Development of an integrated augmented reality experiment module on the topic of motion kinematics on student learning motivation

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Abstract. This study was designed to increase student learning motivation by developing a basic physics practicum module on the topic of integrated augmented reality kinematics. This study uses the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) development model. The subjects tested in this study were students of the physics education study program, at one of the universities in Lampung in academic year 2019/2020. The data collection instrument was in the form of a student learning motivation questionnaire. The data obtained were analyzed quantitatively. The results showed that the developed module was suitable for use in learning and practical activities and was also able to increase student learning motivation.

1. Introduction
It is difficult to imagine studying science including physics without carrying out laboratory experiments or fieldwork [1]. Practicum/experimental activities are important in learning physics. However, there are many challenges in implementing practical activities [2]. These challenges can include innovative science teaching, classroom and school connectivity, differences in expectations between teachers and students, and changing classroom management [3].

Kinematics is a basic concept in physics which forms the foundation for understanding physics concepts. Kinematics focuses on the motion of objects with the assumption that the environment has no effect on systems that affect motion [4]. Achievements in the topic of Kinematics so far have not progressed well. Therefore, the development of essential concepts on the topic of kinematics is considered important to be developed [5].

The use of mobile technology can also be an alternative solution to the problems of limited equipment and laboratory-based learning resources that have existed so far. The use of technology in practicum activities also has the potential to help students in their learning activities. In addition, as a measuring tool, mobile devices are capable of integrating the measurement sensor into an all-in-one which allows various measurements to be carried out. Applications containing mobile devices are intended to take measurements quite quickly and precisely [6]. Simple experiments with even more complex experiments can be performed with a mobile device (device) to determine fundamental
physical variables. Through sensors in the device, experiment-based learning becomes easier to do both in the classroom or at home and in recreational parks [7].

Motivation is an important part of producing good academic abilities for students [8]. However, the problem of motivation in learning physics has been experienced by students since they were at the high school level. The consequences of their difficulty in understanding physics at the high school level made physics even more difficult for them in college [9]. They do not like studying physics because of the complexity of the material, so they need an innovation so that physics learning is more accessible, understandable, and interesting [10].

There needs to be a learning innovation for students in experimental activities, especially on physics material. Along with the 4.0 industrial revolution, advances in science and technology indirectly encourage efforts to use the results of renewal technology in learning that can increase learning motivation. In recent years, with the development of technology, many technological products have occurred both in the laboratory and in the classroom to increase the effectiveness of physics teaching [11]. The use of technology in science learning including physics in it can facilitate the process of describing existing phenomena, and this is better than the traditional learning process [12]. The development of learning media is needed in the implementation of learning that can strengthen the concept of independent learning. This article presents an innovative experiment / practicum module in physics learning that is integrated with augmented reality. The choice of using Augmented Reality (AR) in strengthening the practicum module is inseparable from the ability of AR to make learning activities easier and also able to increase the intensity of teaching and learning activities [13] [14].

AR technology in laboratory-based activities is also proven to increase the motivation of students [15]. In addition, AR is also possible to combine virtual content with the real world well [16]. The hope is that physics learning will be more interesting and able to motivate students.

2. Method
This study uses the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) development model. The analysis was carried out by analyzing the conditions of experimental activities at the college level. The next stage is the design which begins with the preparation of assessment instruments, the selection of animations that will be converted into an augmented reality system, and other learning tools. The development stage is part of the module development which will be integrated with augmented reality-based animation, including the module feasibility assessment and the animations contained therein. The third stage is the implementation of the use of modules that have been integrated with AR in learning activities and assessing the effectiveness of using modules integrated with AR on student learning motivation. The final stage of developing this module is evaluation. At this stage, an evaluation of the deficiencies of the existing modules is carried out. The research was conducted at a tertiary institution in Lampung in the 2019/2020 school year. The research subjects consisted of 12 normal and homogeneous students.

The type of data produced in this study is quantitative data. Product feasibility analysis is seen from two things, namely product validity and feasibility. In this study, two important instruments were used, namely expert validation sheets (content and media experts) and student motivation questionnaires. The data on the validity and feasibility of the module and its tools were analyzed using descriptive statistical analysis techniques using formula as follows:

\[
\text{percentage} = \frac{\Sigma x}{N} \times 100\%
\]

Notes: \(\Sigma x\) = number of scores obtained and \(N\) = maximum number

The guidelines used in decision making in the validation process and product implementation are presented in Table 1. The criteria for the success of the validity and feasibility test of the product if it reaches a minimum score of 75% with a minimum qualification is good.
Table 1. Validity Conversion Guidelines

| No | Interval %     | Category |
|----|----------------|----------|
| 1  | 90,00-100      | Excellent|
| 2  | 75,00-89,00    | Good     |
| 3  | 65,00-74,00    | Fair     |
| 4  | 55,00-64,00    | Less     |
| 5  | 0,00-54,00     | Worst    |

To determine the significance of the increase in student learning motivation, paired t test is used. The paired t-test uses SPSS version 26 software. Before the paired t test is carried out, there must be a prerequisite that is met, namely the normality test [17]. Normality testing uses the Kolmogorov-Smirnov.

