The Development of Interactive Multimedia on Electrical Motor Installation Based on Project Based Learning for Vocational High School

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ABSTRACT
This article explains the development of interactive multimedia for Electrical Motor Installation based on Project-Based Learning for Vocational High School students. The development techniques using Borg and Gall model combined with Luther's model for product development. Interactive multimedia validity was obtained based on an assessment sheet filled by 6 validators consisting of material expert validators, media design expert validators, and instructional design expert validators. The trial subjects in this research were students of class XI Electrical Power Installation Engineering. The hypothesis proposed from this study is that this interactive learning multimedia product is feasible and effective to use in the learning process of Electrical Motor Installation. Data collection was carried out through expert validation questionnaires and student responses and post-test as an instrument of learning outcomes. The feasibility of multimedia products is obtained through testing and validation where the average percentage of the results of the evaluation of material, media, and learning design experts is 86.32%, while the average percentage of student results in individual and group trials is 83.91% which includes within the "very good" rating criteria. The results of the product effectiveness test were carried out using the learning outcome test data on the research hypothesis test through the independent sample t-test at the significance level $\alpha = 0.05$ and the degrees of freedom df = 62, so that $t_{count} > t_{table}$ was obtained, namely 3.85 > 1.67, which means that there is a significant difference in the learning outcomes of students who learn using interactive multimedia learning compared to the learning outcomes of students who learn using classical learning methods. Thus the use of interactive learning multimedia of Electrical Motor Installation is feasible and effective for to improve student learning outcomes compared to classical method learning.

Keywords: *Multimedia, Project Based Learning, Electrical Motor Installation.*

1. INTRODUCTION

Various efforts to improve the quality of vocational education have been carried out by the government in preparing graduates to have the skills and be ready to enter the community according to their competencies, including increasing the qualifications and competencies of educators, providing educational infrastructure, rehabilitation of educational infrastructure, curriculum development and adaptation of the Indonesian National Work Competency Standards (SKKNI).

The reality in the field is that Vocational High School graduates still dominate the unemployment rate because of the imbalance between demand and supply and there are still many Vocational High School graduates who do not have competency qualifications that are in accordance with industry needs both in terms of hard skills and soft skills. Given the limited employment opportunities and high competition among job seekers, unqualified human resources will lead to unemployment.

Electrical motor control is one of the competencies in the course of electric motor installation. This material is related to industrial applications so that it requires understanding and skills in designing, installing and testing electric motor control systems, both electronic, electromagnetic and automatic. In supporting the learning objectives of electric motor control, an adequate workshop or laboratory is needed to carry out tests and measurements of the motor control circuit.

However, in the field, the limitations in practical tools and materials are often an obstacle that causes students to take turns in completing electric motor installation work, so that each student's competence is not evenly distributed in one class, because only highly motivated students are active in practical activities while others are just looking for a ride in grades. Another problem is that if students can assemble and operate the motor installation according to the instructor's instructions, the students are considered to have understood. Students only follow instructions from educators based on job-sheets that have been designed by educators without understanding the knowledge that underlies the practice. Conditions like the above are one of the obstacles to the development of student creativity in developing motorbike installation designs following developments in the industry.

Other facts ini the field based on interviews with educators of learnings model at Vocational High School are still given classically. The lack of ability of educators to collaborate with various learning models in teaching is a contributing factor. This has an impact on the passive attitude shown by students during learning. Innovation is needed in the learning process, one of which is the application of project-based learning models that already exist in the 2013 curriculum, which can build student's knowledge, skills, and attitudes together. Through the constructivist learning model, students are encouraged to build their initial knowledge.

In learning, students still rely on the teachers as the only source of learning. This is also supported by the opinion of educators who say that community learning resources are much more important than other learning sources which become one of the obstacles to the creativity of educators in designing their learning resources that can be used in teaching [15]. Whereas learning resources can be in any form, whether human-based, print-based, visual-based, audio-visual, and computer-based [1,3] the use of which must be in accordance with the objectives, conditions, and environment learners [20]. Inequality in the use of learning resources can be caused by factors such as limited knowledge of learning resources, limited access to learning resources, and the unavailability of adequate and adequate learning resources.

