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Augmented Reality in STEM Using Personalized Learning to Promote Student's Understanding

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ABSTRACT

The current curriculum highlights the premise of self-directed learning performed by students. Additionally, technological uses in educational settings prove to be a challenging task in a sense of implementing them in learning media and materials used in the classroom. This study aims at investigating the utilization of augmented reality (AR) in STEM (Science, Mathematics, Engineering, and Technology) using personalized learning. This study employed pre-experimental research design, specifically adopting One-Group Pretest-Posttest Design. The findings highlight that students' pretest scores on average reached 51,6 and significantly improved to 82,67 in their posttest, whereas students' gain score reached 0,64 which is considered as moderate. Their perspectives towards the use of augmented reality with personalized learning were significantly positive with the percentage of 82,1%. It is evident that the use of augmented reality with personalized learning is a viable option when it comes to affecting the learning outcomes.

Keywords: *Augmented Reality; STEM (Science, Mathematics, Engineering, Technology); One-Group Pretest-Posttest Design; Personalized Learning; Pre-Experimental Design*.

1. INTRODUCTION

Trends in educational fields currently promote the use of technologies in the learning process. However, it is worth noting that utilizing them does not necessarily mean replacing the role of teachers, lecturers, and interactions occurred between teachers and students. The primary reason behind the previous claim lies on the fact that learning is not only about acquiring knowledge, but also highlights cooperation and competence. Currently, it is a challenging task for anyone in the fields to utilize technologies as the primary focus is still on ensuring the transfer of lessons to students. Thus, the current curriculum dictates individual learning or self-directed learning to students.

The 2013 Curriculum directs the learning process that is focused on students' freedom of thoughts in understanding problems, constructing strategies to solve them, and offering ideas freely and openly. The role of teachers in this context is to

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train their students to think critically and creatively in problem-solving activities. It is worth noting that the 2013 curriculum has been administered in every education level, including in vocational high schools [1].

Vocational High Schools (locally known as *Sekolah Menengah Kejuruan* or SMK) are a type of formal education aimed at preparing their graduates with occupational skills. Nationally, the aims of vocational schools are to develop students' critical thinking skills, problem-solving skills, cooperation, communication, knowledge, and attitudes as corporate workers that enable them to compete both nationally and internationally. Additionally, vocational high schools as part of the nation's educational system are to produce competent workers with skills suitable for respective industries as well as to improve their potential in adopting and adapting to the advancement of learning, technology, and arts (*Regulation No. 34 of 2018 of the Ministry of Education, Culture, Research, and Technology*).

One way to foster students' potentials can be achieved through STEM (Science Technology, Engineering, and Math) learning. This particular learning integrates multiple disciplines used in real-life problem-solving activities. STEM also balances creativity, hard skills, and soft skills in the learning process. Undoubtedly, STEM has the ability to improve the learning process and students' motivations [2].

To achieve learning outcomes, a school requires its teachers to prepare many things, including learning media. Learning media used in the classroom must be prepared and designed by focusing on improving students' concentration and dealing with students' boredom. By doing so, it will then contribute to the improvement of students' understanding and retention ability.

Initial observations show that the learning process in a vocational high school in Bandung heavily relied on the use of PowerPoint and text books. Data gathered from observations and interviews show that students would be more engaged in the learning when using interactive learning media such as utilizing augmented-reality-based animations. This type of media incorporates audio, video, pictures, and 3D animations applicable in various learning to achieve the expected learning objectives. The use of such learning media is academically supported by Haghanikar's research, highlighting that augmented-reality-based media are interactive, improving students' motivations, and helping teachers or instructors in the learning process [3].

The effect of using certain learning media by taking into account learning models is certainly positive, especially when compared to one that does not do it such as Chen's research into implementing augmented-reality-based animation in the learning [4]. Similarly, Lucas' and Kanyan's research into augmented reality in STEM learning proves that it is beneficial in improving students' motivations and competence by taking into account engaging learning models [5].

