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The development of metacognition-based learning media for the industrial electronics field in a vocational high school

Purnamawati, Usman Mulbar & Saliruddin

Universitas Negeri Makassar
Makassar, South Sulawesi, Indonesia

ABSTRACT: This study describes a learning device to be used for industrial electronics metacognition at vocational high schools (SMK) in Makassar, Indonesia. In this research, the following were studied: learning devices, including lesson plans, teaching materials, user guide practicum, jobsheet, students' worksheet (LKPD) and assessment of learning. Based on the Plomp model development phases, the following results were obtained. First, the results of earlier investigations have examined theoretically device designs based on learning metacognition; namely: 1) the purpose of learning; 2) methods of learning; 3) character of students at SMK; and 4) learning problems associated with metacognition-based learning activities. Second, the results of experts' validation and testing of the device is limited to learning. It was found that the learning device and instrument studies have valid criteria to be implemented with the same families at SMK.

INTRODUCTION

Learning outcomes in the productive areas of vocational schools (SMK) produce graduates who are competent in hard and soft skills. It is vital for learners to be competent in these skills, so as to prepare themselves for higher level competition in this globalisation era. Suryanto et al state that for graduates to prepare to enter the labour force involves three factors: 1) physiologically: age maturity, physical and health condition; 2) experience: learning and work experience, which includes knowledge and skills (hard skills); and 3) psychologically: mental, emotional and social conditions (soft skills) [1].

One of the hard skills was elaborated in the 2013 curriculum; namely, factual, conceptual, procedural and metacognitive abilities which will help learners to learn how to solve problems [2]. With such abilities, graduates are expected not only to do their practical work, but also to find effective steps to finish it. Learners are directed to grow and develop their industrial electronics skills.

The teachers designed the learning model and instrument in such a way, so as to give learners the opportunity to improve their potential in doing their practical work. The learning syntax was systematically structured and patterned according to the characteristics of the learners. It means that metacognition-based learning media should meet the quality set, in order to achieve the learning objectives; namely, to empower students' critical thinking and to teach them how to be more independent in solving problems.

Problem-solving starts with planning and ends with decision making on the outcomes, and provides solutions to solve problems. Planning, monitoring and evaluation activities in the problem-solving method are part of metacognition. Carman said that limits the metacognitive component to planning, monitoring, evaluation, organising and adjusting one's thinking [3].

Lee and Baylor explain that metacognition has four main components: first, planning that includes the ability to make plans to learn carefully, set learning objectives, determine the order of learning, apply learning strategies and expectations from learning; second, monitoring that includes moderate activity along with the learning progress, such as the ability to make and answer questions during the learning process; third, evaluation that includes learners' ability to assess their learning progress; and fourth, revising that includes the ability to modify learning plans, objectives, strategies and approaches [4].

Metacognition is how people think about the way they think or people's cognition about their cognition. Learners are directed to achieve a high level of competence through various thematic, contextual and open learning activities [5]. Metacognition-based learning media, which was developed in this study, aimed to facilitate the development of high-level ability (factual, conceptual, procedural and metacognitive ability). Contextual problems presented by the teacher would give an opportunity for learners to examine the basic competencies, which had been designed in an interesting, systematic and thorough manner. Through this metacognitive-based learning, the learners would be able to build their critical, creative and systematic thinking ability in solving a problem.

METHOD

This study employed the Plomp development model by using five phases; namely, preliminary investigation; design; realisation/construction; test, evaluation and revision; and implementation phases [6]. Design of learning materials (products) development used was based on Plomp [6]. Preliminary investigation and design phases produced a draft of the learning media, which was, then, assessed according to the learning objectives, analysis of the learners' characteristics and learning analysis.

The draft of the learning media was validated by two experts in the industrial electronics field. After that, the draft was tested on XI grade students at SMK Negeri 2 Makassar, Indonesia, which consisted of 35 students. The research data were collected using a descriptive analysis from the learning media validation result, so that they could be used to test the practicality of metacognition-based industrial electronic learning media design.

RESULTS AND DISCUSSION

Phase of the Preliminary Investigation and Learning Media Planning

The learning media included lesson plans, textbooks, practical guides, jobsheet, students' worksheet (LKPD) and learning assessment at the preliminary investigation stage. The aim of this stage was to find further information through theoretical study based on the curriculum and syllabus. The draft of learning media constructed based on the theoretical study was, then, strengthened through a focus group discussion with the teacher. The result of these discussions was in form of inputs on the improvement of the learning media.