To create a lifelong learning society, educators must strive to create conditions that allow students to have learning experiences from various sources, both learning resources designed by educators and learning sources that are used. As a learning designer, it is hoped that educators' creativity in developing learning resources so that students can explore more information to build their knowledge and reduce dependence on educators [12].

Based on the existing problems, one of the innovative steps that can be taken by educators is the use of computers as learning media in the classroom. Interactive multimedia is a computer-based application that can be developed in the teaching and learning process, which can provide a pleasant learning atmosphere and foster student independence so that the learning process is more meaningful than the lecture method [9]. Through interactive multimedia, students can choose their learning materials and learn at a level that suits their interests and motivation. A student can achieve the desired knowledge and choose to learn through text, images, audio, or video according to his learning style [19]. Multimedia learning can help educators bring the outside world into the classroom so that abstract and foreign ideas become concrete and easy for students to understand. The learning process can run effectively if educators can function multimedia learning appropriately and proportionally [5]. In its application to electric motor control material, it is also assumed to increase mastery of the concept where the use of interactive learning multimedia is expected to develop students' skills in designing electric motor installation in various controls according to developments in the industry.

Following up on the solution above, the research entitled "The Development of Interactive Multimedia on Electrical Motor Installation Based on Project Based Learning for Vocational High School".

2. THEORY

2.1. Constructivism Learning

Learning is a person's activity in obtaining knowledge, skills, and a positive attitude through various sources for learning. The learning process can be said to be effective if students are actively involved in organizing and finding information (knowledge) so that they do not only passively accept the knowledge provided by the teacher and the text [6]. The constructivist approach states that knowledge is a construction (formation) of knowing something. Knowledge is formed by students actively, not only passively received from the teacher. The constructivists position the teacher as a facilitator who is very important for students, providing them with guidance throughout their learning experience based on their needs. The use of appropriate media provides an appropriate learning environment for students so that they can build their knowledge independently. The teacher is only a facilitator who provides learning guides so that students can learn at their own pace to explore the meaning and build their knowledge independently.

2.2. Electrical Motor Installation

Electrical Motor Installation is one of the productive subjects at Vocational High School in the Electrical

Power Installation Engineering expertise competency program which is given in class XI in odd and even semesters. The existence of an electric motorbike in the community is very widely used for housing, offices, companies and industries. Because this material is an industrial application, the achievement of this material competency at Vocational High School includes knowledge of the concept of electric motors, types of electric motors, construction and working principles of electric motors, and skills to install electric motors, control electric motors and test and inspect electric motors. Competence is a person's ability to carry out tasks by integrates knowledge, skills (expertise), personal values and attitudes and the ability to build knowledge and skills and is acquired through work experience and learning by doing [10]. Therefore, apart from having the knowledge, Vocational High School graduates are also expected to be skilled in installing, operating and inspecting electric motors.

2.3. Project Based Learning

The project-based learning is a constructivism-based learning model. Constructivism develops a learning atmosphere that requires students to compile their knowledge. Given that each student has a different learning style, project-based learning provides opportunities for students to explore content (material) using various ways that are meaningful to themselves, and carry out collaborative experiments.

The George Lucas Educational Foundation developed 6 steps of project-based learning, namely: 1) starting with essential questions, 2) planning the project, 3) making a schedule, 4) monitoring learners and project progress, 5) project appraisal, 6) evaluation of experiences. The project results collected by students are carried out collaboratively, innovatively, and uniquely that focuses on solving problems related to the lives of students or the needs of the local community or industry [7].

Student learning activities in a project-based learning climate are carried out collaboratively where students seem to work together on projects that are supported by various learning resources. Products that learners make during the project are tangible and useful products, following the orientation of vocational education in the formation of professional competencies that must be supported by productive, adaptive, and normative abilities through meaningful learning experiences.

Project-based learning has the potential to make learning experiences more interesting and meaningful for students to prepare students to enter the workforce. In project-based learning, students are encouraged to be more active while the teacher is positioned behind in providing convenience and evaluating projects, both their meaning and its application to their daily lives. Therefore, in project-based learning, the teacher is not more active and trains directly, but becomes a companion, facilitator, and partner.