Personalized learning rests on the idea that each student is unique in regard to his or her learning preference. This idea was inspired by Howard's notions concerning multiple intelligences [6]. Thus, it is not surprising that the learning covers students' individual motivations, needs, and competence, as well as identifying the most suitable learning preference for every student [7]. Personalized learning strategies are beneficial compared to its traditional counterpart that is in line with constructivism theories ([8], highlighting that the learning process must be active and knowledge is built upon one's personal experiences [9].

Based on the aforementioned introductory issues, this study aims at developing augmented reality to promote the learning outcomes of vocational high school students in the subject of light vehicle maintenance and repair, primarily in learning a light engine cooling system. This particular topic is regarded as relevant and required skills in automotive industries [10]. In this context, STEM (Science, Technology, Engineering, and Math) were applied to develop students' competence. Similarly, personalized learning was utilized in profiling students' attitudes and activities as the foundations and recommendations for better learning strategies for students.

2. MATERIAL AND METHOD

This study employed quantitative research design, specifically using experimental research design which is aimed at investigating the effect of a particular treatment. Among various types of quantitative research design, this research used One Group Pretest-Posttest design, conducted only in one class with predetermined criteria. The research design can be seen in Table 1.

TABLE 1.
One Group Pretest-Posttest Outline

Class	Pre-test	Treatment	Post-test
Experiment	O1	X	O2
Control	O1	Y	O2

Notes :

O1	=	Administering pretest at the beginning of the lesson
O2	=	Administering posttest at the end of the lesson
X	=	Argument-Driven Inquiry in the experimented class
Y	=	Without Argument-Driven Inquiry (Using inquiry-based learning)

Specifically, this study was conducted in an eleventh-grade class in a vocational high school consisting of 30 students in the experimental group and 25 students in the control group. Research sampling in this study was administered using purposive sampling.

Some classroom practices in learning engine cooling system in the light vehicle maintenance and repair subject for vocational schools using augmented reality in STEM learning with personalized learning can be seen in Figure 1.

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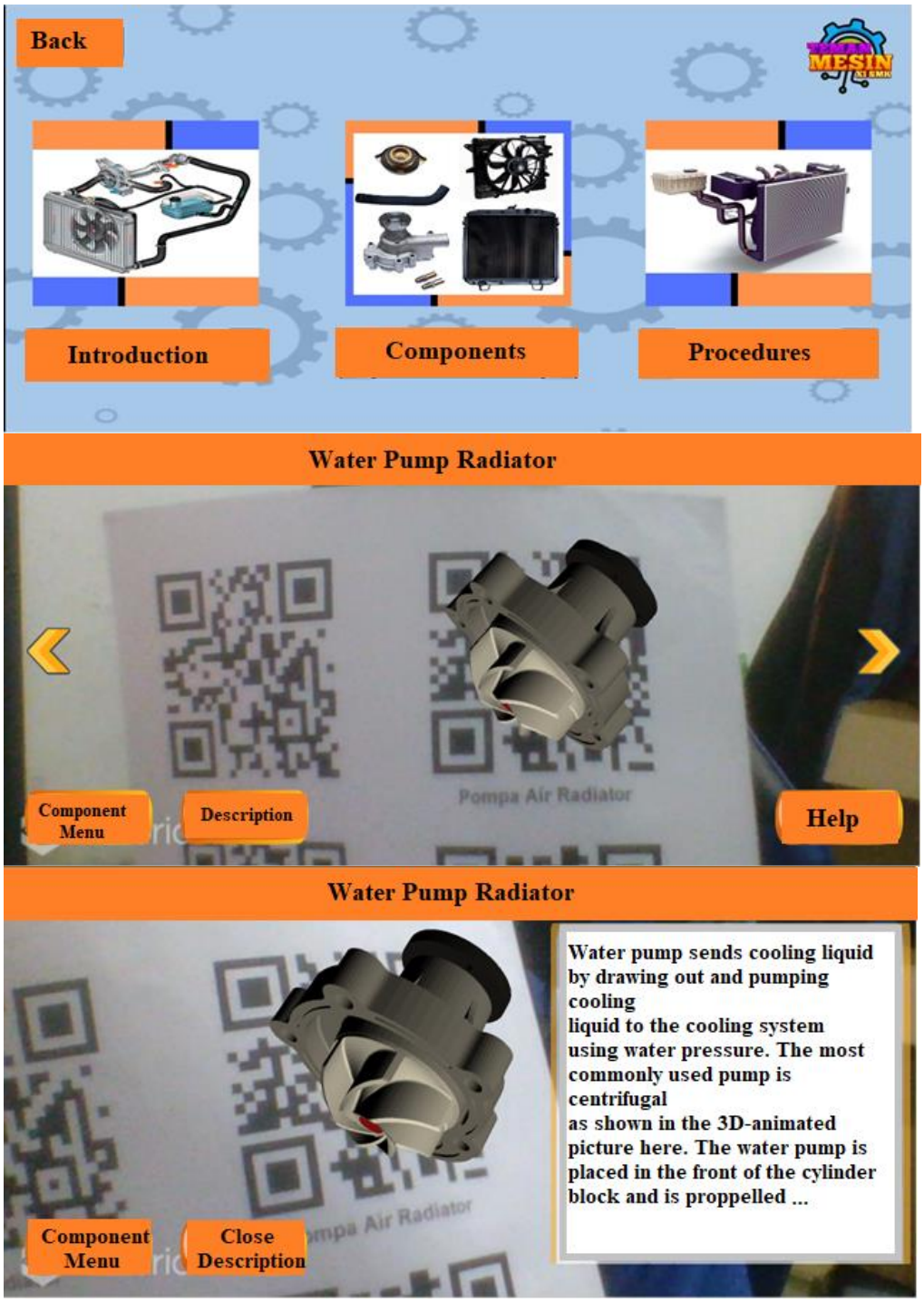

