Preface/Introduction

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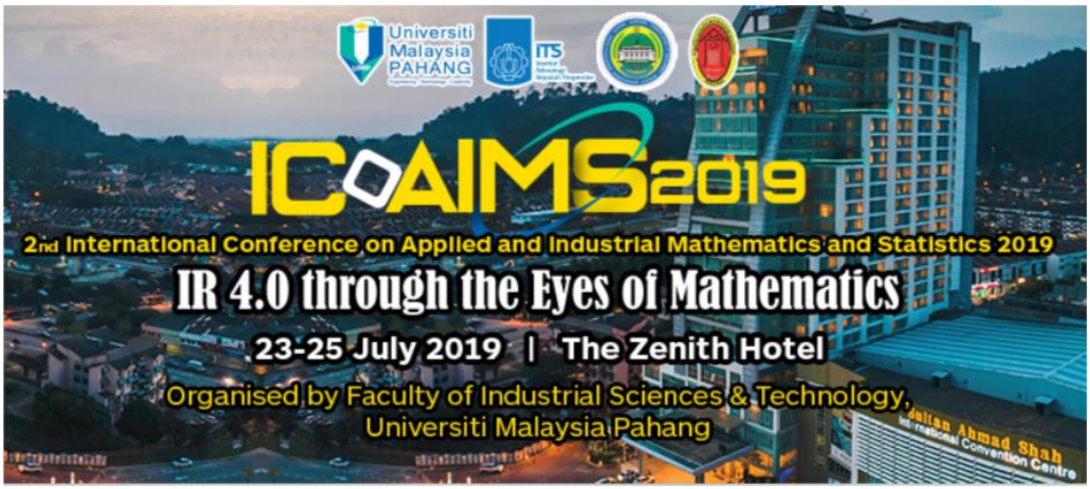

2nd International Conference on Applied & Industrial Mathematics and Statistics 2019 (ICoAIMS 2019)
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2nd International Conference on Applied & Industrial Mathematics and Statistics 2019 (ICoAIMS 2019) is organised by Faculty of Industrial Sciences & Technology, Universiti Malaysia Pahang, Malaysia. Our co-organisers are Institut Teknologi Sepuluh (ITS) Nopember, Surabaya, Indonesia, Malaysian Mathematical Sciences Society (PERSAMA) and Kazakh National Agrarian University, Kazakhstan. The main topics of the conference is divided into six categories; Pure Mathematics, Applied Mathematics, Computational Mathematics, Statistics & Applied Statistics, Operational Research and Mathematics Education including Engineering & Industrial Applications.

The ICoAIMS 2019 with the theme *IR 4.0 Through the Eyes of Mathematics* aims to bring together leading academics, scientists, researchers and research scholars to exchange and share their experiences and research results on all aspects related to Mathematics and Statistics. It also provides a premier interdisciplinary platform for researchers, practitioners and educators to present and discuss the most recent innovations, trends, and concerns as well as practical challenges encountered and solutions adopted in the fields of Mathematics.

ICoAIMS 2019 was an overwhelming success, attracting the delegates, speakers and sponsors from many countries and provided great intellectual and social interaction for the

participants. Without their support, the conference would not have been the success that it was. We trust that all the participants found their involvement in the Conference both valuable and rewarding. Once again, we would like to convey our deepest appreciation for all contributions and wish you success in the years ahead.

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Pre-Service Mathematics Teachers' Knowledge about Higher-Order Thinking Skills

Pre-Service Mathematics Teachers' Knowledge about Higher-Order Thinking Skills

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Abstract. Mathematics learning should be designed to develop students' higher order thinking skills. A deeper understanding of higher-order thinking will support teachers to be able to design mathematics learning that promotes students' higher-order thinking skills. The purposes of this research are to describe pre-service mathematics teachers' knowledge about Higher Order Thinking Skills (HOTS) and their ability in designing HOTS-based problem. The research participants are 9 pre-service mathematics teachers joining profession education for pre-service teachers at Sanata Dharma University. Data sources in this research include a written test about teachers' understanding of HOTS and a written test about teachers' ability to design HOTS-based problem. The analysis of data involved Miles & Huberman model. Qualitative results showed that pre-service mathematics teachers were not able to associate the cognitive demands of HOTS-based problem with the dimension of cognitive processes of Bloom's Revised Taxonomy. Besides, almost all the pre-service teachers were not able to design a non-routine problem, they tended to design a familiar application problem that requires students to memorize facts, concepts, or procedures that have been done before and apply them to the context. Based on the results, can be concluded that pre-service teachers' knowledge about HOTS and their ability to design HOTS-based problem are very low.

