



Project 2-D Motion Simulation Based on Matlab Graphical User Interface in Physics Learning

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Abstract

Learning physics requires students to master the basic concepts of physics. Not infrequently, the physics concept is abstract, so it isn't easy to be perceived by students. However, abstract concepts in physics learning can be overcome by visualizing physics concepts packaged in computer software-based application programs in the form of computer simulations. This study aims to develop a 2-D motion simulation program based on the Matlab GUI. This study uses the Research & Development method. The development of this application program is carried out through 4 stages called 4-D: Define, Design, Develop, and Dissemination. The subjects in this study were 20 students of class XI MAS Nurul Jannah Ampenan. From the results of the study, it can be concluded that the quality of the product that has been developed is very feasible, with a percentage of 89,09% based on the assessment of material experts, 93,33% by media experts in the appropriate category, the response of students in class XI MAS Nurul Jannah Ampenan on the motion simulation application program 2-D-based GUI Matlab with a percentage of 88,20% with an excellent category, and an increase in understanding of physics concepts on the subject of 2-D motion; projectile motion after students use the 2-D motion simulation application program is in the medium category, seen from the class average gain value of 0.62. Therefore, the application program that has been developed has met the eligibility criteria and can be used in physics learning.

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1. Introduction

Learning physics requires students to master the basic concepts of physics that can help students in solving physics problems. One of the basic concepts of physics is the concept of the motion of objects. Mechanics is one of the fields of physics that discusses the basic concepts of the motion of objects. One of the branches of mechanics is kinematics. Kinematics is a branch of mechanics that deals with the basic concepts of motion of objects without considering the causes. Based on the direction of motion of objects in space and the shape of the path of the object's motion, kinematics has a scope of discussion for the motion of objects in two-dimensional (2-D) space such as (1) Projectile Motion, (2) Circular

Motion, (3) Elliptical Motion and (4) Hyperbolic Motion [1]. In the study of 2-D motion, such as Projectile Motion, many mathematical formulas, and abstract concepts are difficult for students to perceive with their senses. Abstract concepts in physics learning require lecturers and teachers to present physics concepts to be more concrete, as well as 2-D motion material, especially projectile motion, so that understanding of the material will be more meaningful.

Simulation is an attempt to overcome the abstraction of physics problems. Physics learning will be effective if it is not only presented in the form of theory but is also accompanied by simulations related to the topic being taught. Interactive physics simulations have proven to be very useful in learning physics because they can visualize pictures of physical phenomena in the classroom [2]. Interactive physics simulations can be packaged in the form of computer software-based application programs by applying computer simulations to help students understand physics concepts [3]. Simulations made on a computer are a learning medium that teachers can use to visualize physics phenomena that previously could not be done because of the limited laboratory equipment available at school, the cost required to experiment is quite expensive, or because the experiment is dangerous to do [4].

One computer software that can be used in making physics simulations is Matlab. By utilizing the Graphical User Interface in Matlab, it can be used to perform simulations and application development [5], [6], [7]. The choice of Matlab as the basis is because Matlab has development facilities in the form of a GUI (Graphic User Interface) so that it can facilitate planning and media creation, especially in the form of simulation interactions [8]. On the other hand, [9] said that MATLAB is a programming language with high capabilities in the field of computing, not only having computational capabilities but also good visualization skills. Therefore, MATLAB can integrate computing, visualization, and programming [9]. Several previous studies have developed many computer simulation application programs, especially projectile motion simulations based on MATLAB GUI [10], [11], [12], [13]. Still, none of the results of these developments have been implemented to determine students' responses and understanding of concepts, for that research was carried out to solve the problem.

Based on the description above, research was carried out to develop a 2-D motion simulation application program based on the Matlab GUI (Graphical User Interface) to find out how the quality and response of students to the application program developed and to increase students' understanding of physics concepts on the subject. 2-D motion; projectile motion.

2. Methods

The method used in this research is the research and development method or R & D (Research and Development). Research and development is a process or steps to develop a new product or improve an existing product, which can be accounted for [14]. The development of this 2-D motion simulation application program refers to the 4D development [15] model, which consists of 4 stages: Define, Design, Develop, and Disseminate. A detailed description of the stages of developing the 4D model used in this study are as follows (Figure 1): The Define stage includes (1) analysis of physics material, (2) analysis of student achievement indicators, and (3) task/evaluation analysis; Design phase includes (1) selection of format (design form), (2) selection of application program (application program limitation) and (3) initial design.

