Developing Mathematics Learning Materials Based on CO-PROL to Improve Cadets’ Learning Outcomes

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Abstract. This research’s aims to produce applied mathematics learning materials for Nautical Science grade III based on CO-PROL (Cooperative On Problem Based Learning) models which is valid, practicable and effective. This study was a research and development (RnD) with Branch (ADDIE) model which is consisted of 5 (five) steps, those are: (1) Analysis, (2) Design, (3) Development, (4) Implementation, and (5) Evaluation. The quality of learning resource is determined based on Nieveen criteria, including validity, practicality, and effectiveness. The subject of this research were 36 cadets of Nautical Science Yogyakarta Maritime Academy. The research instrument included validation and observation sheets for learning implementation, questionnaires for lecturers and cadets, and the instrument of effectiveness of learning resources. The data analysis technique is a quantitative descriptive technique. The result shows that the teaching materials are valid, practicable, and effective in terms of improving cadets’ learning outcomes.

1. Introduction
The important factor to determine the success of teaching is a clear idea of the material that is arranged and prepared [1,2]. Careful preparation is needed for the success of learning. The form of learning preparation is learning administration. Learning administration is something or some preparations prepared by educators so that the implementation and evaluation of learning can be carried out systematically and obtain the expected results [3, 4]. Learning administration such as learning materials are very helpful in the process of teaching and learning activities [4, 5]. Therefore, educators must be able to make learning materials with the material which will be learned by students well and correctly accepted by students [6]. In order to make the learning materials can play a good role, learning materials must meet good criteria. The criteria used in this study were product quality criteria according to Nieveen. Nieveen explained that the quality of product development can be measured from three aspects, which are validity, practicality and effectiveness [7].

Effective use of instructional materials can improve student learning outcomes [8,9]. It has been widely assumed that low learning outcomes of students are caused not only by ineffective use of instructional materials but also inappropriate use of learning approaches and models [10]. Some studies prove that a learning model that combines cooperative learning and problem based learning is very suitable to be applied to seafarers’ characters [11,12]. This is in line with Yusof who has also developed a Cooperative Problem-Based Learning model which consists of three learning phases, including the learning activity, the teaching activity and the task activity [10].

CO-PROL is Cooperative on Problem-Based Learning in which combines cooperative learning and problem based learning. Cooperative learning refers to instructional methods in which students work in small groups to help each other learn[13]. Cooperative learning has three main objectives: tolerance,
acceptance and academic achievement of diversity and the development of social skills[13,14]. While Problem-based Learning is a teaching model which makes problems as the basis of the students’ learning [15,16]. Barrows states same characteristics of Problem-based Learning, i.e.: (1) New information is obtained by self-directed learning; (2) Problems become the means to develop the ability to solve problems; (3) The teaching process is cadets centered; (4) The teaching process occurs in small groups; (5) The teacher plays the role as facilitators or guide; and (6) The problem presented becomes the stimulus for learning [17]. Indirectly, the attainment of the ability to solve problems can be developed by the Problem based learning model.

It is therefore necessary to conduct a study on the development of instructional mathematics learning materials that can improve the learning outcomes of cadets based on CO-PROL, especially in the Nautical Study Program at Yogyakarta Maritime Academy.

2. Method
This research belongs to research or development research (R n D) used the ADDIE model development method. The ADDIE development model consists of five stages: analysis, design, development, implementation and evaluation [18]. This research was conducted in the Nautical Study Program at Yogyakarta Maritime Academy. The instrument of this research included the assessment of three criteria, namely aspects of validity, practicality and effectiveness.

3. Result and Discussion
In this study, the development of learning materials was carried out through the Branch stages. Through those stages, researchers could find out the quality of the developed learning materials. According to Nieveen [7], a quality development products must meet the criteria of validity, practicality, and effectiveness with the following phases:

3.1 Analysis phase
This development model was started with analysis phase by conducting the curriculum analysis and analyzing the characteristics of cadets. The curriculum which was applied in the Nautical Study Program was according to the Regulation of the Head of the Transportation HR Development Agency No. PK. 07 / BPSDMP-2016 about “Curriculum for Education and Training Programs for the Formation and Competency Enhancement in the field of shipping”[19]. The curriculum had been elaborated on the syllabus and Semester Lesson Plans (RPS), which were strengthened by the IMO Model Course 7.03 guidelines on “Officer In Charge of A Navigational Watch”, so that the development of learning materials is still needed [20]. The cadets characteristic analysis phase was carried out through observation when the cadets in the learning process, at this stage it was obtained that the learning model needed by the cadets was the one which implementing the character values needed in the shipping industry through Cooperative On Problem Based Learning (CO-PROL) learning models.

