If the photo and carton are real, specify the length of the remaining cardboard left."
The above problem represents the ability to think critically, the dimension of the use of concepts, indicators have basic skills said not HOTS by expert experts because the problem can be solved by using only the basic formula, not the basic concept that uses basic skills.
Therefore the problem is revised to be:
"Find all nonnegative integer pairs (a, b, x, y) that satisfy the system of equations
$$\begin{cases} a + b = xy \\ x + y = ab \end{cases}$$
About the Issuer representing the ability to think critically, the dimensions of the use of concepts, indicators have basic skills HOTS by expert said the matter because it can solve by utilizing the concepts and basic skills but students must be able to think critically to find a relationship between mathematical systems."
b. A quadratic number when divided by 3, then the likelihood of the rest is ...
About the Issuer represents creative thinking ability, competence limited to dimensional works with high motivation indicators and contains said not HOTS because of their working process is not reflected by the high motivation.
Therefore the problem is revised to be:
"Andy wants to make a right triangle. The number of right triangles having vertical edges p, q and the oblique side q + 1, where p, q is an integer and b <101, is ...."
About the Issuer represents creative thinking ability, competence limited to dimensional works with high motivation indicators and contains said HOTS by expert because of their working process students are required to be able to think creatively and students should require high motivation because in this matter required a high willingness.
The instrument would be ready as an instrument to measure HOTS after three revisions by expert and all instrument declared valid and worthy to be used.
7. Field Trials
Field trials conducted as much as 2 times in the class 15 AT 1 Department PGSD FIP UNP. Data collections by giving HOTS instruments that have been validated by expert experts. The first meeting lasted for 90 minutes with a total of 9 questions. And the second meeting in the next week with time for 90 minutes with the number of questions 9 pieces. The student answers the question on the answer sheet provided and the lecturer declares the time to begin the process of completion of the answer and is collected after the time stated otherwise. As for example student's answer at first meeting can be seen in Figure 1.
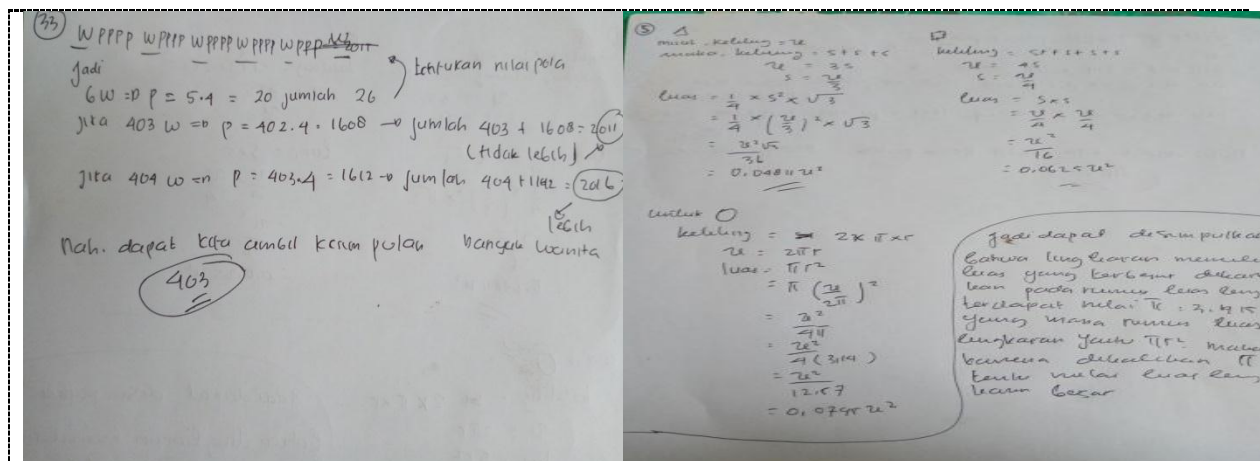
Figure 1. Sample student answers on the matter of critical thinking 1st meeting

