Analysis stage in the development of a virtual laboratory electric motor installation for vocational high schools

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Abstract. The study aimed to find out the design of instructional media which is suitable for practical learning of electric motor installation. It used needs analysis and front-end analysis which was carried out at Vocational High Schools in Yogyakarta. The result showed that the developing two-or three-dimensional media in the form of virtual laboratories was strongly recommended. Virtual laboratories was able to visualize the components according to real conditions. The concepts and work principles of electric motor installations were showed in the form of a two- or three-dimensional simulation. Virtual laboratories was expected to help virtual learning and train students' independence and competence in practicing electric motor installation.

1. Introduction

The vocational education in industrial revolution 4.0 has a main role in producing a qualified and competent employee. A skilled employee can be obtained by taking secondary level vocational education or Vocational High School (VHS). VHS is focused on students developing specific skills in accordance with the demands of the world of work and the world of industry. Development of industrial-oriented skills and practical skills obtained through vocational education so that each individual is able to work according to his / her expertise [1].

The Covid-19 pandemic has an impact on student learning so that the learning and teaching process is carried out online. VHS must be ready to provide facilities and infrastructure that can train the skills of students online. The standard of facilities and infrastructure owned by VHS greatly affects the quality of education. Practical facilities and infrastructure that are owned are limited in terms of quality, quantity, and utilization of technology. The use of technology becomes an obstacle in the distance learning process [2]. This condition can affect the competence of graduates when they enter the world of work. Practical facilities and infrastructure are basic needs informing the skills of students.

Software-based learning media need to be applied in online practicum learning to train the skills of students. The use of software-based learning media can present abstract concepts to become real in visual form. Technology-based learning media can act as a bridge to convey ideas and provide practical experiences during the learning process [3]. The subject of Electrical Motor Installation is a subject that is difficult for students to understand because it uses various kinds of connections and components. Students are required to have competence in planning, assembling, and operating electric motors. This competence can be formed by doing practical work directly. Practical experiences can be done by utilizing virtual learning media.
The use of virtual laboratory in the learning process is growing rapidly. The use of technology as a bridge in the learning process to improve student competencies and skills. Virtual laboratories can provide practical experience according to laboratories in schools. The availability of virtual laboratory can save in the provision of facilities and infrastructure and students can carry out the practice anytime and anywhere. Technological developments can overcome potential difficulties in the development of virtual laboratory including augmented reality, computer graphics, computational dynamics, and the virtual world [4]. It is possible to develop a virtual laboratory in the world of education.

Practical experiences using virtual laboratory obtained by students are in line with a practicum in school laboratories. Existing research mentions the development and application of a virtual induction machine laboratory to recreate the fundamental aspects of induction machine testing. Students can do a step-by-step practicum in a virtual laboratory by connecting the cable to the terminal so that it forms a circuit that is similar to real-world practice. The advantage of this virtual laboratory is that it provides safety equipment and displays the parameters of the induction machine equivalent circuit [5].

The electric motor installation laboratory can be visualized on a computer basis. The teaching aids contained in the laboratory can be visualized virtually on a computer with the same concepts and principles of work as real conditions. This article describes a needs analysis in the development of virtual laboratories as learning media for the practice of electric motor installation. The use of components and equipment is packaged according to the teaching aids available in the school laboratory. Through the virtual laboratory, students can carry out the practicum installation of electric motors with various connections independently from home. Students have more free time to develop their competencies without assistance from the teacher.

2. Method

The stages of the needs analysis for the development of an Electric Motor Installation simulator refer to the stages of the needs analysis in the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation). The data were obtained by interviewing and observation techniques conducted in VHS according to the needs analysis stage. The analysis stage is divided into two parts, namely needs assessment and front-end analysis [6]. The needs assessment is a systematic method of determining gaps in current conditions with expected conditions in VHS. Front-end analysis is needed to determine techniques in determining solutions to gaps that occur in VHS. Figure 1 shows that the needs analysis and front-end are interrelated, so that the data information obtained from the needs analysis provides input to the front-end analysis to determine the solution.