FIGURE 1. Learning activities using augmented reality in STEM using personalized learning

On-field research instruments were used by the researcher to determine the needs in carrying out the research and in developing augmented reality in STEM with personalized learning.

An instrument was used in this study to verify and validate the augmented reality media in STEM using personalized learning that had been developed, as well as the learning materials and test items of this study. Such an instrument refers to the

scoring rubric of Learning Object Review Instrument (LORI) [11] that can be seen in Table 2.

TABLE 2.
Learning Object Review Instrument (LORI) Indicators

No.	Assessment Criterion	Indicator
1	*Content Quality*	Materials' thoroughness, accuracy, arrangement, depths and details
2	*Learning Goal Alignment*	Alignments with learning objectives, alignments with learning activities, alignments with assessments, alignments with students' characteristics
3	*Feedback and Adaptation*	Adaptation and feedback can be carried out by students or different models of students
4	*Motivation*	Learning media can motivate students in understanding the lesson

The results from data analysis of this study are in the form of rating scale. In this context, students or respondents had to fill out one quantitative answer. The scale ranges from Strongly Agree, Agree, Moderately Agree, Disagree, to Strongly Disagree

The instrument used to determine students' responses in this study was adapted from Technology Acceptance Model (TAM) framework [12]. It covers several aspects: (1) perceived usefulness; (2) perceived ease of use; (3) attitude toward using; (4) actual use; (5) and behavioral intention. The questionnaire consisted of 10 items with the Strongly Disagree as the lowest scale. The greater the percentage highlights the more positive responses towards the personalized learning [13].

In analyzing students' responses, this research uses the same rating scale as in analyzing and validating the learning media. A simple equation in analyzing students' pretest, posttest and answers to the questionnaire can be seen below in equation (1).

$$Final\ Score\ = \frac{Score}{Max\ Score}\ x\ 100\% \tag{1}$$

The collected quantitative data were analyzed using SPSS and Ms. Excel.