3. Results And Discussions

3.1. Results

The feasibility of the practicum/experiment module consists of two components, namely the feasibility of the material and the design of the instructions/practicum module and the feasibility of the AR-based animation in the practicum module. The results of the feasibility assessment of the context and the experimental module design resulted in the mean value of each component of the rater was 84.4. Thus, the module can be categorized as feasible as shown in Figure 1. The assessment indicators consist of 5 components, namely cover, illustration, format, content, and language. These indicators are part of the feasibility section for the module in terms of design and content.

Furthermore, if it is viewed from the point of view of the feasibility of the animation integrated into the practicum module, it produces a mean value of 87.4. Thus, the module can be categorized as feasible as shown in Figure 2. The assessment indicators consist of 4 components, namely Usability, Ease of Use, Positive Attitude, and Follow-Up.
The results of the module development were then tested on students as research subjects to determine their motivation after using the developed modules. Before the trial was carried out, the prerequisite test was first carried out on the trial subject. The results of the normality test, as a prerequisite test, are known as shown in Table 2, the significance value (p) of the Kolmogorov-Smirnov test is 0.2 (p > 0.05), so based on the Kolmogorov-Smirnov normality test the data is normally distributed. The significance value (p) in the Shapiro-Wilk test was 0.616 (p > 0.05), so based on the Shapiro-Wilk normality test the data were normally distributed.

Table 2. Tests of Normality

| Test                | Kolmogorov-Smirnov<sup>a</sup> | Shapiro-Wilk |
|---------------------|-------------------------------|--------------|
| Statistic           | Statistic                     |              |
| df                  | df                            |              |
| Sig.                | Sig                            |              |
| tes1                | .140                          | .949         |
| df                  | 12                            | 12           |
| Sig.                | .200                          | .616         |

Table 3. Paired Samples Test

| Paired Differences | Mean     | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | 95% Confidence Interval of the Difference | t     | df | Sig. (2-tailed) |
|--------------------|----------|----------------|-----------------|------------------------------------------|------------------------------------------|-------|-----|----------------|
| tes1 - tes2        | 3.83333  | 3.45972        | .99874          | 1.63513                                  | 6.03154                                  | 3.838 | 11  | .003           |

After the prerequisite test, a hypothesis test is carried out on the test subject. The results of hypothesis testing as shown in table 3 produce a significance value (2-tailed) of using the integrated AR module on student learning motivation is 0.000 (p < 0.05). So that the results of the initial test and final test experience significant changes (meaning). Based on the descriptive statistics, the pre-test and post-test proved that the final test was higher. It can be concluded that the use of the integrated AR module can increase student learning motivation.
3.2. Discussions

In an effort to increase motivation and also support practicum activities, practicum modules can be integrated with the use of mobile devices. In this research, the practicum module is integrated with animation based on augmented reality. The expert test results stated that the developed module was in the usable category both in terms of module content and the animation contained therein. The results of using a practicum module that is integrated with augmented reality results in an increase in motivation to learn physics. This is in line with the results of the study which states that students who carry out experimental activities integrated with cell phones and computers experience an increase in learning motivation [18] [19] [20] [21] [22]. Increased motivation also indirectly reinforces Akçayır's (2016) opinion that the use of AR can help them build positive attitudes towards physics laboratories [23]. Indicators of learning motivation used in this study are self-efficacy, active in learning activities, learning values for physics, target achievement. When viewed from each aspect / indicator of motivation in the study, this study also shows similar results that the use of AR can increase self-efficacy [24] [25]. In addition, the integration of AR in physics laboratory activities also increases the active attitude of students in the learning process [26]. Aspects of increasing values and understanding of concepts in learning physics have also increased and improved targets in learning physics.

However, the use of modules also has weaknesses, including that some interfaces cannot play the AR applications provided. The reason is, the device used does not meet the minimum specifications, namely 4 GB RAM, 16 MP camera, Android 5.0 Operating System, and 1.8 GHz Dual-core Processor. This is also in accordance with the research of Chen et al. (2012) who experience problems using AR in learning activities because the use of AR requires special devices that are in accordance with the prerequisites required by AR [27]. This weakness causes not all students to be able to access and use this AR integrated module. this is because there are still many students who have smartphones with the Android platform that do not match the minimum specifications required.

4. Conclusion

The results of module development that are integrated with augmented reality according to expert judgment fall into the usable category both in terms of the Feasibility of the Practicum Instruction Module and the Eligibility of AR Animation. When viewed from its effect on the learning process, the use of a practicum module integrated with augmented reality can increase student learning motivation in learning physics by reviewing the aspects of motivation consisting of self-efficacy, active in learning activities, learning values for physics, target achievement. Apart from the advantages of using the integrated augmented reality module, there are also disadvantages in using this module. some students find it difficult to activate the application provided. This is because the software specifications used by students do not comply with the minimum criteria required.

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