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Enhancing the Prospective Teachers' Higher Order Thinking Skills in Solving Pedagogical Problems

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Abstract*: A prospective teacher requires a Higher Order Thinking Skills (HOTS) in solving pedagogical problems. On the other hand, in reality, this ability was still relatively low. The general purpose of this study was to improve the quality of the learning process in the mathematics learning strategy course to strengthen students HOTS in solving pedagogical problems. Furthermore, the purpose of this research specifically was to determine the validity, practicality, and effectiveness of the module. This study was development research (Research & Development) using Thiagarajan, Semmel and Semmel model (4D model) which consist of four stages: defining, designing, development and disseminating. The instruments used were validation sheet, HOTS test, observation sheet, and questionnaire. The subject of this research was the undergraduate students of class A on trial I and class B on trial II, where each class consists of 48 and 39 people respectively. The finding of this study shows that the module developed was valid, practical, and effective to use. Moreover, students' HOTS increased significantly.

***Index Terms*: Development research, higher-order thinking skill, problem-based learning.**

I. INTRODUCTION

A lecturer should use a module that can improve students' higher order thinking skills because the skills are required to solve various complex problems. However, in reality, the modules of mathematics teaching and learning strategy cannot be used to improve the competency. Because the modules were designed only as a source of information, and none was developed based on problems. Consequently, students' cognitive development is only limited to knowing, understanding and applying (lower-order thinking). As a result, they cannot solve pedagogical problems at a high level of thinking.

Understanding pedagogical problems is an absolute requirement to be a professional teacher [1]. As a teacher will face various pedagogic issues that must be solved professionally to achieve learning goals. However, based on diagnostic test results, the ability of prospective teachers to solve educational problems is still relatively low. Therefore, an effort is needed to enhance these competencies.

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Higher order thinking (HOT) is a skill of processing information to solve complex problems. If associated with taxonomy, it is a process of thinking at the level of analysis, synthesis and evaluation [2-4]. Furthermore, the definition was revised to be analyzing, evaluating, and creating [5]. In general, thinking skills consists of four levels: recall, basic, critical, and creative thinking [6]. Besides, the convoluted thinking process can be categorized into four groups: problem-solving, decision making, critical thinking, and creative thinking [7]. Besides, this skill consists of critical, logical, reflective, cognitive and creative thinking [8]. Brookhart [9] defined that HOT in three categories, which are related to transfer, critical thinking, and problem-solving.

Moreover, Brookhart [9] stated that to evaluate HOTS can be carried out of assessing analysis, evaluation, and creation, logic and reasoning, judgment (critical thinking), problem-solving, and creativity and creative thinking. However, in this study that the HOTS was measured based on critical thinking, problem-solving and creative thinking skill. Critical thinking is a reasonable reflective way of thinking that focuses on deciding what is believed or done [10]. Besides, problem-solving is an attempt to find a way out of difficulty and achieve a goal [11]. Moreover, creativity is the process of generating valuable new ideas [12]. There are two concepts related to creativity: imagination and innovation. Creative thinking is a skill to create new approaches to achieve various goals [13].

The problem-based module is a set of a module designed based on the problem. It means that the problems as a focus in developing material and HOTS. Thus, students will easily recall and transfer their knowledge to solve new problems [14].

II. THEORETICAL REVIEW AND RESEARCH METHODS

This research is Research and Development (R&D) of the 4D model (defining, designing, development and disseminating [15]. The purpose of this study is to develop materials, learning activities and learning tools to achieve learning goals [16]. In this study, a mathematical learning strategy module was developed based on a problem to increase HOTS in solving pedagogical issues. Moreover, this research is successful if the module developed is valid, effective and practical. The subjects of this study were students of mathematics education A and B with the number of students 39 and 48 respectively.

The instruments used were: 1) validation and test sheets 2) student activity observation sheets, 3) and student and lecturer response questionnaires. Besides, the data were analyzed descriptively.

The validation sheet aims to see the level of suitability of the content, language, format, and illustrations with the learning objectives. All validation sheets were analyzed using the formula: the average validation score (VL) is equal to the total score divided by the number of assessment aspects [17]. The following table 1 reveals the criteria for validity [17].

