The Development of Students Worksheet Based on Problem-Based Learning to Escalate High Order Thinking Skills

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ABSTRACT

The present study was concerned with developing students’ worksheet (known as LKM), oriented to Problem-Based Learning. The worksheet was designed within the context of problems concerning higher-order thinking skills. The worksheet development applied the framework proposed by Dick and Carry, comprising of analysis, design, development or production, implementation or delivery, and evaluations. The findings of this study indicate that worksheets meet the validity standards with respect to the validity of the content, language, and presentation. The practicality and effectiveness of the worksheets are rated at high category, which is also corroborated by the excellent students’ responses.

INTRODUCTION

In higher-education institutions that focus on education, especially Mathematics, students are projected to become a prospective competent and professional. The competency requires students to be able to utilize comparative, competitive, innovative, and collaborative skills so that they can absorb new information more easily. Consequently, these students are expected to master high-order thinking skills (HOTS). As prospective educators, these teacher candidates should be able to develop the thinking ability of their future student to think critically, creatively and innovatively. Therefore, the role of students as teacher candidates becomes substantially important in advancing education in Indonesia.

High-Order Thinking Skills (HOTS) occurs at high level of cognitive process. Schraw & Robinson (2011) classify Bloom's thinking skills into two levels, namely Lower Order Thinking Skills, which include knowing and understanding; and High-Order Thinking Skills, namely applying, analyzing, synthesizing and evaluating.
However, Anderson & Krathwohl, (2001) categorize the LOT skills into remembering, understanding, and applying, meanwhile the HOT skills are classified into analyzing, evaluating, and creating. The ability to think at a higher level will help students as prospective Mathematics teachers face increasingly more life in the future.

Van De Walle (2008) states that understanding and skills are best developed when students are allowed to grapple with new ideas, make and maintain problem solving and participate in the community of Mathematics students. As such, this learning process requires specific learning models to foster their high curiosity so as to develop their own understanding. One of them is through problem-based learning. Arends (2008) admits that the nature of PBL consists of some difficult and authentic questions for students, which can be used as springboard for investigation and implementation.

Problem-based learning is learning by utilizing problems, in which students must search information to solve these problems. Rusman (2011) states that one alternative learning method that allows students to develop thinking skills (reasoning, communication, and connections) in solving problems is Problem-Based Learning (PBL). This is supported by Suprihatiningrum (2013) who points out that PBL is a learning method, where students are assigned to solve on a problem, then followed by a process of finding information that is student-centered. It is obvious that Problem-Based Learning utilizes problems calling for apt solution, which thus develops students' thinking skills.

Based on theory developed by Barrow, Min Liu (2005) explain that the characteristics of PBM are learning is student-centered, authentic problems form the organizing focus for learning, new information is acquired through self-directed learning, learning occurs in small groups, and teachers act as facilitators. In its application, lecturer acts as a supervisor by providing opportunities for students to learn actively. In the delivery, student teaching materials are not revealed in advance so that some concepts or all of them are discovered by students. Problem-Based Learning (PBL) which is applied to a student worksheet is expected to provide opportunities for students to practice the problem solving process in daily life. Therefore, this study aims to develop a student worksheet based on Problem-Based Learning to improve the ability of High Order Thinking Skills (HOTS).

METHODOLOGY

The present study applied the framework of development research. It was projected to develop student worksheet to improve the ability of high-order thinking skills (HOTS). The study applied the framework proposed by Dick and Carry (1996) known as the ADDIE Model (Analysis, Design, Development or Production, Implementation or Delivery and Evaluations). The research participants are students of Mathematic Education Program at a private University. Students’ Problem Based Learning based Worksheet (LKM) was developed based on vector analysis subject to improve the ability of high-order thinking skills (HOTS).

RESULT AND DISCUSSION

In this research, the process of developing student worksheet based on PBL referred was entrenched to ADDIE Model (Analysis, Design, Development or
Production, Implementation or Delivery and Evaluations). In detail the process of developing the worksheet is elaborated in the following sections.

The analysis phase is the stage where the researcher analyzes the needs which foreground the development and project the essentials of the development. The analysis phase includes needs assessment (identifying needs), identifying problems (needs), and carrying out task analysis. In the needs analysis activity (needs assessment) is done to analyze the character analysis of students. This analysis is conducted to investigate the attitudes, interests, motivations, and abilities of students in accomplishing tasks oriented to HOTS in vector analysis courses. The initial activity was laden with tasks on analyzing problems/gaps that occurred during lectures. The problem analysis investigated the availability of teaching materials and determined the form of teaching materials that needed to be developed. Task analysis was carried out to determine the form of assignments needed to address the students’ needs, which was fundamental to solving problem in question and ensuring learning objective accomplishment, as necessitated by curriculum requirements.