In the lesson plan, the name of programming competencies from Programming 1, Programming 2 and Programming 3 was changed into Assembler 1, Assembler 2 and Assembler 3. The written learning objectives were adjusted to the 2013 curriculum format, which used K-1, K-2, K-3 and K-4 indicators. Teaching materials were not constructed properly and systematically. The figures/pictures had to be improved, because it was difficult for the learners to understand them. They had not been able to develop and train learners' ability to think. The learning approach used the lecture method, meaning that teacher had the dominant role. Metacognition orientation that emphasises learners' independence is yet to be found in all learning steps. These conditions provide opportunities for learners to develop their critical, creative and analysis skill.

The jobsheet had to provide examples, which are simple and easily understood. There were many imperative sentences that could not be understood and had double meanings. As a result, jobsheet could not help the learners to be more independent in solving simple assembler examples. Learning assessment using the standard assessment (KTSP) should be adjusted to the C13 format. The blue print has not yet reflected the learning indicator. It was suggested to review the assessment format according to the C13 format. The sentences given in the test questions did not reflect the metacognition orders. Thus, the sentence structure in some of the items was reconstructed/corrected.

The seventh phases-lesson plan syntax started with an introduction conveying the learning objectives and ended with the closing phase. The flow of the lesson plan in Phase III and Phase V integrated metacognition that guided learners to solve problems independently. The stages of metacognition questions were clearly described in each jobsheet, teaching materials and practical guide, so that the students would first read the metacognitive question before carrying out their task. The questions contained metacognition activities; namely, a) developing an action plan; b) monitoring practice activities; and c) evaluating it. Every learner had to construct a resumé based on those metacognitive questions and the results would guide learners in completing the students' work sheets, based on the jobsheet given.

The results of the preliminary investigation, design and the planning of learning media in this study resulted in a product that contains the metacognition-based learning steps (syntax). The orientation of metacognition that emphasises the independence of learners was constructed and is found in the syntax. These conditions allowed the teacher to give learners a chance to develop their critical and creative thinking, as well as their analysis skill. The flow of the lesson plan (RPP), jobsheet, textbooks and students' worksheets integrated the metacognition that guided the learners to solve problems independently.

The metacognitive syntax was found in Phases III and IV, and in the early stage of teaching-learning activities, the teacher should explain the importance of knowing every problem in the industrial electronics practices by solving metacognitive questions. The result is in line with the research done by Qiuye et al [7]. In their study, it was found that the metacognition concept is revised and, then, used in the trial of electric power system. The use of metacognition can accelerate learning efficiency, especially, in practical learning. The combination of metacognition revision and innovation used in the model of practical learning was one of the solutions to overcome the problem. The result showed that metacognition was very important in practical learning and produced qualified graduates who were able to learn independently.

Phase of Realisation/Construction

In this phase, a draft of the learning media was produced and, then, validated by two industrial electronics experts. The validators reviewed all the components in the learning media, which included lesson plans, textbook, practical guide, jobsheet, students' worksheets (LKPD) and learning assessment. The comments/suggestions from the validator were as elaborated on below.

Result of Learning Media Validation

The learning media were integrated with metacognition components, which were the important part of industrial electronics. Therefore, the learning media should be validated by experts and practitioners prior to its utilisation. The validation was done by submitting a copy of the lesson plan, textbook, practical guide, jobsheet, students' worksheet (LKPD) and learning assessment, as well as the validation sheet to the validator. The result from the validator was, then, revised and became the learning media draft. The assessment results from the validator are presented in Table 1.

Table 1: Learning media validation results.

No.	Learning media	Validator 1	Validator 2	Mean of score	Description
1.	Lesson plan	3.80	3.85	3.83	Valid
2.	Practical guide	3.55	3.69	3.62	Valid
3.	Learning material	3.85	3.70	3.78	Valid
4.	Students' worksheet	3.80	3.85	3.82	Valid
5.	Jobsheet	3.75	3.80	3.78	Valid
6.	Learning assessment	3.85	3.82	3.84	Valid
Mean score				3.78	Valid

Based on the data presented in Table 1, it could be concluded that the learning media had met the validation criteria. The assessment results from the validators of the learning media included the lesson plans, textbook, practical guide, jobsheet, students' worksheet (LKPD) and learning assessment. The validation of the learning media was done on five aspects with the range of one to five scores for each aspect. The overall average score was 3.78 and was qualified as valid. The suggestions for improvements given by the validator concerned time allocation, instructions for filling the instrument and the way the instructions for the instruments was written.

a. Lesson plan validation report:

