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Needs analysis for the development of interactive virtual reality-based educational media on combustion engine mechanical technology

Sutiman^{1*}, A Yudiantoko¹, A Yudianto¹, M Solikin¹, I W Adiyasa¹, N M Suaib^{2,3}, F Sholichin², D A Irawati²

¹ Automotive Engineering Education Department, Universitas Negeri Yogyakarta, Colombo Street 1, Yogyakarta, Indonesia.

² School of Computing, Universiti Teknologi Malaysia, 81310 UTM Skudai, Johor, Malaysia.

³ UTM Big Data Center, Ibnu Sina Institute of Scientific and Industrial Research, Universiti Teknologi Malaysia, 81310 UTM Skudai, Johor, Malaysia.

*sutiman@uny.ac.id

Abstract. Needs analysis is the first and necessary step for the researchers to design a newly developed learning media to find out a set of specific requirements to conduct the research activities. The study aims (1) to investigate the user's learning preference, (2) to select the suitable learning materials and to choose the appropriate type of engines, and (3) to identify the needs for the virtual reality development. A focus group discussion (FGD) comprising some representative users and experts in learning media has been involved in the activities with the use of the FGD guidance sheet as the supplementary tools. Additionally, the literature study has also been conducted to collect the necessary additional data to perform a 3D design of the engine. The data were analyzed qualitatively by examining the comment from the users, the experts, and the outcome of the literature review study. It was then concluded that (1) the users require the learning process, which does not need to alternate the learning objects. (2) The two-stroke single-cylinder engine was decided to choose by considering the complexity of the engine mechanical construction. Finally, (3) the needs for engine assembly drawing and virtual reality development have also been described.

1. Introduction

Practical lessons are necessary for students in the engineering field of vocational education to master several skills related to the area of study. However, some parts of the equipment to conduct the lesson are costly and possibly risky for students to use. The emerging technology in virtual reality (VR) has great potential to be implemented in the learning environment to overcome the cost and the risk problem in the vocational engineering education field. The utilization of VR has widely implemented many others fields such as medical training [1], military training [2], automotive and aerospace design [3], product design [4], entertainment [5] and engineering education [6]. The already implemented VR for learning environment proofs that these applications can be means of enhancing motivation and stimulating student's understanding of certain events [7], especially those students who cannot follow the conventional way of using the instructional materials for learning.



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The field of combustion engine mechanical technology is chosen in this study, considering that the skills in mastering the subject related to the combustion engine are one of the cores of the learning activities. Considering the fact that the different technologies can be fully utilized in a VR system, it is expected that learning via a VR system will enable students to interact with a virtual scenario in a multi-sensory manner [8], the difficulties of the students to assemble the mechanical components for the real activities could be possibly replaced and benefits in better understanding of the practical lesson. The fully digitalized system of the technology allows the students to eliminate the risky interaction with heavy mechanical parts of the combustion engine and removing the limitation of the used space. Moreover, the study for the affordance in utilizing VR for learning and teaching achieved positive effects in supporting pedagogical aspects [9]. The mentioned capability of the VR system has a promising probability of creating interactive learning experiences in the topic of combustion engine mechanical technology as compared to contemporary educational media settings.

The requirements identification to conduct research in question is an essential activity to perform at the beginning stage of the research. Several previous studies conducting similar activities demonstrate that the need analysis is an inseparable activity in conducting the research. In this phase, the review of the VR utilization for learning will be conducted to review the types of VR used for training, the theoretical framework for a VR environment, and together with the environmental design for this technology in the learning environment [10]. The need for a VR simulator has been reviewed before developing the real equipment in dental education. The overview of the simulators and the link between VR simulation and current pedagogical knowledge was clearly identified [11]. A previous related study in determining the need for a virtual laboratory, according to the chemistry teachers, was conducted before developing the real equipment [11]. The results indicated that the majority of the respondents require this kind of integrated virtual chemistry laboratory in hybrid learning. The identification of the appropriate topic for the implementation of this technology was also identified. However, this work mainly analyzes the need to develop an interactive VR-based educational media for the subject related to the assembly process of a combustion engine mechanical technology. The project will be implemented for students in the subject area of engineering for vocational education as one of the topics of the practical lesson.