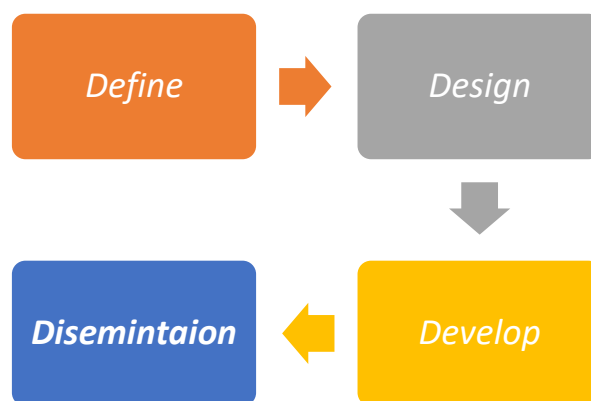


Figure 1. Stages of 4D Model Development

The learning media simulation 2D produced at this stage is then called Prototype 1; the develop stage includes (1) validation of the application program with two validators according to their respective fields, namely learning media experts and physics material experts; the application program produced at this stage is then called Prototype 2, (2) product trials, where trials are limited to the fieldwork was carried out on 20 students of class XI MAS Nurul Jannah Ampenan, the application program produced at this stage was called Prototype 3, lastly (3) data analysis at each stage of development to find out the weaknesses or shortcomings of the application program that is being developed so that the final form is produced. In an application program called Prototype 4, the Dissemination stage in this study was not carried out; this was because the implementation of the research was only on limited trials.

The instrument used to obtain data in this research is to use a questionnaire. From each item in the questionnaire, the test subjects gave an assessment. The assessment is done simply by given a tick () in the space provided. The range of values for media experts, material experts, and audiences (students) ranges from 1-5. After the scores have been collected from each aspect of the questionnaire given to the test subjects, the percentage calculation is then carried out using the following equation 1.

$$P_k = \frac{S}{N} \times 100\% \quad (1)$$

information: P_k : component percentage, S : total score of research results components, and N = maximum score [16]. Calculating the percentage of components according to equation (1) is then converted based on the assessment criteria in Table 1.

Before and after the learning process a concept understanding test was conducted to determine the extent of students' understanding of physics concepts on the material in the development of a 2-D motion simulation application program. Pre-test and post-test were carried out using tests, for each trial stage an evaluation was held to determine the increased understanding of the concept after participating in the activity. Normalized gain is by measuring the improvement in student scores before and after participating in learning activities with the Hake normalized gain equation 2.

$$\langle g \rangle = \frac{\langle Sf \rangle - \langle Si \rangle}{100 - \langle Si \rangle} \quad (2)$$

Table 1. Percentage Range and Assessment Criteria

Interval	Criteria
$81\% \leq \text{skor} \leq 100\%$	Very Worthy
$61\% \leq \text{skor} < 80\%$	Worthy
$41\% \leq \text{skor} < 60\%$	Quite Decent
$21\% \leq \text{skor} < 40\%$	Not Worth It
$0\% \leq \text{skor} < 20\%$	Very Unworthy

information : $\langle g \rangle$ = gain; S_f = final grade average (post-test score); S_i = the average value of the first class (pretest value). The 100 in the formula is the maximum value of the pre-or post-test. After obtaining each student's gain value, they are classified based on the gain value to determine the quality of increasing concept understanding according to Table 2 [17].

Table 2. Interpretation of Normalized Gain

Normalized Gain Value $\langle g \rangle$	Interpretation
$\langle g \rangle \geq 0,7$	High
$0,7 > \langle g \rangle \geq 0,3$	Medium
$\langle g \rangle < 0,3$	Low

3. Results and Discussion

The final result of this development research is the creation of a 2-D motion simulation application project based on Matlab GUI, which is packaged in the form of an executable (*.exe) file extension so that it allows the program to be used on various computer specifications without installing the Matlab software used to create application programs. From validation activities and products to trials carried out on applications that have been developed, there are several inputs from the validators and respondents. The revision results resulted in a MATLAB GUI-based project application to visually display projectile motion simulations, so the research team named this application "PROMOTION (Projectile Motion Simulation)". The resulting application program (in Indonesian) contains six main views consisting of : Depan, Bantuan, Materi, Simulasi, Profil, and Keluar. The menus and sub-menus of the developed application programs can be seen in Table 3 and Figure 2.

Table 3. Outline of The Developed Application Program

Menu	Submenu
Depan	-
Bantuan	Peta Konsep, Kompetensi Inti dan Kompetensi Dasar, Tujuan Pembelajaran
Materi	Materi 1 – Materi 10
Simulasi	Simulasi 1 , Simulasi 2
Profil	-
Keluar	-



Figure 2. Front of View 2D Simulation

The 2D Simulation program developed has undergone a feasibility assessment stage by material experts, media experts, and audiences (students) to know the quality and response to the application program and obtain constructive suggestions and input so that the application program developed is better. The following presentation of the feasibility assessment according to material experts and media experts is shown in Figure 3.