In project-based learning, besides being able to increase understanding in knowledge, skills in working and managing projects, it also forms soft skills of collaborative, honest, responsible, caring, and disciplined students which are part of the work culture that must be instilled in Vocational High School so that participants Vocational High School students can be declared competent and ready to enter the business or industrial world of work.

2.4. Instructional Media

As learning designers, apart from being able to apply a learning model, educators are also required to be able to develop learning resources so that students can dig up more information to build their knowledge and reduce dependence on educators. Learning resources can be anything available to help everyone learn, it can be human-based, print-based, visual-based, audio-visual, and computer-based according to the goals, conditions, and learning environment of students [1,3,20].

One of the steps that educators can use is to use learning media. Miarso [20] also states the benefits of learning media include: (1) providing variations in stimulation to the brain so that it functions optimally; (2) overcoming the limitations of the experience students have; (3) beyond the classroom boundaries; (4) allows direct interaction between students and their environment; (5) produce uniformity of observations; (6) generate new desires and interests; (7) motivates and stimulates learning; (8) provides a comprehensive experience of something concrete and abstract; (9) provide opportunities for students to study independently at a place and time that is determined by themselves; (10) enhancing new readability, namely the ability to distinguish and interpret visible objects, actions and symbols, both experienced and man-made, in the environment; (11) increasing the effect of socialization, namely by increasing awareness of the world around them; (12) improve the self-expression skills of teachers and students.

2.5. Interactive Multimedia Learning

Multimedia provides a constructivist technology-based learning environment, where students can solve problems through self-exploration, cooperation, and active participation. Independent learning multimedia provides a flexible learning environment for students, where and whenever students can study material according to their respective learning speeds.

The cognitive theory of multimedia learning specifies five cognitive processes in multimedia learning, namely (1) choosing the appropriate words from the text or story that is displayed; (2) select an image from the illustrations shown; (3) organize the selected words into a coherent verbal display; (4) organize the selected images into a coherent series display; and (5) integrating visual, verbal and initial knowledge. Multimedia learning messages must be designed to package this process [8].

According to Winarno, interactive multimedia can change the way a person acquires knowledge and the way a person learns. With the use of interactive multimedia by students, it is expected (1) to facilitate student-centered learning because students are given the freedom to choose their learning materials and learn at a level that suits their abilities, (2) serve different learning styles of students through elements The elements contained in multimedia, (3) promote multimedia learning and interaction among students through discussion and group assignments, and (4) facilitate constructivism-based learning [19].

There are several aspects to assess or evaluate multimedia learning, namely (1) subject matter, (2) auxiliary information, (3) effective considerations, (4) interface, (5) navigation, (6) pedagogy, and (7) robustness. If all aspects of this assessment have been fulfilled in interactive multimedia products, the media can be said to be suitable for use in experimental testing [19].

2.6. Learning Outcomes

Student learning outcomes include the competencies possessed by a student after the learning process. Competence is the ability to carry out a role or task, the ability to integrate personal knowledge, skills, attitudes, and values, and the ability to build knowledge and skills based on experience and learning [10].

The learning result of the electric motor installation is the success of learning that can improve the thinking skills of students in new knowledge both cognitive and psychomotor as an effort to improve good mastery of electric motor installation subject matter which is marked by an understanding of job preparation, installing jobs, checking work results, and make reports on electric motor installation work and get good and very good criteria or at least complete.

3. METHOD

3.1. Research Design

This research uses a research and development approach (R&D) with Borg and Gall's development model [17] and Luther's product development model [14]. There are ten stages of developing the Borg and Gall model, but only 7 are developed in this research, namely: (1) research and information collecting, (2) planning, (3) develop preliminary form of product, (4) preliminary field testing, (5) main product revision, (6) main field testing, and (7) operational product revision.

The research and information collecting stage include analysis of initial needs through distributing questionnaires to subject teachers and Vocational High School students of class XI TITL, identification of students through interviews, and classroom observations to determine learning support facilities.