1. Introduction

Education has evolved to meet the challenges of the 21st century. There are three main frameworks of 21st century skills, namely 1) learning and innovation skills, 2) life and career skills, and 3) information, media, and technology skills [1]. In Indonesia, these competencies/skills have been adopted by the Curriculum 2013 with the term 4C namely critical thinking, communication skills, creativity and innovation, and collaboration.

Critical thinking constitutes the key aspect to the 21st century skills. To promote students critical thinking, teachers should design instructional learning so that students have to think critically about something. Therefore, one of the abilities that is very important to be considered by teachers in 21st century learning is higher order thinking. Higher order thinking is a way of thinking at a higher level than memorizing. This mental skill was initially determined based on Bloom's Taxonomy which categorized the cognitive domain, from the lowest to the highest, namely knowledge, comprehension, application, analysis, synthesis, and evaluation. This cognitive domain was later revised by Lorin Anderson, David Krathwohl, et al. in 2001 [2]. The order of thinking levels was changed to remembering, understanding, applying, analyzing, evaluating, and creating. The levels of remembering,

understanding and applying are categorized as low-level thinking abilities (LOTS). While analyzing, evaluating, and creating are categorized as high-level thinking skills (HOTS).

HOTS cannot be directly taught to students. Students should be exposed with learning activities that support HOTS development. Therefore, teachers should have adequate competencies to support students' HOTS development by planning, implementing, and evaluating HOTS-oriented learning. A study about Indonesian teachers' understanding of HOTS showed that not all teachers understand HOTS [3]. Moreover the study revealed that the low level of pedagogical abilities relating to HOTS is in line with the low ability of teachers' HOTS.

One of the programs designed by Indonesian government to improve the quality of teachers is Teacher Professional Education Program. The implementation of Teacher Professional Education (PPG) in Indonesia is intended so that teachers have pedagogical competence, personality competence, social competence, and professional competence. Since 2017, teacher candidates with bachelor's degree are allowed to take professional education for pre-service teachers to have the competence and acquire teacher certificate.

Based on the above review, the study that specifically analyzes the ability of teachers in the PPG program to develop HOTS problem is very important. This study can be used as an evaluation of the PPG program so that the quality of this program can continue to be improved for the advancement of national education in Indonesia.

2. Research methodology

This research is a qualitative study. This research aims to investigate pre-service mathematics teachers' knowledge about Higher Order Thinking Skills (HOTS) and their ability in designing HOTS-based problem. The participants were 9 pre-service mathematics teachers joining profession education for pre-service teachers at Sanata Dharma University. They were graduates from seven different institutes of teacher education in Indonesia.

In this study, the pre-service teachers passed two written tests. In the first test, the pre-service teachers were asked about the meaning of higher order thinking skills, the relationship between HOTS and levels of cognitive learning according to the revised version of Bloom's taxonomy, and the characteristics of HOTS-based problem. In the second test, the pre-service teachers were asked to formulate an indicator based on the given competency related to a linear equation system of two variables, design a HOTS-based problem in accordance to the indicator, and also argue about the reason why the proposed problem is a HOTS-based problem.

Data from the tests were analyzed and presented in a table to be classified into sub-themes. The analysis of data involved Miles & Huberman model consisting of three flows of activity namely data reduction, data display, and conclusion drawing/verification [4].

3. Research results

Based on the written tests, the researchers describe the results in two parts. The first is about Pre-service mathematics teachers' knowledge about HOTS and the second is about pre-service mathematics teachers' ability in designing HOTS-based problem.

3.1 Pre-service mathematics teachers' knowledge about HOTS

To know the pre-service mathematics teachers' knowledge about HOTS, the researchers delivered a test that consist of three questions. These questions explored teachers' ability in defining HOTS, associating HOTS with revised Bloom's Taxonomy, and explaining the characteristics of HOTS-based problems. The qualitative results of their knowledge about HOTS are as follows:

3.1.1 Teachers' ability in defining HOTS.

To see how deep teachers' understanding about HOTS, teachers attempted to define what HOTS is. Researchers collect the data about teachers' ability in defining HOTS from the test result. These data,

we reduce by coding the data that relevance to the problem and have important information and then display them in the table form. The data display of teachers' ability in defining HOTS can be seen below:

Table 1. Data display of the pre-service mathematics teacher's knowledge in defining HOTS.