The main research problem in this study is how to develop an educational media based on VR technology to be implemented on combustion engine mechanical technology. Therefore, the needs analysis to develop the VR-based educational media is necessary to perform. The aims of the study are to investigate the student's learning preference, to select the most appropriate learning materials, and to identify the needs of engine drawing to be implemented in the VR technology. This work will essentially contribute as the initial pace to develop the VR-based educational media and properly identify the requirements to conduct the subsequent research.

2. Research Method

The ADDIE model was employed, comprised of Analysis, Design, Development, Implementation, and Evaluation phases [12] to develop the entire system of VR-based educational media. This work was the first step of that model, which was the Analysis Phase. In this phase, there are three kinds of analysis that had been done which were student learning preference analysis, learning materials analysis, and needs of VR development analysis. This research adopted a descriptive study with a qualitative approach to analyze the results through the needs analysis.

The research respondents involved amounted to 56 (Table 1). The involved respondents were chosen to represent the students, lectures, and some experts in the required field. Questionnaire and Focus Group Discussion (FGD) were used in this work as a data collection technique, in which the questionnaire sheet and FGD guidance sheet were used as instruments in this work. The data from the questionnaire was analyzed quantitatively and the data from FGD was analyzed qualitatively.

Table 1. List of Respondents.

No	Respondents	Number
1	Automotive Vocational Students	40
2	Automotive Vocational Lecturers	4
3	Automotive Vocational Experts	2
4	Educational Media Experts	2
5	Instructional Design Experts	2
6	Automotive Industry Practitioners	6

3. Result and Discussion

Educational media could support students during their learning activities. Their achievements, motivation, and also collaboration skills could be developed by using educational media [13]–[17]. In addition, educational media also help teachers to deliver learning materials during their teaching and learning processes [13], [18], [19]. Developing educational media could have a positive effect on teaching and learning processes. However, the development of the educational media has to accommodate the needs of the users, so that the benefits of the educational media can reach the targeted outcome. The identification learning preferences perceived by the users, the choice of the most appropriate learning material, and the needs for VR-development need to be conducted before building the entire VR-educational media system.

3.1. Student Learning Preference

It is indispensable to determine whether a particular teaching methodology positively or negatively affects students' satisfaction with the learning process [20]. As a matter of fact, students need to be supported in their learning processes, both theoretical and practical lessons. The identification of the students' learning preferences can help students to maximize their true potential and to become lifelong self-directed learners [21]. It is because of the data from the questionnaire and also the FGD hint that they need support by developing educational media to make them easy to understand and master the required skills. The results of the data collection are depicted in the following figures. The first identification aims to analyze the perceived level of difficulties of the subject. The data was collected by means of a questionnaire having the total number of respondents depicted in Table 1. Figure 1 shows the level of difficulties of the automotive mechanical technology subject. The vast majority of the respondents involved in the survey said that the difficulties level of automotive mechanical technology is difficult. These results are described by 48% of the respondents said that the difficulties level of the subject is high and 20% of them said that the subject is very high. However, only a small percentage of students involved in the survey feel that the subject is easy by the results in 2% of them say that the subject is easy. The other respondents said that the subject is rather easy.

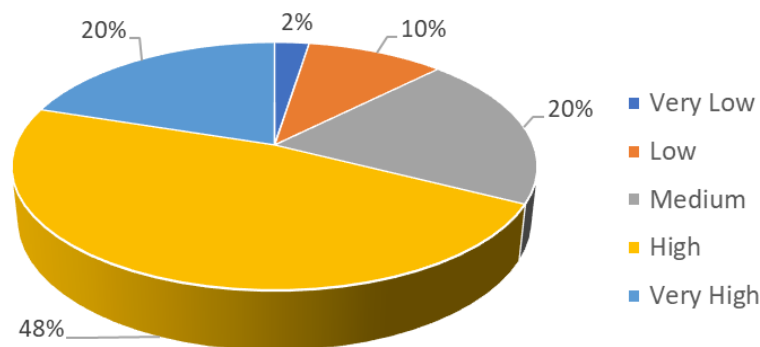


Figure 1. Level of Difficulties of Automotive Mechanical Technology Subject.