In addition, sample student answers at the second meeting can be explained in Figure 2.
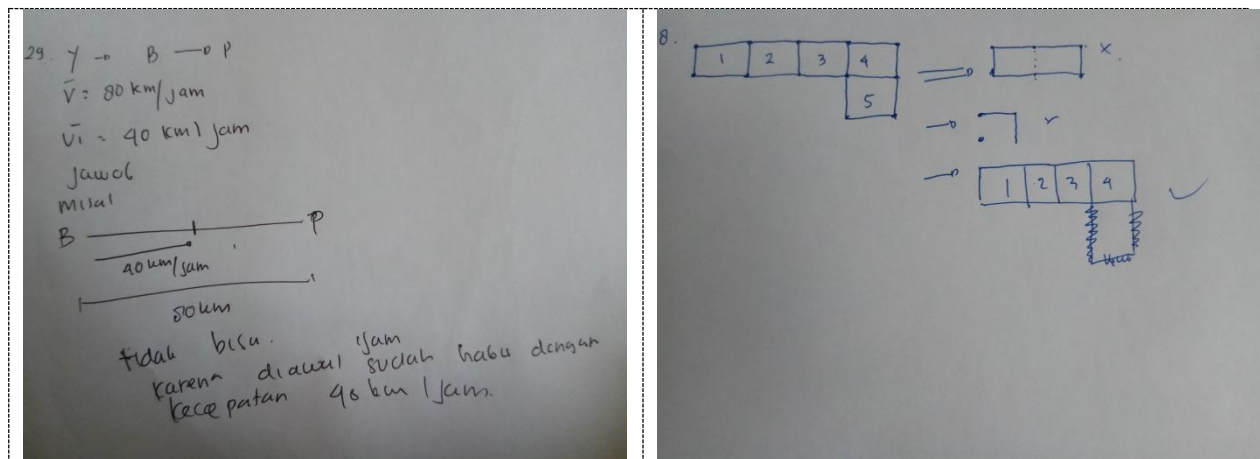

Figure 2. Sample student answers on the matter of critical thinking 2nd meeting

8. Data analysis

Data analysis was performed twice in accordance with the trial. The first analysis of the results of answers from students is there are some problems that students have difficulty that is a matter of number 6. The item is, the operation * for the set of numbers S = {0, 1, 2, 3, 4, 5, 6} is defined according to the Table 3.

Table 3. The operation of *

*	0	1	2	3	4	5	6
0	0	0	0	0	0	0	0
1	0	1	2	3	4	5	6
2	0	2	4	6	1	3	5
3	0	3	6	2	5	1	4
4	0	4	1	5	2	6	3
5	0	5	3	1	6	4	2
6	0	6	5	4	3	2	1

If for every integer n which is greater than 1 defined x n = x n -1 * x, then 5 2015 = ...

Of the 30 students, none of the students were able to answer this question. This proves that the problem requires higher thinking for its accomplishment. In the solve process, students are required to think critically, dementia work indefinitely with high motivation indicators and contains. This fact also proves that PGSD students are still not maximized in work and lack of high motivation.

HOTS measurement using three sections, namely, understanding the question, answer procedure, and the truth of the answers. Each type has a value of 0-4 per item. For the matter of Assessment of Work Results Time value received by students are grouped into five categories of HOTS can be seen in Table 4.

Table 4. HOTS Criteria

No	HOTS value	Category
1	≥ 76	Very high
2	≤ 61 HOTS <76	High
3	$46 \leq$ HOTS <61	Medium
4	HOTS $\leq 31 <46$	Low
5	<31	Very low

Students are said to be successful in mathematics if 50% of the value obtained HOTS students included in the category of very high or at least reach the high category [1]. The results of the first meeting is only 1 person (3.33%) who is moderate category, 11 people (36.67%) are low and 18 people (60%) are very low. This proves that PGSD UNP students still have low HOTS level. Furthermore, for the second meeting PGSD students have been able to solve about HOTS. The scores obtained at the second meeting were 5 people (16.67%), 18 people (60%) low category, and 7 people (23.34%) were very low category.

The researcher's analysis of this result is the low level of HOTS students of PGSD FIP UNP. This is caused by PGSD students are students who come from high school majoring in science, social studies, and vocational school. This fact cannot be denied because the department of PGSD FIP UNP does not restrict prospective students who enroll in PGSD. So the basic mathematics of each individual is different. In addition, the development of HOTS instruments can be utilized and meaningful for PGSD majors to measure HOTS level of PGSD students.

4. Conclusion

The developed instrument is categorized as valid and unbiased by expert. This validity is illustrated by expert test results by expert experts in terms of construction, content, language and practically seen during field trials. In addition, the instrument can prove that the ability of HOTS PGSD UNP students is still low category based on the development process.

Acknowledgment

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