Data	Pre-service Teachers
Incorrect HOTS definition	T1, T2, T3, T4, T7, T9
HOTS as student's ability in solving high level problem, and they were able to associate it with the fourth cognitive process dimension in Bloom's Taxonomy (analyse)	T5, T8
HOTS as student's ability in solving high level problem, and they were able to associate with the cognitive process dimension of revised Bloom's Taxonomy (analyse, evaluate, create)	T6

Based on Table 1, the researchers conclude by verifying the data with the indicators of teachers' knowledge in defining HOTS. Table 2 shows the conclusion of each teachers' knowledge in defining HOTS:

Table 2. Conclusion of the pre-service mathematics teachers' knowledge in defining HOTS.

Indicator	T1	T2	T3	T4	T5	T6	T7	T8	T9
HOTS as student's ability in solving high level problem	-	√	-	-	√	√	√	√	√
Associating HOTS with the fourth of cognitive process dimension of Bloom's Taxonomy, namely analyse	-	-	-	-	√	√	-	√	-
Associating HOTS with the fifth of cognitive process dimension of Bloom's Taxonomy, namely evaluate	-	-	-	-	-	√	-	-	-
Associating HOTS with the sixth of cognitive process dimension of Bloom's Taxonomy, namely create	-	-	-	-	-	-	-	-	-

3.1.2 Teachers' ability in associating HOTS with revised Bloom's Taxonomy. HOTS is very closely related to Blooms' taxonomy. The next question is posed to obtain teachers' understanding about the relation between HOTS and Blooms' taxonomy. Researchers collect the data about teachers' ability in associating HOTS with revised Bloom's Taxonomy. These data, we reduce by coding the data that relevance to the problem and have important information and then display them in the table 3.

Table 3. Data display of the pre-service mathematics teachers' knowledge in associating HOTS with revised Bloom's taxonomy.

Data	Pre-service Teachers
Could not explain the association between HOTS and revised Blooms' taxonomy	T1, T3
Could not mention correctly which are the cognitive process dimension that are used in HOTS. Some teachers mentioned the level of cognitive dimensions used starting from level 3 (apply), there were those who mention from level 5 (evaluate), some even said only levels 4 and 5	T2, T4, T5, T6, T7
Had been able to see the association between HOTS with Blooms' taxonomy, which was seen from the dimensions of cognitive processes that was starting from level 4.	T8, T9

Based on Table 3, the researchers conclude by verifying the data with the indicators of teachers' knowledge in associating HOTS with revised Bloom's Taxonomy. Table 4 shows the conclusion of each teachers' knowledge in associating HOTS with revised Bloom's Taxonomy:

Table 4. Conclusion of the pre-service mathematics teacher's knowledge in associating HOTS with revised Bloom's Taxonomy.

Indicator	T1	T2	T3	T4	T5	T6	T7	T8	T9
Able to relate HOTS with the fourth cognitive process dimension in Bloom's revised taxonomy, namely analyze	-	√	-	-	√	√	√	√	√
Able to relate HOTS with the fifth cognitive process dimension in Bloom's revised taxonomy, namely evaluate	-	√	-	√	√	√	√	√	√
Able to relate HOTS with the sixth cognitive process dimension in Bloom's revised taxonomy, namely create	-	-	-	√	√	-	√	√	√

However, T5, T6, T7 argued that the third cognitive process dimension in Bloom' revised taxonomy, namely apply, include in HOTS cognitive process dimension.

3.1.3 Teachers' ability in explaining the characteristics of HOTS-based problems.
The third question, researchers asked the teachers to explain the characteristics' HOTS-based problems. The data display of teachers' knowledge in explaining the characteristics of HOTS-based problems can be shown on the following table:

Table 5. Data display of the pre-service mathematics teacher's knowledge in explaining the characteristics of HOTS-based problems.