![Figure 1. Analysis Phase in the Virtual Development of Electric Motor Installation Laboratory](image-url)
3. Finding and Discussion

3.1 Finding

3.1.1 Needs Assessment

Learning on Electric Motor Installation during the Covid-19 pandemic was conducted online. Students ‘understanding of cognitive and psychomotor is considered lacking, this is indicated when many students’ exams whose scores have not reached the graduation criteria. The basic concept of the electric motor installation is abstract and invisible so that the electric motor installation material is difficult for students to understand. Students can only imagine the concept of learning electric motor installations because there is no learning medium that can resemble a trainer such as those available in laboratories or workshops. The absence of practicum tools available at home or virtual learning media that do not support learning electric motor installations is also an obstacle to practical learning. When learning online, students can simulate a series of electric motor installations with software with a two-dimensional display of symbols. This results in weak knowledge and competence of students towards contextual learning.

When learning offline, students use electric motor installation trainers available in laboratories or workshops. Based on observations in VHS in Yogyakarta, the average condition of the electric motor installation practicum equipment owned by schools is outdated, the number is limited, and some components have been damaged. The trainer owned by the school is used by a practicum of 30-36 students. This condition affects the students’ practicum abilities unevenly. Students in accessing the laboratory or workshop outside of class hours are limited because the workshop is used for another class and safety reasons. Students are given access only during class hours and must be accompanied by a technician and limited to working hours. This causes students not to have independent practicum learning outside of class hours.

Ideally, the number of practicum tools for offline learning is in accordance with the number of students, or one practicum tool can be used by 2 students. As for online learning, ideally, students can carry out practicum on electric motor installation at home. Students can do practicum online with the help of multimedia software-based learning. Availability and adequacy of the number of practicum tools can even out the competence of each individual, so as to improve the abilities and competencies of students. There needs to be additional access to the use of laboratories for students to support their independent learning experience. This additional access also needs to be accompanied by a technician so that laboratory security is maintained. In addition, learning media are needed that can be used for practicum learning online.

The imbalance between the number of practicum tools and the number of students can lead to gaps. The gap that occurs is the learning received by students is not evenly distributed so that the understanding of the material for each individual is different. Learning media that do not support online learning can also lead to gaps in student competencies. Students lose practical experiences that resemble trainers available at school, so that mastery of electric motor installation materials is less than optimal. Achievement of less than optimal learning outcomes results in weak student skills and competencies.

The procurement of practicum components for each student so that they can be independent practicum at home is not an effective and burdensome solution for students. Financial constraints for each student become a separate problem when it comes to procuring practicum tools. The use of multimedia learning as a substitute for practical unit tools is an effective and efficient alternative solution when learning online. Multimedia electric motor installation simulator based on two/three-dimensional models is able to describe the working principle of a system. Multimedia allows students to study independently at home because multimedia is flexible.
3.1.2 Analysis Front-end

The front-end analysis stage is carried out to explore in more detail the problems obtained from the needs analysis. Ten activities must be done to obtain data in the front end analysis. Activities in front-end analysis include (1) analysis of students; (2) situation analysis; (3) technology analysis; (4) objective analysis; (5) significant incident analysis; (6) analysis of current issues; (7) task analysis; (8) analysis of instructional media; (9) analysis of existing data; and (10) cost analysis.

Student analysis includes the characteristics of learning, background identification, and pre-requisite skills of students. The characteristics of VHS learning are 30% theory and 70% practicum, so there is a lot of practical learning. The educational background of students comes from junior high school, so the knowledge they have is still heterogeneous. The prerequisite skills for an electric motorbike installation practicum are students who have taken basic electricity lessons in the previous semester.

The situation analysis of the electric motor installation practicum is carried out to determine the environmental constraints that occur when carrying out online learning carried out at home or offline learning in the laboratory or workshop. The condition when learning online is that students learn the learning module provided by the teacher and practice using simulations in symbols. Conditions when learning in a laboratory or electric motorbike installation workshop uses a trainer that is not flexible. This situation analysis focuses on developing contemporary and flexible practical tools based on multimedia.