3. RESULTS AND DISCUSSION

3.1. STUDENTS' RESPONSES ANALYSIS

At the end of the lesson, the researcher distributed a questionnaire sheet to students to obtain their responses or attitudes towards the use of augmented reality

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as the learning media. The instrument was adopted from Technology Acceptance Model (TAM) framework and the following are the results:

TABLE 3.
Students' responses towards the use of Augmented Reality using Technology Acceptance Model (TAM)

No.	Crierion	Ideal Score	Score	Percentage
1	Perceived Easy of Use	150	131.4	87.6%
2	Perceived Usefulness	150	132	88.0%
3	Attitude Toward Using	150	99.6	66.4%
4	Behavioral Intention To Use	150	129.6	86.4%
5	Actual Use	150	123.4	82.3%

Based on the table above, Perceived Ease of Use reached an average score of 131,4 with the percentage of 87,6%; it is considered as 'Excellent'. Perceived Usefulness had an average score of 132 with the percentage of 88% and is also considered as 'Excellent'. Attitude Toward Using only reached an average score of 99,6 with the percentage of 66,4% and is considered as 'Good'. Behavioral Intention to Use had an average score of 129,6 with the percentage of 86,4%, categorized in 'Excellent' range. Lastly, Actual Use reached an average score of 123,4 with the percentage of 82,3%, categorized in the same range as the previous criterion. The average across all criteria reached 123,2 with the percentage of 82,1% and is considered as 'Excellent' based on various research into augmented reality using Technology Acceptance Model (TAM) framework [14]. Figure 2 highlights the percentage of each criterion.

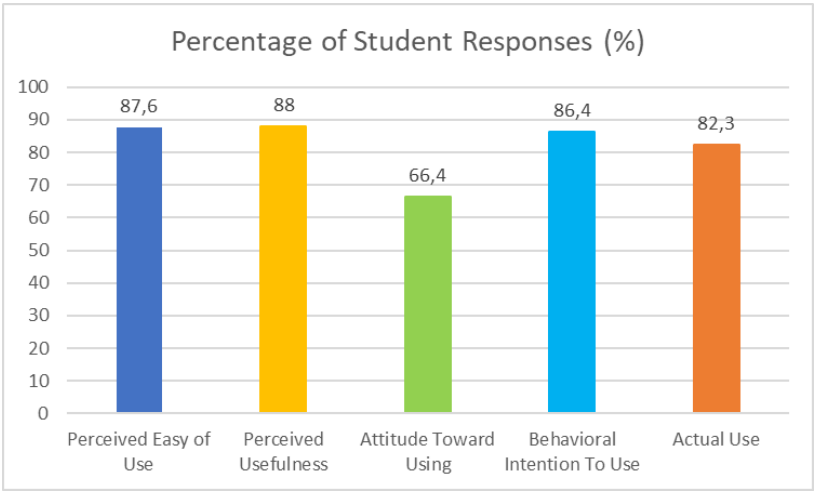

FIGURE 2. The comparison of students' responses towards Augmented Reality using Technology Acceptance Model (TAM)

After students' responses were analyzed using the rating scale and a conclusion was acquired with the aforementioned details, the next step covered investigation on the relationship or correlation between each component using the product moment correlation technique by Pearson. Observably, there are five components, namely:

Perceived Usefulness, Perceived Ease of Use, Attitude, Intention to Use, and Actual Use. The correlation results from students' responses can be seen in Figure 3.