The interrelation between theoretical and practical lessons of a subject will altogether determine the quality of the learning and teaching process as well. Therefore, it is essential to identify the effectiveness of the educational media during the theoretical lesson of the related subject to the practical lesson under-identification. Figure 2 indicates the effectiveness of the educational media during the theoretical lesson of the subject related to combustion engine mechanical technology. 60% and 5% of the respondents indicate that the effectiveness of the educational media is respectively low and very low during the theoretical lesson. Approximately 22% and 13% of the students involved in the survey answer by medium and high. It can be derived that the effectiveness of the utilization of educational media needs to be improved.

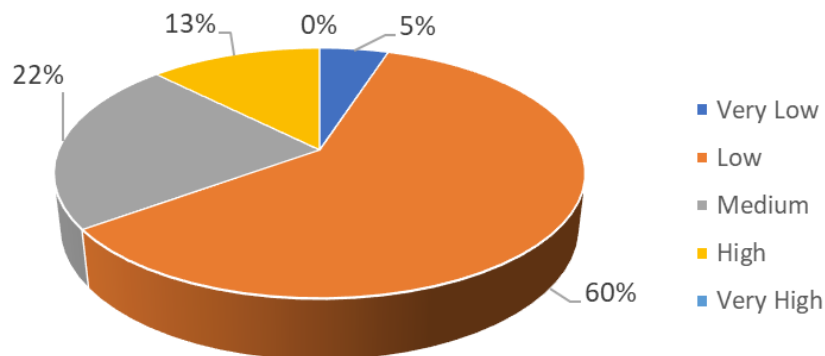


Figure 2. Level of Educational Media Effectiveness during Theoretical Lesson.

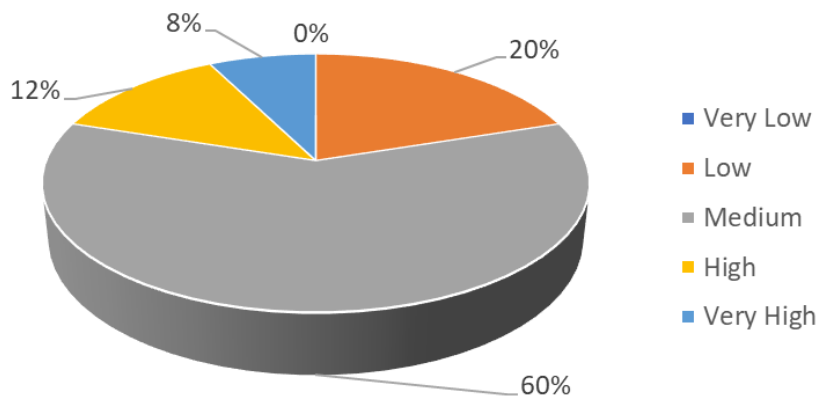


Figure 3. Level of Effectiveness of Automotive Mechanical Technology Practical Lesson.

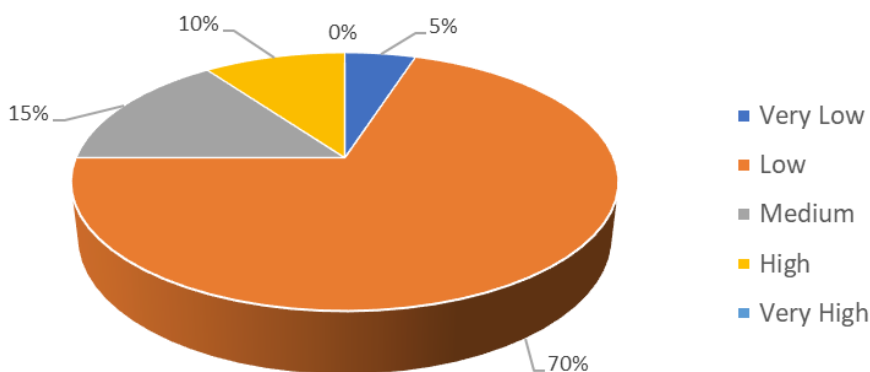


Figure 4. Level of Facility Availability during Automotive Mechanical Technology Practical Lesson.