3.2 Design phase
In the design phase, the researcher created the instruments used to test the aspects of validity, practicality, and effectiveness of the produced learning materials. Then, the researcher created the learning materials based on the Cooperative On Problem Based Learning (CO-PROL) learning model entitled Mathematics Navigation. The creation of the learning materials in this development research was made by designing learning materials with the provision of good media aspects and the creation of contents/teaching material. To create interesting learning materials development in terms of media aspect, it contained several components as follows: covers, preface, table of contents, the identity of the learning materials, the learning material pages, and bibliography. The contents of the learning materials were arranged in stages according to competency standards, basic competencies, and indicators. To meet the standards of competency and basic competencies, various references were needed to support the creation of the developed learning materials.
3.3. Development phase

The development of this learning textbooks was done by referencing to the applicable curriculum and the Semester Lesson Plans. The researcher then made the developed learning materials product through the validation stage to determine the quality of the product carried out by the validator according to his expertise. The product revision suggested by the validator was an effort to achieve the expected quality. The evaluation of the learning materials was conducted by the validators who are competent in their field to assess the quality of validity from the material aspects and media aspects. With the conversion criteria, the data was evaluated as the following table 1:

| Score Interval | Classification |
|----------------|----------------|
| \( \bar{x} + 1.8 \times SBx \) | Very Good |
| \( \bar{x} + 0.6 \times SBx < X \leq \bar{x} + 1.8 \times SBx \) | Good |
| \( \bar{x} - 0.6 \times SBx < X \leq \bar{x} + 0.6 \times SBx \) | Pretty Good |
| \( \bar{x} - 1.8 \times SBx < X \leq \bar{x} - 0.6 \times SBx \) | Less Good |
| \( X \leq \bar{x} - 1.8 \times SBx \) | Not Good |

Note:
\( X \): respondent's score
\( \bar{x} \): ideal average
\( SBx \): ideal standard deviation

Where:
\( \bar{x} = \frac{1}{2} x \) (ideal maximum score + ideal minimum score)
\( SBx = \frac{1}{6} x \) (ideal maximum score - ideal minimum score)

The results of the validator's assessment of the validity of material quality are shown in Table 2.

| No | Assessment Aspect | Total Score | Total Score | Average | Classification |
|----|-------------------|-------------|-------------|---------|----------------|
|    |                   | Validator 1 | Validator 2 |         |                |
| 1  | The quality of material in teaching materials | 62          | 64          | 126     | 4.84           | Very Good |
| 2  | The suitability of teaching materials with the CO-PROL approach | 23          | 20          | 43      | 4.30           | Very Good |
| 3  | Technical (media aspects) | 24          | 18          | 39      | 3.90           | Good       |
| total |                   | 109         | 102         | 208     | 4.35           | Very Good |

The result of the validity assessment of the final product of the navigation mathematics learning materials based on the assessment carried out by the experts was that the final product had met the valid criteria which categorized very good with an average empirical score of validator I of 109 and validator II of 102 from the score range 23 to 115. The teaching material had also been revised based on the advice and input from the experts so it is feasible to use. The developed learning materials had been valid because in the development process it had been developed based on relevant theories. However, even though it had been declared valid with a very good category, there was still an aspect that was only in the good category, that was the technical / media aspects. After being declared valid, the developed learning materials were then implemented to the Nautical study program cadets of Yogyakarta Maritime Academy.

3.4 Implementation phase

The implementation phase of the learning materials was carried out through the trial in the mathematics learning of Nautical Study Program Cadets with the number of 36 cadets. The next stage of the learning
The process for initial implementation was by preparing the produced learning materials. In the implementation phase, the researcher used CO-PROL learning model of a conceptual model that applied two learning methods: Cooperative Learning and Problem Based Learning which implemented by combining presentation, discussion and problem solving in groups.