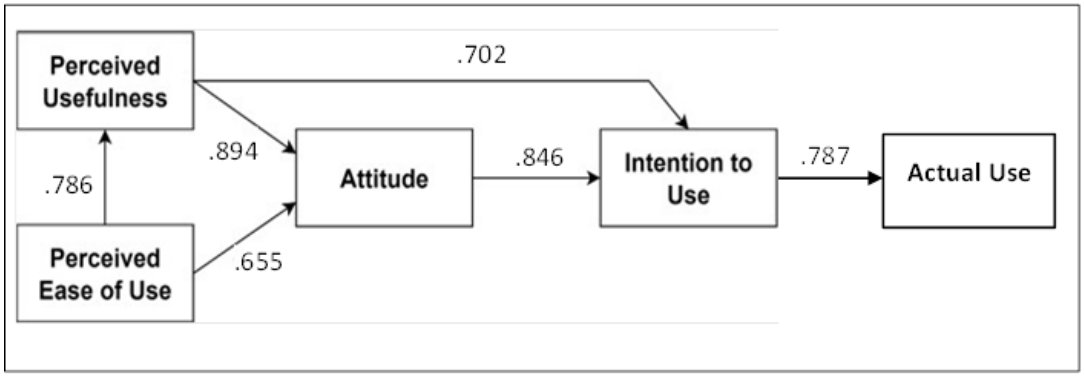

FIGURE 3. Correlation of Technology Acceptance Model (TAM)

Based on the data above, it is evident that there is a significantly positive relationship among all five aspects. Perceived Ease of Use affected Perceived Usefulness by 0,786 which then affected Attitude with the correlation coefficient of 0,894. Perceived Ease of Use also affected Attitude by 0,655. Additionally, Perceived Usefulness affected Intention to Use by 0,702. Attitude affected Intention to use by 0,846 which then affected Actual Use with the correlation coefficient of 0,787. Throughout all six aforementioned correlations, there is one correlation coefficient greater than r with significant level of 1%, that is 0,665. All six values approach 1 and are positive, meaning that all relationships among the components are strongly connected and converge [15].

3.2. ANALYSIS OF THE EFFECTS OF AR ON STEM LEARNING

After all data have been collected, namely pretest and posttest scores, the AR trials, and the questionnaire, we can see that Augmented Reality affected STEM learning in terms of improving students' performance in learning light engine cooling system.

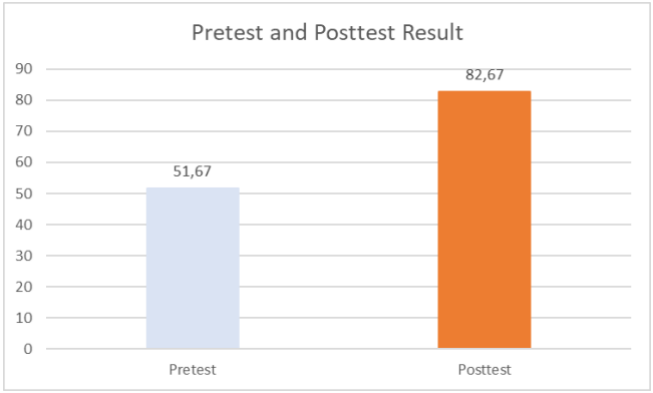

FIGURE 4. Pretest and posttest results

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Based on the figure 4, we can see an improvement in students' average scores that initially reached 51,67 and increased to 82,67. With an improvement of 31 points in the average score, students were deemed proficient in learning light engine cooling system using augmented reality in STEM learning [16].

Additionally, the augmented-reality-based application also improved students' motivations in learning as evident in the students' responses to the questionnaire. They were engaged by the application due to its attractive interface, making them motivated in learning the subject.

3.3. ANALYTICAL DATA OF STUDENTS' LEARNING PROCESS IN AR-BASED STEM USING PERSONALIZED LEARNING

Analytical data of students' learning process in AR-based STEM were gathered from the experimental group. Overall, analytical data show that most of the students had positive responses with the average score of 44,3 [17]. It can then be inferred that students in the experimental group were interested in using augmented reality in STEM learning, primarily in learning the light vehicle maintenance and repair subject at the vocational school level.

4. CONCLUSION

The utilization of augmented-reality-based application had an average percentage of 92,67%, which according to experts, it is regarded as 'excellent'. Similarly, the learning materials used in this study reached a percentage of 84%, making it fall into the same criterion. The implementation of AR-based application with one group pretest-posttest design can be seen from the gain score of students' pretest and posttest scores of 0,64, falling into the 'moderate' criterion. Overall, analytical data taken from the questionnaire show that most of the students in the experimented class had positive responses with a score of 44,3. This indicates that there was an improvement regarding students' understanding of the lesson using AR-based application.

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