Based on the results of the needs analysis through questionnaire distributed to the students of the Mathematics Education Study Program at the Islamic University of Jember on vector analysis courses, 83% of respondents stated that the teaching materials used in vector analysis courses were textbooks and sources from the internet. This was inadequately helpful for students in understanding the material, especially vector concepts. 80% of students were happy and enthusiastic in learning vector concepts. However, 83% of respondents had difficulty learning the vector concept because the material was classified to be abstract in nature. In addition, problem solving in the vector concept appeared difficult as it required high-order reasoning. The present study strived to address the issue by developing student worksheet based PBL, aimed at assisting the learning process on concept of vector.

The second stage of the ADDIE development model is the design stage. In this activity, the researchers designed the student worksheet as required. The worksheet contained problem-solving activities designed to improve the level high-order thinking skills (HOTS). In addition, this activity also designed research instruments in the form of: (1) expert validation sheets (2) evaluation sheet on practicality (3) evaluation sheet on effectiveness, (4) student questionnaire.

The developed worksheets were tested for their level of validity. The level of validity was assessed based on 3 aspects, comprising of content eligibility, presentation eligibility and language eligibility, all of which were based on standard issued by BSNP. Based on the results of validation by 3 experts the content validity received a score of 0.89 marked at very-high category, while the presentation achieved score of 0.82, also rated at very-high category. The language validation according to BSNP obtained a score of 0.83, indicative of very-high category. These validation results concluded that the development product was feasible to be implemented.

At this stage, the worksheet developed was implemented in a real classroom. After the implementation, an initial evaluation was conducted by distributing questionnaire students so as to collect feedback concerning the development as well as the product. Based on the results of the implementation, practicality aspect (IP) was rated at 4.0, indicating a high category and the level of effectiveness (IE) was marked at 4.4, also indicating high category. The worksheet received positive response from the users, as portrayed by the large number of responses on Agree and Strongly Agree. The student responses through questionnaire data showed that 92% of them gave a positive
rating, at excellent category. The findings concluded that the worksheet was applicable and supportive in learning Vector Analysis, especially on vector concept material.

Evaluation was carried out in two forms, namely formative and summative evaluation. Formative evaluation was done as a revision requirement while summative evaluation was aimed at measuring expected final competency. In this case, the competency measured was higher-order thinking skills, measured through a summative test. Based on the results of formative tests on each student worksheet, the study concluded that several aspects needed revising, which included the level of difficulty of the questions, material, and some formulas not yet listed. These revisions were deemed essential to assist the students to complete formative tests in each student worksheet.

Based on the results of summative tests 1 and 2, it can be seen that the students’ ability after the application of PBL on Vector material increased. In the summative test 1, out of 20 students, 50% of the students achieved analysis level, 40% of them were capable of evaluation, and 20% of them posed the skills at creating level. With regard to the summative test 2, 80% of the students achieved analysis skills, 50% of them were found to master analysis-skill level, and 40% of the students were capable of creating-level skills. This finding indicated that students’ high-order thinking skills were increased through the application of student worksheet oriented to PBL.

Expert validation was carried out on the student worksheet under development using validation sheet. The validation included 3 aspects, namely the content, the presentation, and the language by referring to standard stipulated by BSNP. With respect to the content validation, indicators include the contents of the material and the use of the material. The presentation aspect was germane to the presentation technique. Language validation according to BSNP included such criteria as the extent to which the language used was straightforward, communicative and accurate to language conventions. The results of worksheet validation analyzed by 3 experts are presented in Table 1.

<table>
<thead>
<tr>
<th>Aspects</th>
<th>Validity</th>
</tr>
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<tbody>
<tr>
<td>Content</td>
<td>0.89 (High)</td>
</tr>
<tr>
<td>Presentation</td>
<td>0.83 (High)</td>
</tr>
<tr>
<td>Language</td>
<td>0.83 (High)</td>
</tr>
</tbody>
</table>

After the validation, analysis was run on the validation results, and the researchers evaluated the instrument validity by identifying coefficient (α). The instrument for validation analysis is available in the Appendix. Based on the results of the validity test, the content validity level reached 0.89, indicating very-high category, and the presentation was rated at 0.83, indicating similar level of validity. The language eligibility according to BSNP obtained a score of 0.83, marking very high validity.