The next step done by the researcher, as well as the lecturer, was to conduct a CO-PROL model action plan in the Applied Mathematics course using the developed learning materials. The application stage conducted through classes which consisted of 4 meetings. (1) In the first meeting, the lecturer explained the learning activities plan by using the CO-PROL learning model and the developed learning materials, guided the group formation and gave the assignments in groups with the topics according to the drawing results to investigate trigonometric problems in the navigation field, while cadets do the work according to the formed group (2) In the second meeting, the lecturer acted as the facilitator and evaluator in group 1 presentations using the developed learning materials, cadets did the presentations according to their group topics and played an active role in discussions on the topics such as trigonometry, side lengths and triangle angles. (3) In the third meeting, the lecturer acted as the facilitator and evaluator in the presentation of group 2 using the developed learning materials with the topic of angles comparison in various squares, cartesius and polar coordinates, cadets independently working on revisions from the results of presentations and discussions, and conducting investigations in libraries or other sources if it was needed. (4) In the fourth meeting, the lecturer acted as the facilitators and evaluators in cadets presentations and discussions with the topics in group 3 using the developed learning materials with the topic of sine and cosine rules and the triangle area on the navigation field.

3.5 Evaluation phase

The last stage of this study was the evaluation of the learning materials that had been applied to the learning process. The evaluation was done by analyzing the data that had been obtained to determine the assessment of product quality, that are the practicality and effectiveness aspects especially in increasing the cadets’ learning motivation. The next evaluation to the quality of practical aspects of teaching materials was based on the results of the questionnaire responses from the cadets during the trial process in the learning process. The data of response questionnaire was obtained from 36 cadets with the maximum score instrument given to each item was 4, while the minimum score was 1.

The results of the cadets' response questionnaire are presented in the following Table 3 based on the Table 1 above.

| No | Assessment Aspect       | Total Score | Average | Classification |
|----|-------------------------|-------------|---------|----------------|
| 1  | Attractiveness          | 359         | 3.32    | Very Good      |
| 2  | Convenience             | 817         | 3.24    | Good           |
| 3  | Helpfulness             | 708         | 3.27    | Very Good      |
| 4  | CO-PROL Approach        | 360         | 3.33    | Very Good      |

The practicality of the product which was assessed based on the attractiveness aspect was categorized very good with the total empirical score of 359 from a score range of 144 to 576, with an average of 3.32. The assessment based on the convenience aspect was categorized good with the total empirical score of 817 from the score range 252 to 1008, with an average of 3.24. Assessment based on the helpfulness aspect was categorized very good with an empirical total score of 708 from a score range of 216 to 864, with an average of 3.27. Assessment based on the CO-PROL approach aspect was categorized very good with a total empirical score of 360 from the score range of 108 to 432, with an average of 3.33. The field trial data showed the results of the cadets' assessment of the developed learning materials was categorized very good with an empirical total score of 2244 from the score range of 720 to 2880, with an average of 3.29. Thus, it can be stated that the quality of the learning material products in the form of learning modules that had been tested with the practicality classification is very good.
The achievement of this classification was due to the researcher's anticipation, for instance after implementing CO-PROL learning model on trigonometry in the field of navigation, the researcher as the expert and lecturer in Applied Mathematics conducted the reflection activities to find out the lacks that occurred during the mathematics learning process that day. If there were any lacks, improvements were made to the learning process at the next meeting. The lecturer provided suggestion and guidance for the cadets when there were group discussion activities, problem solving activities, and other activities in the learning process so that it could make the learning process more focused, fun and meaningful for the cadets.

The analysis on the effectiveness of the learning materials was conducted using the $Z$ proportion test with the test statistics according to Walpole as follows [21]:

$$Z = \frac{x - np_0}{\sqrt{np_0q_0}}$$

Where $q_0 = 1 - p_0$

Information:
$x$: the number of cadets who reach the specified criteria
$p_0$: the proportion of samples hypothesized
$n$: the number of cadets

The effectiveness of the mathematics developed learning materials was measured based on the results of the cadets' mathematics learning test. The test results were measured through tests arranged based on the test grid adjusted for trigonometric material in the field of navigation. For effectiveness aspects, using $\alpha = 0.05$. The test results showed that the average score obtained by cadets was 84.09 and the graduation percentage was 83.33%. This could already be said that the developed learning materials are effective because the percentage of classical completeness in the mathematics test results has exceeded 75%.

4. Conclusion

The development model of applied mathematics learning materials based on Co-Prol for the cadets of Nautical Study Program, Yogyakarta Maritime Academy based on the analysis can be summarized as follows: The developed learning materials met valid criteria and categorized very good based on the results of material and media expert validation. The developed learning materials met practical criteria and categorized very good based on the results of cadets' evaluations, so that it was suitable to be implemented in the learning process in the Applied Mathematics Course of Nautical Study Program, Yogyakarta Maritime Academy. The developed learning materials met the effective criteria in terms of student learning outcomes with percentage completeness classical on the results of the math test was 83.33%. The developed learning materials had been proven to be successful in improving cadets learning outcomes.

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