Technology analysis is an identification of the technological capabilities used when learning electric motor installation practicum. The development of technology and information has increased drastically, including in the world of education. The use of gadgets and hardware has become a lifestyle that is growing rapidly among vocational students. Technology analysis focuses on developing computer-based multimedia.

The objective analysis serves to determine the objectives to be achieved in the electric motor installation practicum. The electric motor installation practicum aims to prove the concept of an electric motor through a series of laboratory experiments. The concept of electric motor installation in theory can be proven through the practicum procedure of electric motor installation. Practicum of electric motor installation includes direct on line (DOL) motor connection, sequential, reverse forward, and triangular stars. Knowledge and skills can be developed through direct experience during the electric motor installation practicum.

Analysis of important events during the electric motor installation practicum, namely knowledge and skills in operating an electric motor with various connections. Students are asked to apply safety and work safety (K3) elements when operating props for electric motor installations. The element of K3 is related to the safety of the students and the safety of the practicum tools, where there is an element of electricity which is an invisible danger. The important incident analysis focused on K3 students in assembling and operating an electric motor.

Task analysis is the achievement of learning electric motor installations. The learning achievement of electric motor installation is that students can assemble and operate an electric motor with various connections using electric motor installation props. The electric motor installation circuit test is focused on knowing the performance of the electric motor rotation based on the connection and protection system which can be seen on the measuring instrument. Task analysis focuses on the performance of a series of electric motor installations with various connections.

Learning media analysis serves to determine strategies in media delivery to each student. The use of technology in all activities allows delivery to be carried out using limited storage media. Based on this, multimedia can be used independently or with assistance.

Analysis of existing data includes the identification of learning materials, references, job sheets, and syllabi. Existing data were analyzed through a review of ongoing practicum procedures. Practical electric motor installation through certain procedures that require students to master the knowledge of electric motor installation until they pass the exam.

Cost and benefit analysis includes the identification of costs and benefits and returns on investment when developing multimedia learning. Virtual simulation-based multimedia development is cheaper
than the provision of teaching aids for new electric motor installations. The benefit obtained is that it can overcome the gaps in the knowledge and skills of students when practicing the installation of electric motors. The investment obtained is in the form of a virtual independent learning experience that is flexible and is not limited by space and time.

3.2 Discussion
The conditions of the Covid-19 pandemic have forced the teaching and learning process to be carried out online. The unavailability of software-based practical learning media becomes an obstacle when learning online. Learning media is the main thing in the delivery of learning material to students. Learning media can also provide learning experiences for students to develop their competence. Learning media need to be packaged in a flexible, online-based, and provide opportunities for students to develop their competences [7]. The use of instructional media can improve student competence. The use of technology in online learning can help students understand the material through virtual laboratories [8]. Learning using a virtual laboratory is more efficient, the learning conditions are cheerful, and students can receive material virtually. Not only supporting online learning, but virtual laboratories can also support offline learning at school.

Virtual laboratories need to be developed to support the improvement of the competence of electric motor installations in online learning. The concept of virtual laboratory development resembles the props for installing electric motors in schools so that students can do practicum online which can then carry out practicum using real teaching aids. It is possible to develop a virtual electric motor installation laboratory by reviewing previous research, as well as the ease and advantages of using virtual laboratories for online learning.

4. Conclusion
Online learning of the electric motor installation practicum requires software-based learning media. The development of a virtual laboratory for installing electric motors in a two/three dimensional model is an alternative solution to improve student competence. Students interact through a screen on a computer/laptop to assemble and operate an electric motor, so that the practical experience can be directly obtained by students. The virtual electric motor installation laboratory will be equipped with a virtual measuring instrument to find out the parameters of the electric motor.

Acknowledgments
This research is fully supported by Master Education Program of Electrical Engineering, Faculty of Engineering Universitas Negeri Yogyakarta for providing the Research Grant.

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