Table 1 Univariate analysis for genre

No	VL (Average Value)	Validity Criteria
1	$1 \leq VL < 2$	Poor
2	$2 \leq VL < 3$	Fair
3	$3 \leq VL < 4$	Moderate
4	$4 \leq VL < 5$	Good
5	$VL = 5$	Excellent

Besides, the learning devices are valid if the validity level is in good or excellent category. Student response data is useful to identify positive responses (happy, interest, New, interest, and clear) on the devices developed. Additionally, to determine the percentage of many students who gave a positive response to the categories in each item, the following formula was used: the proportion of students who responded to certain aspects, divided by the number of all students, then multiplied by one hundred percent [18]. In this study, student response is positive if the positive reaction reaches at least 80%. Besides, an analysis of the teacher's response aims to determine the teacher's positive response to the devices developed after using it. Based on the score range, the response is categorized into 4: poor in the field 1 to 1.74, fair, good, and excellent in the range, 1.75 to 2.49, 2.50 to 3.24, 3.25 to 4 respectively [19]. In this study, the module is practical if the lecturer response is in the good or excellent category.

Furthermore, to determine the level (percentage) of student activities, the following formula is used: the frequency of each aspect that is carried out by students is divided by the number of all elements observed. Then the criteria for the effectiveness of student activities are determined based on the provisions [20].

Design of this study was one group pre-test and post-test design. An increase of HOTS was determined based on the index gain. The formula for deciding it was as follows: the difference between the post-test and pre-test scores, then divided by the difference between the ideal score and the pretest score [21]. Besides, Hake [22] stated that the gain value (g) was categorized as high if $g>0.7$, while for the medium and low categories if the score is in the range of $0.3<g \leq 0.7$ and $g \leq 0.3$. The index gain should be in a high class to meet the effectiveness criteria.

III. RESULT AND DISCUSSION

A. Defining Process

Based on front-end analysis, students' HOTS in solving pedagogical problems were still relatively low. In contrast, based on the results of an analysis to the level of intelligence, they were categorized as medium and high. Furthermore, after an in-depth analysis, it was concluded that it was necessary to develop a module that could be used to solve the problem. After that, the process of task analysis and concepts produced the following hierarchy of material: mathematics learning strategies, learning theories, mathematical abilities, approaches to mathematics learning, methods and learning models. Finally, learning objectives were formulated, where the specific objectives were determined based on basic competencies and indicators that had been determined by the study program. The general goal was to increase students' HOTS in solving pedagogical problems.

B. Designing Devices

At this stage, modules and test instruments were designed to produce a prototype. The material was developed based on a problem that aimed to improve students' HOTS. The module contains not only explanations but also various pedagogical problems. In addition, 6 essay tests were developed based on basic competencies and learning objectives. Furthermore, several slides and movies were constructed to support the use of the book.

C. Developing Learning Devices

The process in this phase aimed to produce the best final teaching material. Therefore, the module was assessed by expert appraisals and developmental testing outside the research population, until the module was in the category of valid, effective and practical.

The module was validated by four lecturers who are experts in their field before the trial. This module is valid if it is in a good or excellent category. The following Table 2 reveals the results of the validity.

Table 2 Module validation

Aspect	Validator				Average	Validity Criteria
	1	2	3	4		
Format	4.3	4.2	4.7	4.5	4.4	good
Language	4.0	3.9	4.1	4.0	4.0	good
content	4.2	4.4	4.3	4.0	4.3	good
Ilustration	4.0	4.2	4.2	4.4	4.2	good
learning objectives	4.0	4.1	4.1	4.2	4.1	good

Table 2 shows that the module is valid in the good category. In other words, the module is suitable to use. On the other hand, the note on the validation sheet is "the module is in good category and can be used with little revision in aspects of language."

The following Table 3 explains the results of the validation of 9 essay tests. In general, Table 3 reveals that all tests (problems) are valid and can be used to measure HOTS. However, there are some items recommended for revision.

Module effectiveness is measured based on student activity and index gain. The module is effective if student activities are in the ideal category and the gain value for each indicator is in the high class. Table 4 shows the level of active student activities. Table 4 reveals that all items the trial I are ideal except in finding ways and solving problems. Moreover, there are 11% of activities that are not by the learning plan.

After interviewing ten students, this occurred because they were still confused about the problem-solving procedure. On the other hand, in trial II there was an increase in active activities, where all items were in the ideal category.

Moreover, the following Table 5 shows that the average score and gain value for each indicator.

Table 5 reveals that the skill of problem-solving and creative thinking is still in the medium category in trial I. It means that the effectiveness criteria are not fulfilled. However, in trial II the three aspects are in the high group. Furthermore, based on the index gain, it is known that the students HOTS increased dramatically after trial II. Finally, it can be concluded that the module is practical.

The first criteria of the module is practical if at least 80% of students' response are positive in every aspect. Table 6 states that in the trial I the positive response of students was more than 80%, except in the language aspect. After conducting interviews, they noted that the language in the module was not easy to understand. After revising it, then tried in trial II. As a result, in this phase, all positive responses exceeded 80%.