The findings indicated that the worksheet developed satisfied validity criteria. Although the worksheet was found to be valid, few revisions were still required. These revisions were carried out by taking into account experts’ suggestions. To measure the worksheet practicality, a practical level test was carried out through instruments previously developed. The purpose of the practicality test was to find out the extent to
which the worksheet was easily implemented. The aspects under observation included criteria indicating whether the worksheet was effective, creative, efficient, interactive and interesting. Each indicator had several aspects assessed by practitioners. The analysis of the results of the practicality level test is in the Appendix. Based on the analysis results, the level of practicality reached a score of 4.0 with a high category, indicating that the worksheet based on PBL satisfied practicality standards.

To find out the worksheet effectiveness, effectiveness test was also carried out through instruments which had been developed. The effectiveness was also assessed by practitioners. A product is said to be effective if it poses influence or effect. Put simply, the product leads to satisfying activity subsequent to its implementation. In this study, the effectiveness was investigated by comparing the learning before and after implementing the worksheet. The effectiveness test was broken down into several aspects. The analysis results of the effectiveness test are presented in the Appendix. Based on the results of the analysis, the level of effectiveness before using the worksheet was 3.6, classified in the medium category, and after using the worksheet the level of effectiveness reached 4.4, indicating high category. The test results concluded that the students’ performance increased, as portrayed by the differences between learning process before and after implementing the worksheet. The test results concluded that the worksheet satisfied effectiveness criteria.

Analysis of students’ responses was performed using the questionnaire developed by researchers. The questionnaire consisted of 3 aspects which included material, language, and interests. Each aspect was designed along with several related indicators. The questionnaire is in the appendix. The analysis of student responses concluded that in general students' responses to the worksheet were positive in the sense that students voiced agreement and strong agreement toward the worksheet quality. On average students’ responses achieved 92%. This clearly indicated that worksheet received a very good response.

This research has developed student worksheet grounded within problem-based learning. The development of worksheet applied framework proposed by Dick and Carney (1996) known as the ADDIE Model (Analysis, Design, Development or Production, Implementation or Delivery and Evaluations).

At the analysis phase, the present research revealed the needs for specific student worksheet oriented to problem-based learning to teach Vector concepts. At the design stage, the worksheet design on Vector concept material was produced. In addition, this activity also designed research instruments which covered expert validation sheets, practicality evaluation sheets, effectiveness evaluation sheets, and student questionnaire.

At the development stage, validation activities carried out by 3 experts proved that the content validity got a score of 0.89 and that the presentation validity gained a score of 0.82. In the same vein, the language validity test generated a score of 0.83. These data have concluded that the worksheet is feasible to be implemented.

At the Implementation stage, the study collected data concerning practicality (IP) marked at 4.0 indicating high category, and the level of effectiveness (IE) was scored 4.4 also indicating high category. The student questionnaire showed that 92% gave positive ratings in the excellent category. The evaluation phase through formative tests was carried out to identify the need for revision on the worksheet. Furthermore, summative tests 1 and 2 are conducted to measure students' high-order thinking skills
(HOTS). The research findings have concluded that the application of Problem Based Learning (PBL) improves students’ high-order thinking skills.

CONCLUSION

Research on Development of Student Worksheet based on Problem-Based Learning to escalate High-Order Thinking Skills (Hots) applies the model proposed by Dick and Carry (1996) known as the ADDIE Model (Analysis, Design, Development or Production, Implementation or Delivery and Evaluations). Based on the research results and discussion of the development stage, the study has drawn the following conclusions.

The development process applies ADDIE model which consists of four stages namely the analysis phase, planning stage (Design), development stage (Development or Production), the implementation phase (Implementation or Delivery), and evaluation phase (Evaluations).

The need analysis results indicate that specific student worksheet grounded within problem-based learning is required to aid learning process on Vector concepts. The student worksheet developed is analyzed, resulting in validity level of 0.87. At the implementation stage the practicality level \( (IP) \geq 4 \) is 4.00 and the level of effectiveness \( (IE) \geq 4 \) is 4.4. Students’ responses to the worksheets portray positive comments with a percentage reaching 92%. The findings in evaluation phase concluded that students’ high-order thinking skills increase subsequent to the implementation of worksheet based on PBL.

With regard to the findings, the research posits the following suggestions. First, needs analysis activities should not only be done through closed questionnaires but through interviews and observations. This is important to ensure that the data obtained is more accurate. Second, the development of student worksheet should be supplemented with questions ranging from C1 to C6 in order to facilitate the assessment on students’ competence.

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