The lesson plan (RPP) provides the guidelines for teachers since it contains systematic steps or phases for the teaching and learning activities. After the validation, the mean score of the lesson plan was 3.83. It showed that the designed lesson plan was valid. The lesson plan assessment was done on six aspects; namely, core competence (KI-2, KI-3, KI-4), indicators of competence achievement, content and learning activities, language, time and closing. Based on notes for revision from the validator, some corrections and improvements were made to the lesson plan; namely, 1) the lesson plan was constructed from the 1st until the 9th meeting; 2) the lesson plan format was tailored to the school lesson plan format; and 3) only the title of the sub-subject of each meeting should be written in the lesson plan.

b. Practical guide validation report:

The implementation of laboratory practice required a practical guide, so that the practice requirements, work safety and the use of practical activities could be implemented optimally. The systematic plan of practical guide consisted of: 1) introduction; 2) implementation of practical activities; 3) technical guidelines and procedures; and 4) closing.

Based on the validation conducted by the experts and practitioners, the mean score obtained was 3.62 and, thus, the practical guide was qualified as valid. Some of the suggestions for improvements given by the validators were: 1) to include the design of microprocessor Z-80 program with MPF-1 display as an attachment; 2) to add a simple example of how to use MPF-1; 3) the guidelines given were not communicative, because the language and sentence structure were not systematic; and 4) to add new material from the main menu of MPF-1. Based on these suggestions for improvement, research trials would be conducted.

c. Validation results of the learning material:

Learning materials were one of the important learning media. Learning materials consisted of a set of materials/ substances of the subject, which were systematically constructed and showed the whole picture of competencies mastered by the learners in the learning activities. Learning materials allowed learners to acquire basic competence in a coherent and systematic manner and, eventually, the learners would be able to master all competencies. Therefore, before being tested, the learning materials should be validated by experts and practitioners. Based on the validation results, the mean score of the learning material was 3.78 and was qualified as valid. Suggestions for improvement were given on four aspects; namely, the format, language, illustration, content and sentence structure.

The details of the improvement for learning materials were: 1) the material's identity should be written systematically based on C13; 2) the concept map of material should be made in such a way, so that learners could easily understand the flow of learning material; 3) the metacognitive steps were still unclear; and 4) the material was too theoretical. The learning materials should be prepared in an interesting way and a description of how to solve simple problems should be given.

d. Students' worksheet (LKPD) validation results:

Students' worksheet (LKPD) was revised based on the validators' findings. The suggestions for improvements were: 1) to provide the identity of learning at each meeting; 2) pictures that were easily understood were given in each concept; 3) metacognitive questions should be integrated in simple cases; 4) an example should be provided before the next task was given, so that learners would be able to solve the problem; and 5) an answer sheet for each case/question should be provided. The mean score of students' worksheet validation results was 3.83 and was qualified as valid.

e. Jobsheet validation results:

Before designing the jobsheet, it should be discussed with the team of teachers and researchers and from those discussions the jobsheet was constructed for four meetings. Some important components from jobsheet were transferred to the practical guide. The sentence structure and language were quite good, but there were some typographical errors, and pictures of the practice flow were not systematic and, thus, making it difficult for learners to complete their task. The mean score of jobsheet validation results was 3.78 and was qualified as valid.

f. Learning assessment validation results:

Learning assessment was done through an achievement test and assessment rubric. After that, content validation was conducted by industrial electronics experts and practitioners. The stages done were to discuss and carefully examine the content of the test that would be given to students, so as to check whether it was in accordance with the learning materials created. The next stage was to make test items according to the level of knowledge (analysis, application, synthesis and evaluation).

The results of the validation analysis are presented in Table 1, where the learning assessment met the valid criteria with a mean score of 3.84. Suggestions from Validator 1 were: 1) to change the interrogative sentences in each item to be affirmative sentences; 2) the items should have as many as 40 questions, since there were some items that were not valid. If only a few items are presented, then, the representation of learning indicators might not be met; and 3) interrogative sentences should be clear and easily understood by learners. Suggestions from Validator 2 were: 1) the item should include C1 (knowledge), C2 (comprehension) and C3 (the application), because the cognitive level at SMK still uses C1, C2 and C3; 2) images in every item should be made clear since the learners had a hard time to understand it; 3) in practical problems, the systematic assessment rubric should be made, so that the practical activities and their results can be assessed objectively; and 4) sentence structure and language should be revised because they had double meanings.

Instrument Validation Result

The feasibility of the learning instrument for industrial electronics was assessed by experts and practitioners. The validation assessment for each instrument was based on three aspects, namely: instructions, materials (content) and language.

Table 2: Learning instrument validation result.