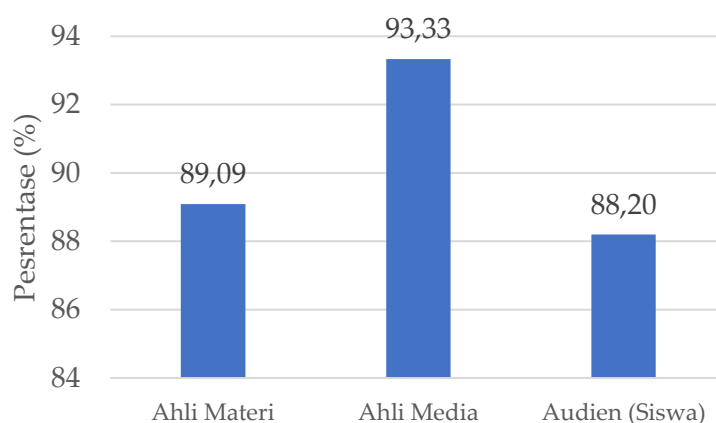


Figure 3. Percentage of Feasibility Assessment Results

The material expert's assessment results showed that the percentage of components was 89.09%. Thus, the application program developed is included in the "Very Eligible" category according to material experts. Meanwhile, the media expert's assessment results showed that the percentage of components was 93.33%. Thus, according to media experts, the application program developed is included in the "Eligible" category. A limited trial was conducted to find out the audience (students) response to the application program that has been developed. The little test was born on 20 students of class XI MAS Nurul Jannah Ampenan. Student responses to the 2-D motion simulation application program based on the questionnaire results obtained an overall percentage in the limited trial of 88.20% in terms of content quality, media display, and technical quality, so it was included in the Very Eligible category.

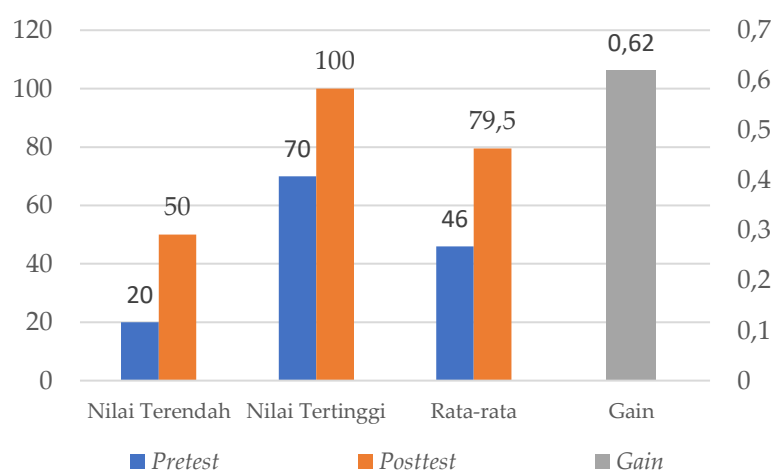


Figure 4. Improvement Students Physics Concept

Apart from questionnaires, data were also obtained from interviews with students and tests used to measure the improvement in understanding of physics concepts (Figure 4). The tests were given in the form of pre-test and post-test. Based on interviews with students, several notes were obtained, including a) Students enjoy using simulations; b) the 2-D motion simulation application program is something new for students; and c) the developed 2-D motion simulation application program is exciting and can be used for learning physics.

Based on the pre-test and post-test, it was found that there was an increase in students' understanding. This can be seen from the gain obtained. In more detail, the results of the pre-test and post-test, as well as the gain value, can be seen in Figure 4. Based on the pre-test and post-test results, the gain or increase in students' understanding of 2-D projectile motion can be determined. The average value of the pre-test is 46, and the average value of the post-test is 79.5. With Hake's normalized gain equation, the gain value is 0.62. Based on these results, there is an increase in the level of student understanding which is indicated by the gain value. This means that the 2-D motion simulation application program that has been developed is in the Medium category. This finding is supported by the findings of [18] which state that simulations and animations provide learning assistance to each student to understand the concepts and physics phenomena being studied. Other findings by [19], [20] show that Phet simulation can help overcome students' misconceptions and present physics concepts more realistically and improving student problem solving ability.

4. Conclusion

Based on the description of the results of the research and discussion, it can be seen that the level of feasibility of the learning media developed is 89.09% according to material experts, the percentage is 93.33% according to media experts, and the ratio is 88.20% according to students, as for the increase in understanding of physics concepts in the subject matter. 2-D motion discussion; projectile motion after students use the 2-D motion simulation application program is moderate, as seen from the class average gain value of 0.62. So it can be concluded that the application program that has been developed has met the proper criteria and can be used in physics learning.

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