Data	Pre-service Teachers
The problems measure high-level thinking skills	T1, T2, T3, T4, T5, T6, T7, T8
The problems are contextual problems	T1, T8, T9
The problems have more than one solution	T2, T3, T4

Based on Table 5, the researchers conclude by verifying the data with the indicators of teachers' knowledge in explaining the characteristics of HOTS-based problem. Table 6 shows the conclusion of each teachers' knowledge in explaining the characteristics of HOTS-based problem:

Table 6. Conclusion of the pre-service mathematics teachers' knowledge in explaining the characteristics of HOTS-based problem.

Indicator	T1	T2	T3	T4	T5	T6	T7	T8	T9
HOTS-based problems measure high-level thinking skills	√	√	√	√	√	√	√	√	-
HOTS-based problems are contextual problems	√	-	-	-	-	-	-	√	√
HOTS-based problems have more than one solution	-	√	√	√	-	-	-	-	-
HOTS-based problems are not routine problems	-	-	-	-	-	-	-	-	-

3.2 Pre-service mathematics teachers' ability in designing HOTS-based problem

To investigate the pre-service mathematics teachers' ability in designing HOTS-based problem, they were asked to formulate an indicator based on the given competency related to a system of two linear equations, design a HOTS-based problem in accordance to the indicator, write several solutions regarding the problem, and also argue about the reason why the proposed problem is a HOTS-based problem.

3.2.1 Teachers' ability in formulating HOTS-based problem. In order to know the pre-service teachers' ability in designing HOTS-based problem, first they were asked to formulate an indicator based on the given competency related to a system of two linear equations. The data display of teachers' knowledge in formulating HOTS-based problem can be showed on the following table:

Table 7. Data display of the pre-service mathematics teachers' ability in formulating HOTS-based problem.

Data	Pre-service Teachers
Formulated an indicator that measures the third cognitive process dimension of revised Bloom's Taxonomy (C3) namely apply	T1, T2, T3, T4, T5, T6, T7, T8, T9

Designed a problem according to the indicator that measures the third cognitive process dimension of revised Bloom's Taxonomy (C3) namely apply	T1, T2, T3, T4, T5, T6, T8, T9
Designed a problem that measures the fourth cognitive process dimension of revised Bloom's Taxonomy (C4) namely analyse, but the indicator is written in the third level (C3)	T7

Based on Table 7, the researchers conclude by verifying the data with the indicators of teachers' knowledge in formulating HOTS-based problem. Table 8 shows the conclusion of each teachers' knowledge in formulating HOTS-based problem:

Table 8. Conclusion of the pre-service mathematics teachers' ability in formulating HOTS-based problem.

Indicator	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**
Wrote an indicator that measures the last three cognitive level in revised Bloom's Taxonomy	-	-	-	-	-	-	-	-	-
Designed a problem according to the last three cognitive level in revised Bloom's Taxonomy	-	-	-	-	-	-	√	-	-
Designed a contextual problem that requires students to analyse, or evaluate, or create	-	-	-	-	-	-	-	-	-

3.2.2 Teachers' ability in explaining about the reason why the proposed problem is a HOTS-based problem. After formulating a problem, the pre-service teachers were asked about the reason why the proposed problem is a HOTS-based problem. The results can be showed on the following table.

Table 9. Data display of the pre-service mathematics teachers' explanation about the reason why the proposed problem is a HOTS-based problem.

Data	**Pre-service Teachers**
The problem is a contextual problem	T8, T9
The problem has several alternative solutions	T1, T3, T4
The problem requires students to interpret answers according to the context	T2, T3, T4, T9
The proposed problem is non-routine problem so that students will try to find solutions	T7
The proposed problem requires students to do problem solving steps	T5, T6, T9

Based on Table 9, the researchers conclude by verifying the data with the indicators of teachers' explanation about the reason why the proposed problem is a HOTS-based problem. Table 10 shows the

conclusion of each teachers' explanation about the reason why the proposed problem is a HOTS-based problem.

Table 10. Conclusion of the pre-service mathematics teachers' explanation about the reason why the proposed problem is a HOTS-based problem.