The planning stages include (a) planning learning materials such as indicators and learning objectives, learning material topics, simulations and animations, project questions (skills), and knowledge questions as material for evaluating students. and (b) product planning such as the intended use of the product, product users, and a description of the product components to be developed.

The develop preliminary form of product stage is carried out by adopting the Luther development model, which has six stages including concept, design, material collecting, assembly, testing, and distribution.

The preliminary field testing was carried out to see the feasibility of the multimedia learning product being developed. Early-stage trials involve learning design experts to assess the appropriateness of learning device instruments, material experts to assess the feasibility of material as multimedia learning materials, and media experts to assess the feasibility of multimedia products.

The main product revision stage is carried out based on the results of the analysis of the expert validators. The validator's assessment becomes a recommendation for product improvement until the product is declared fit for use and can be tested through experimentation.

The main field testing stages include individual trials consisting of 3 students, small group trials consisting of 12 students, and product testing in a class consisting of 32 students. Students in individual trials and small group trials each consisted of students with high, medium, and low learning achievement. At the field trial stage, a pre-test and a post-test were carried out to determine the effectiveness of multimedia. Analysis of the effectiveness of the product was carried out through the t-test with a quasi-experimental research method. The field test design for this study uses the Matching-Only Pretest-Posttest Control Group model which requires two groups to be paired as a research group, namely the experimental group and the control group. The experimental group and the control group had the same or homogeneous characteristics, but the class was not taken randomly. At the end of the lesson, the two groups were tested through posttest with the same questions and then measured. The final test results of

the two groups were compared (tested for differences). The difference in the results obtained from the measurement is an indicator of the impact resulting from the use of the product.

The operational product revision stage is carried out based on suggestions and input from class XI students as end-users of the product. If the results of the product appraisal have not shown significant results, namely the results still get a value of 60% of the expected value, then a product revision is still necessary.

3.2. Research Subject

Learning development products require feedback in context of formative evaluation. This feedback can be obtained from research subjects consisting of instructional design experts, material experts, media experts, and students of class XI Electrical Power Installation Engineering at Vocational High School.

3.3. Research Instrument

The data in this research were obtained through questionnaire instruments and learning outcomes tests instruments in the form of pretest and posttest. The questionnaire is used to find out about the correctness of the concept, material, media design, the attractiveness of the learning media being developed, and the response to the motivational aspects. Questionnaire sheets are given to material validators (experts), media experts, learning design experts, and to students (individual tests, small groups, and large groups).

The learning outcome test is used to see the effectiveness of using multimedia learning electric motor installations in learning compared to classical method learning. The form of the test used is multiple choice with four choices (a, b, c, and d) where each correct answer is 1 and the wrong answer is 0 (zero).

The learning outcome test instrument that had been compiled was tried out first on the XII TITL Vocational School students to determine the quality of the instrument in the form of validity, reliability, difficulty level of questions, and distinguishing power. From the test results of the learning outcomes test instrument, 25 items were declared valid to be used in testing the effectiveness of the product.

3.4. Data Analysis

This research used three data analysis techniques, namely 1) qualitative descriptive analysis techniques, 2) quantitative descriptive statistics, and 3) inferential statistical analysis (t-test).

This qualitative descriptive analysis technique is used to process data from the assessment of learning device design experts, subject matter experts, instructional media experts, and student trials. This data analysis technique was carried out by grouping information from qualitative data in the form of input and suggestions for improvement contained in a distributed questionnaire.

Quantitative descriptive analysis techniques are used to process data obtained through numbers in the form of percentage descriptive. The eligibility data for the validation instrument consisted of qualitative data and quantitative data. The description of the conversion of the assessment of each aspect of the criteria into qualitative values using the following formulas and criteria [11].