The module is practical if it fulfills the second criterion, where the teacher's positive response should be in the good or excellent category in every aspect. Table 7 reveals that the module is still in the fair and poor category in the content and illustrative aspects. After finding the mistake, then continued to develop and use it on trial II. Consequently, all elements were in a good category. In conclusion, the module was practical.

D. Disseminating

At this stage, the module was only introduced to the lecturers in Universitas Negeri Medan (UNIMED). Furthermore, it can be used in the teaching and learning process in the upcoming academic year, especially in the mathematics learning strategy course.

IV. CONCLUSION

The module fulfilled the requirements of validity, effectiveness, and practicality. After using it, there was a sharp increase in the higher order thinking skills in solving pedagogical problems. The highest increase was found in critical thinking and then followed by problem-solving and creative thinking. Finally, the author suggests using this module, especially during the mathematics learning strategies class.

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Budi Halomoan Siregar from Nort Sumatera, Indonesia. He graduated from Universitas Riau (UR) with a degree in mathematics education and master in mathematics from Universiti Kebangsaan Malaysia (UKM). He has been a lecturer at department of mathematics education of Universitas Negeri Medan (UNIMED) since 2008. His main areas of research interest are in reseach and development (R&D), mathematics learning media, and learning models. Process in conducting research in Developing of Program Linier Book and online Media.

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Ahmad Fudholi, Ph.D REN, M.Sc, S.Si obtained his S.Si (2002) in physics. He was born in 1980 in Pekanbaru, Indonesia. He served as was the Head of the Physics Department at Rab University Pekanbaru, Riau, Indonesia, for four years (2004–2008). A. Fudholi started his master course in Energy Technology (2005–2007) at Universiti Kebangsaan Malaysia (UKM). His M.Sc thesis was on Wind/PV Hybrid System, and his Ph.D thesis was about the Finned Double-Pass Solar Collectors for Drying of Seaweed. His M.Sc and Ph.D theses were conducted under the supervision of Prof. Dato' Dr. Kamaruzzaman Sopian. After obtaining his Master's, he became a research assistant at UKM until. After his Ph.D (2012) in renewable energy, he became postdoctoral in the Solar Energy Research Institute (SERI) UKM until 2013. He joined the SERI as a lecturer in 2014. He received more than USD 389,000 worth of research grant (16 grant/project) in 2014–2018. He supervised and completed more than 27 M.Sc projects. To date, he has managed to supervise eleven Ph.D (seven as main supervisors and four as co-supervisor), three Master's student by research mode and five Master's student by coursework mode. He was also an examiner (three Ph.D and one M.Sc). His current research focus is renewable energy, particularly solar energy technology, micropower systems, solar drying systems and advanced solar thermal systems (solar-assisted drying, solar heat pumps, PVT systems). He has published more than 150 peer-reviewed papers, of which 60 papers are in the Web of Science (WoS) index (40 Q1 or Top 25% and Top 10% jurnal, impact factor of 4-10), and more than 110 papers are in the Scopus index (Q1 and Q2 of 75 papers). In addition, he has published more than 80 papers in international conferences. He has a total citations of 878 and a h-index of 15 in WoS index. He has a total citations of 1530 with a h-index of 20 and total papers more than 110 in Scopus (Author ID: 57195432490). He has a total citations of 2240 with a h-index of 22 and total papers more than 170 in Google Scholar. He has been appointed as reviewer of high-impact (Q1) journals, such as Renewable and Sustainable Energy Reviews, Energy Conversion and Management, Applied Energy, Energy and Buildings, Applied Thermal Engineering, Energy, Industrial Crops and Products and so on. He has been appointed as reviewer of reputatable journals, such as Drying Technology, International Journal of Green Energy, Biosystem Engineering, Journal of Sustainability Science and Management, Journal of Energy Efficiency, Sains Malaysiana, Jurnal Teknologi and so on. He has also been appointed as editor of journals. He has received several awards, such as the Gold Medal Award at the International Ibn Al-Haytham's Al-Manazir Innovation and Invention Exhibition 2011, the Silver Medal Award at the International Technology EXPO (ITEX) 2012, the Silver Medal Award at the Malaysia Technology Expo (MTE) 2013, the Bronze Medal Award at International Exposition of Research and Invention (PECIPTA) 2011 and two Bronze Medal Awards at PECIPTA 2017. He has also been invited as speaker in the Workshop of Scientific Journal Writing; Writing Scientific Papers Steps Towards Successful Publish in High Impact (Q1) Journals. He owns one patent and two copyrights.