Indicator	T1	T2	T3	T4	T5	T6	T7	T8	T9
The problem measures the last three cognitive level in revised Bloom's Taxonomy	-	-	-	-	-	-	-	-	-
The problem is a contextual problem	-	√	√	-	-	-	-	√	√
The problem is a non-routine problem	-	-	-	-	-	-	√	-	-
The problem allows students to make different alternative solutions	√	-	√	√	-	-	-	-	-

4. Discussion

4.1 Pre-service mathematics teacher's knowledge about Higher Order Thinking Skills (HOTS)

Based on the results, it was found that 6 out of 9 pre-service mathematics teachers were unable to understand what HOTS is. From six teachers, some of them defined HOTS as an instrument to test or know the level of thinking of students, others defined HOTS as a demand for high thinking, and the rest of pre-service mathematics teachers defined HOTS as a thinking ability which consists of various levels in solving a problem. Only one pre-service mathematics teacher defined HOTS correctly. She defined HOTS as the students' ability to solve problems to the stage of analytical skills to determine strategies and solutions. She has defined HOTS by associating with the level cognitive process dimension of Bloom's revised taxonomy. The results showed that most of pre-service mathematics teachers joining profession education for pre-service teachers at Sanata Dharma University still misunderstand HOTS. This result in accordance to the research that had been done by [3]. They found that the possibility of teachers to understand the whole concept of HOTS is still lacking

In associating HOTS with revised Bloom's Taxonomy, no more than 50% pre-service mathematics teachers could associate HOTS with Bloom's taxonomy correctly. Only 2 out of 9 pre-service mathematics teachers were able to connect between HOTS and Bloom's taxonomy specifically on the cognitive process dimension starting from C4.

In mentioning the characteristics of HOTS-based problem, 8 out of 9 pre-service teachers mentioned that HOTS-based problem could measure high-level thinking skills and 3 out of 9 pre-service mathematics teachers could mentioned the characteristic of HOTS-based problem was contextual problem. None of the pre-service mathematics teachers mentioned that the HOTS-based problems should be non-routine problems.

4.2 Pre-service mathematics teacher's ability to design HOTS-based problem

The indicators formulated by the pre-service teachers measured the third cognitive process dimension of Bloom's revised taxonomy. It means that the indicators measure middle order thinking skills. Moreover, based on the problem designed, it was found that 8 out of 9 pre-service mathematics teachers designed problems that measure the third level of Bloom's revised taxonomy that is applying information to different domains. The problems formulated by 8 pre-service mathematics teachers are contextual problems that contain all the information needed to solve the problem. These findings show

that the pre-service teachers categorized application problems as HOTS-based problems. There was only 1 pre-service mathematics teacher (T7) who was able to make a problem that measure the fourth cognitive level, which was analyzing the relationship between the form of system of two linear equations and the type of the solutions. But the problem developed by T7 was not a contextual problem.

This research reveals that most of the teachers have difficulties in designing HOTS-based problem. In accordance with this finding, Indonesian teachers have difficulties in designing problem that can promote students' HOTS [5]. This result showed that most of the teachers misinterpret higher-order thinking level of Bloom's Taxonomy. Although Bloom's Taxonomy is one of the pedagogical concept that is very familiar to the pre-service teachers, the concept is not understood deeply. The pre-service teachers also categorized word problem as a problem that measure problem-solving skills and therefore solving word problems are placed at the higher-order thinking level. They did not consider that HOTS can be developed when students encounter unfamiliar problems, uncertain conditions, or new phenomenon where no specific algorithm has been taught to the students. In line with these findings, teachers often misinterpret the concept of higher order thinking skills [6, 7].

5. Conclusion

Qualitative results showed that pre-service mathematics teachers misunderstood HOTS and were not able to associate the cognitive demands of HOTS-based problem with the dimension of cognitive processes of revised Bloom's taxonomy. The low understanding of HOTS of pre-service teachers impacts their ability in designing HOTS-based problem. Almost all the pre-service teachers were not able to design a non-routine problem that requires students to analyze or evaluate or create. They tended to design a familiar application problem that requires students to memorize facts, concepts, or procedures that have been done before and apply them to the context. Based on the results, can be concluded that pre-service teachers' knowledge about HOTS and their ability to design HOTS-based problem are very low.

6. Limitations

There are some limitations in this study. First, pre-service mathematics teachers were restricted to design problems only for linear equations system of two variables. This topic is often taught procedurally, teachers often provide similar word problems, and thus emphasizes lower order thinking. Asking teachers to design problems for other topic might lead to different results. Second, pre-service mathematics teachers were not randomly selected and were restricted to a small group of pre-service mathematics teachers joining profession education for pre-service mathematics teachers in Sanata Dharma University. Result may differ for more diverse sample of pre-service mathematics teachers.

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