Instead, Figure 3 depicts the effectiveness level of automotive mechanical technology practical lessons. More than half of the respondents answered with the medium level of effectiveness of the practical lesson. Only 12 % of them answered with high effectiveness, and the others are at a low level of effectiveness. Figure 4 describes the availability of the facility related to automotive mechanical technology practical lessons. The similar results indicate that almost three-quarters of the student involved in the survey said that the facility that is available to support the practical lesson of automotive mechanical technology is low.

Therefore, it can be derived from the results of the survey that there are many aspects that need to be improved in the teaching and learning process for automotive mechanical technology lessons. This subject is considered a difficult subject with the relatively low effectiveness of the theoretical lesson that is related to the practical lesson of the subject. Additionally, the practical lesson itself is perceived by the student to have a medium effectiveness level of the lesson activity. This problem might be related to the facility available to perform and support the practical lesson to be more accessible and understandable.

After answering the questionnaire, students were involved in FGD with lecturers that have three topics, which are a possible solution, educational media, and VR technology. The result says that VR technology could be as an educational media in order to be a possible solution for that problem. The students need an interactive educational media that use a state-of-the-art object and the one that is relatively new technology. Some already old educational media need to be replaced with the new one so that the effectiveness can be improved since the newly developed educational media with new technology is relatively more attractive for students. Modern educational media is also possible to improve the learning motivation for both theoretical and practical lessons in automotive mechanical technology. The students also require educational media that do not need to alternate the learning objects. The VR technology is finally preferable to be developed based on the mentioned considerations.

3.2. Suitable Learning Materials

The enormity of learning materials contributed to the struggle of choosing the most appropriate learning materials for a specific learning topics [22]. The FGD was used to find the most appropriate educational media materials to be chosen to develop the VR based educational media in this work. Vocational students, lecturers, automotive vocational experts, and automotive industry practitioners are involved in this FGD. The topic is to choose the kind of automotive mechanical component that needs to be developed. The answer is two-stroke engine mechanical components. There are some considerations in choosing this type of engine. Since this VR project is the initial project to be further developed for educational media in this work, the two-stroke engine is chosen by considering the level of complexity of the component. Therefore, two-stroke engine components are very considered appropriately to become a pilot project for VR technology as an educational media.

3.3. Needs for 3D Design in VR Development as an Educational Media

A VR system incorporates a set of technologies that allows users to experience and explore three-dimensional environments generated by computer [23]. It is necessary to identify the needs to build the virtual learning environment to be the educational media applied in the teaching and learning process. In this step, FGD was also used in this issue by involving educational media experts and instructional design experts. There are several results from this FGD. Firstly, in order to draw the engine components as materials to be developed in VR technology, the computer that has minimum RAM 8 GB and Graphic Card 4 GB is required. Secondly, Autodesk Inventor 2019 Student Version is chosen for this project. Thirdly, the reverse engineering method was chosen as the method to draw the engine mechanical component. In order to verify the drawing, the so-called motion and component interference conformity are used to ensure the drawing of the object. Other tools are also required to conduct the VR Development, such as vernier calipers, micrometers, cylinder bore gauge, and wrench set are required

as measurement tools. After finishing the drawing of the object, The Unity software is the preferred platform to create the VR experiences for the educational media.

4. Conclusion

A conclusion can be derived that the needs analysis is an essential step for the development of VR educational media for automotive mechanical engine technology. The students require a learning and teaching process by employing state-of-the-art technology to facilitate students during theoretical and practical lessons. The learning object preferable by students is the one that does not need to alternate between the students and to maximize the utilization for students. The two-stroke single-cylinder engine is decided to be developed in the VR system. The need for VR development in terms of drawing and VR development system requires software and hardware related to component drawing and development of VR program.

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