Table 1. Assessment Criteria

Score Interval	Criteria
Mi + 1,5 Sbi < x ≤ Mi + 3 Sbi	Very Good
Mi < x ≤ Mi + 1,5 Sbi	Good
Mi - 1,5 Sbi < x ≤ Mi	Pretty Good
Mi - 3 Sbi < x ≤ Mi – 1,5 Sbi	Less Good

In this research, it was determined that the product was considered feasible if it obtained the ideal assessment criteria least good. Furthermore, the percentage of the ideal product is calculated using the formula shown below.

$$\%\ \text{of Idealism} = \frac{\text{average score of all aspects}}{\text{the maximum ideal score in all aspects}}\ \text{x } 100\%$$

The data analysis technique used to analyze student learning outcomes through posttest during field trials is inferential statistical analysis (t-test). The use of descriptive statistics aims to find the highest, lowest, mean, median, mode, and standard deviation scores, then compiled in a frequency distribution table and the form of a histogram chart. Inferential statistical analysis in this study used the t-test (independent sample t-test) by comparing two unpaired groups to test the hypothesis proposed in the study as follows.

$$t = \frac{\overline{X_1} - \overline{X_2}}{s\sqrt{\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} \quad (1)$$

Where, t = value of t count; $\bar{x}$ = sample mean; s = sample standard deviation; and n = number of samples.

4. RESULT AND DISCUSSION

The product development produced in this study is in the form of interactive multimedia learning media using a project-based learning model, which contains innovative and collaborative elements. The development process is carried out by the stages which include the concept, design, material gathering, assembly, testing, and distribution stages.

At the concept stage, it was determined that the purpose of developing interactive multimedia applications for electric motor installations was to help students learn independently and to assist teachers in delivering electric motor control material interactively.

At the design stage, the design is carried out using a storyboard and a navigation structure to describe the appearance of the multimedia face from one scene to another.

The material collection stage was carried out by determining the learning material based on the basic competency analysis developed, namely KD 3.6 and 4.6 regarding the application of various electric motor control installations. The materials collected are in the form of images, animated simulations, teaching materials, evaluation questions, and voices that used as intros.

The assembly stage is carried out by the stage of combining and installing multimedia components, including intro, main, and page. The application development is based on the storyboard design stage and the navigation structure.

The testing phase runs the application/program to see if there is an error or not. The testing phase involved material experts and media experts in alpha testing and class XI students as respondents in beta testing. Respondent assessment data will be used as a consideration in evaluating the media.

The distribution stage of the resulting product is stored in flash and compact disk (CD) media to be distributed to teachers who teach subjects and to students as end-users.

One of the important stages in the development process of interactive learning multimedia is evaluation. Evaluations are carried out in the form of formative and summative evaluations. The implementation of evaluation aims to determine the quality of multimedia that has been developed, to determine the effectiveness and impact of multimedia programs in learning.

Formative evaluation is carried out by experts (validators) during the implementation of product development to assess the feasibility of the product before the product is widely used by users. So that a quality multimedia product can be obtained according to predetermined criteria. Several aspects used in evaluating multimedia include subject matter, auxiliary information, affective considerations, interface, navigation, pedagogy, and robustness [19].

The average percentage of the results of the assessment of instructional design experts, learning material experts, and media experts are as follows.

Table 2. Average Percentage of Expert Validation Results

No.	Expert	Idealism Percentage	Criteria
1.	Media expert	85,37 %	Very Good
2.	Content expert	88,57 %	Very Good
3.	Instructional expert	85,01 %	Very Good

From the results of the expert's assessment, it was obtained that the ideal percentage of 86.32% was included in the Very Good criteria, which means that the development of interactive learning multimedia on the topic of 3-phase electric motor control systems in class XI of Vocational High School, the competence of Electrical Power Installation Engineering is fulfilled needed and good for use by teachers and students. The results of the analysis are then used as guidelines for revising product deficiencies based on suggestions and recommendations for product improvement by expert validators so that the interactive learning media developed becomes feasible to be used and tested through experiments. Because all aspects of the assessment of the media are in the valid category, the learning media that has been developed can be used in field trials in classroom learning, to then measure its effectiveness.

Summative evaluation is carried out when the product is finished and ready for use by the user, aiming to determine the effectiveness level of the multimedia product. The average percentage of the assessment aspects of the individual student assessment results and student group trials can be seen in the following table.