No.	Type of Instruments	Assessment result validator		Mean score	Description
		1	2		
1.	Validation sheet of lesson plans	4	4	4	Very valid
2.	Validation sheet of practical guideline	3	3	3	Valid
3.	Validation sheet of learning activities	4	4	4	Very valid
4.	Validation sheet of students' worksheet	3	4	3.5	Valid
5.	Validation sheet of jobsheet	4	4	4	Very valid
6.	Validation sheet of learning assessment	3	4	3.5	Valid
Mean of score				3.67	Valid

Based on the instrument validation results, the mean score of the research instruments was 3.67. From this result, it was found that the following 1) assessment sheet (validation) of the lesson plan; 2) assessment sheet (validation) of practical guidelines; 3) assessment sheet (validation) of learning materials; 4) assessment sheet (validation) of jobsheet; 5) assessment sheet (validation) of students' worksheet; and 6) assessment sheet (validation) of learning assessment were qualified as valid. Thus, the assessment sheets (validation) could be used to assess the feasibility of the learning media.

The validation sheet contained three aspects of assessment; namely, instruction, material (content) and language aspects. Corrections and suggestions for improvements given by the validator on the assessment sheets were: 1) revision/improvement in the sentence structure; 2) affirmative sentences that had double meaning; 3) the same understanding of the concepts; and 4) the consistency of writing. Validator 2 gave suggestion for improvement; namely, 1) to add the point of assessment in the practical guideline; 2) to clarify the learning concept; 3) revise the sentence structure; and 4) revise the repetitive affirmative sentences in the sheet.

Learning media validation results showed that the draft of the learning media met the valid criteria. This result was based on the experts' validation that obtained a mean score of 3.78, which included lesson plans, textbooks, practical guidelines, jobsheet, students' worksheet and valid learning assessment used to perform the next test. The validator provided suggestions for improvement regarding the content, writing and language used in the learning media. After that, focus group discussions with teams of researchers and teachers were conducted to provide explanations about the learning media design that had been declared valid. The mean score from the validation results of the learning media instrument sheet was 3.67 and was qualified as valid. The feasibility results from the validator were also equipped with recommendations for improvement of the instrument, content and products of the metacognition-based learning.

The results of this study showed that metacognition-based learning media integrated metacognitive skills in learning syntax. The metacognitive component was very important in instilling critical thinking ability and to solve problems. Thus, students were able to solve the problems they faced both in the laboratory and in the work environment in industry. This statement is in line with Rahman and Philips's opinion that there is a positive relationship between metacognition awareness with academic achievement [8].

Learners could develop their thinking ability by utilising learning media that had been integrated with metacognitive skills. Some learning syntax motivated and provided the opportunity for the learners to present their practical results based on their opinions according to the rules of measurement and circuit testing. Pardjono finds that students are said to have technical competence, if they have vocational skills and also problem-solving skills, have the ability to innovate and can adapt to situations [9]. In addition, Karadimos concludes that metacognition is an important component in determining the success of students [10]. Furthermore, Stewart et al state that there is strong correlation between students' metacognition and task completion [11].

Munby et al conducted a study about learning in the workplace and the need to recognise the contextual nature of work [12]. The approach taken was to understand the teaching-learning activities and cognitive work and, it is assumed that the learning setting could be determined by its ability to offer access to knowledge for the students as the basis for a complex activity. Recent research on learning has emphasised metacognition. Metacognition refers to a higher level of thinking, which assumes that knowledge involves the cognitive function and active control over one's cognitive processes, while engaging in the task of learning.

Phases of Test, Evaluation and Revision

The test, evaluation and revision stages would still be in another development process in future studies, after the draft of learning media and instruments had been declared valid for use in metacognition-based learning. The next stage was done by testing the earlier drafts; they were reviewed and, then, implemented in limited and extended classes.

In the test phase, tests will be conducted, evaluated and revised on the learning media to provide a description of the practicality and effectiveness of the learning media which had been declared valid and fit for use. However, this study had not yet developed a focus on the practicality and effectiveness of the metacognition-based learning media at SMK. Thus, study on this subject needs to be done as soon as possible. Metacognition-based learning has some benefits; namely, 1) to train learners to work independently, think critically and creatively, to work more quickly and efficiently to achieve the desired objectives; 2) train learners to use their metacognitive ability to think systematically in solving problems; 3) train learners to collaborate (cooperate) with other in solving problems; 4) improve the competence of academic learning and develop social skills; and 5) improve learners' understanding of the systematic steps of work and practical ability.

CONCLUSIONS

Metacognition-based learning media and research instruments were valid and fit for use in metacognition-based learning. Learning media with their learning syntax provide opportunity for learners to improve their potential in solving practical tasks. Learning syntax was systematically structured and always patterned on the characteristic of the learners in the industrial electronics expertise.

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