Table 3. Average Percentage of Students Assessment Result

No.	Expert	Idealism Percentage	Criteria
1.	Individual trial	84,31 %	Very Good
2.	Small group trial	82,41 %	Very Good
3.	Field group trial	85,02 %	Very Good

From the results of the student assessment, an average percentage of 83.91% ideal is included in the Very Good criteria, which means that the development of interactive learning multimedia on the topic of 3-phase electric motor control systems in class XI of Vocational High School is feasible to be used and have benefits in the learning process for teachers and students. The learning process is said to be effective in building students' memory and understanding if students are actively involved in organizing and finding information not only passively accepting knowledge provided by teachers or textbook. The effectiveness of a lesson is not only shown through increasing understanding but also by increasing the creative

thinking skills of students. Creative thinking will bring out creativity and make students have many ways to solve problems with different perceptions and concepts.

Several things are the cause of the lack of understanding and creative thinking skills of students in learning Electric Motor Installation. First, teachers do not know the right way to increase the creativity of students in the learning process in the classroom. Students have not been able to relate material concepts to everyday life and do not have creativity in developing their own motorbike installation designs according to industrial developments, because so far they have only followed instructions and job sheets given by the teacher. Second, teachers do not have experience in practicing creative thinking by integrating it into the learning they do. The lack of the teacher's ability to collaborate with learning models and media in teaching results in the passive attitude of students in learning. In Osuala & Onwuagboke's research it is said that the mastery of the creative aspects of students, especially in the aspects of planning and assembling tools, is still low, and the ability to come up with ideas, ways, suggestions, questions, or ideas is still too low and has not varied, this is because one of them is the less than the optimal role of the teacher involves students to develop their thinking skills. Third, schools lack access to students to develop their thinking skills independently. Learning sources that support students' knowledge have not been seen as an important factor in schools, it was found that most students still use textbooks and place teachers as the only learning source, even though learning resources can be anything, can be human-based, print-based, visual-based, audio-visual and computer-based according to the goals, conditions, and learning environment of students [1,3]. In project-based learning, the teacher acts as a facilitator, provides materials and work experience, encourages students/learners to discuss and solve problems, and ensures students/learners remain enthusiastic while they carry out the project. This is in line with the opinion of Goodman and Stivers which states that project-based learning creates a constructivist learning environment where students build their own knowledge and the educator is only a facilitator [2].

The results of using multimedia showed a positive and significant influence on the level of mastery of the factual, concept, and procedural knowledge for class XI-2 students in the Electrical Power Installation Engineering expertise program at Vocational High School. This means that this learning multimedia is very suitable to be applied in the subject of Electrical Motor Installation because it can build not only knowledge but form a good work attitude and improve the skills of the projects it completes. Overall the multimedia learning products developed in this study are effective in achieving all components of the assessment of both knowledge, skills, and attitudes. So that this multimedia will also be effective for other basic competencies that have identical characteristics.

5. CONCLUSION

Based on the results of the research, it can be concluded that the research on the development of interactive multimedia of the Electrical Motor Installation through the Borg and Gall stage by adopting the Luther model for product development to product testing shows that the media product that have been developed are suitable for use in electric motor installations based on project-based learning in class XI TITL students. The average validation results of of the expert are 86.32% and the average student assessment is 83.91% which is included in the "Very Good" category.

Interactive multimedia products are declared effective in the learning process and can improve student learning outcomes compared to conventional learning. This can be seen from the percentage of learning outcomes where for the experimental class 81.25% of students have mastery learning with an average value of 86.17 which is higher than the specified minimum completeness value of 75. This means that there is an increase in the value of 11.17 from the value limit of KKM. While the control class 78.12% of students had mastery learning with an average value of 75.50. This means that there is only an increase in the value of 0.5 from the KKM value limit. Through the t-test at the significance level of 0,05 for the independent sample t-tes, the t-test > t-table value is 3.85 > 1.67 where the Ho hypothesis is rejected and Ha is accepted. So it can be concluded that there is an increase in the learning outcomes of students who learn using interactive multimedia compared to the learning outcomes of students who are taught by classical methods in learning Electric Motor Installation.

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