Helping senior high school student to learn momentum and impulse by developing a learning material using the scratch programming language

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Abstract.
A software consists of an animation and a simulation of physics phenomenon which shown the linear momentum in the daily life experience has been developed. The software is developed for helping the student in the senior high school to learn a linear momentum. The software is developed using the Scratch (*https://scratch.mit.edu*) which is an open source software developed by MIT Media Lab. The ADDIE (Analysis, Design, Development, Implementation and Evaluation) model is used as a framework to developed the software. As a learning material, the software is validated by a competent people such as the researcher on educational physics and the high school teacher who teach physics. The mean score from the validator is approximately 8.6 from 10 for the software. Which mean the software is appropriate as a learning material for helping students to learn a linear momentum. The software was implemented for teaching the student at Bani Saleh high school Bekasi Indonesia. After pre-test and post-test resulted in the normalized gain value, G, approximately 0.53 which shows the performance of the software was help for increasing a comprehensive understanding in a student.

1. Introduction

Nowadays, the advancement in computer technology gives a powerful influence on the education. This advancement gives promises for significant and desirable changes in education and also gives new problem which is caused by the changing of the way of student learn [1]. By using a computer technology, a teacher can develop an appropriate learning material or use which already made to helping a student learn a new subject, for examples, the android application for learning a gas ideal subject [2], using PhET Simulation to enhance learning [3], or using a computer program to shows a superimposed image for learning stereopsis[4]. Furthermore, an appropriate learning material can give positive value to the comprehensive understanding in a student [5-6]. However, the lack of knowledge in computer programming usually became a teacher problem to develop a learning material with basis a computer technology. The scratch programming language can assist this problem. Because scratch is a visual programming environment that lets users learn to create interactive media-rich projects without must knowing a programming language such us visual basic or C++ and very user-friendly [7]. We developed software consists an animation and a simulation of physics phenomenon which shown the linear momentum in the daily life experience using the scratch programming language and implemented it for teaching physics in a senior high school.

In this paper, the result of the implementation of the software and how it is developed are reported in detail.

2. Literature Review

2.1.ADDIE model

ADDIE model is a framework consist a list of generic processes which guide the instructional designers or training developers to develop an instructional design or a learning material. Analyze, Design, Develop, Implement, and Evaluate (ADDIE) describes a process applied to instructional design or a learning material in order to generate episodes of intentional learning [8]. The ADDIE framework is a cyclical process that evolves over time and continues throughout the instructional planning and implementation process (Fig.1).

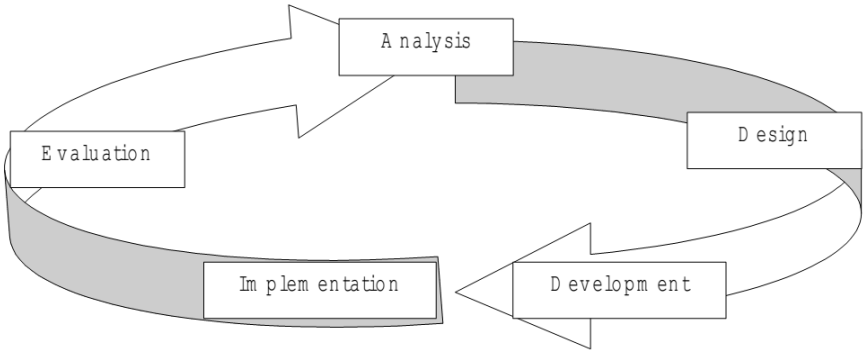

Figure 1. The ADDIE framework. Ref. [9]

Creating products using an ADDIE process can generate most effective products as example its proven by the second life (SL) (*http://www.secondlife.com*), a 3D multi-user virtual environment (MUVE) that enriched learning experience the educator and students [10].

2.2.Scratch

Scratch was created by the Lifelong Kindergarten Group at the MIT Media Laboratory in collaboration with Yasmin Kaifai's group at UCLA. Scratch is a visual block-based programming language designed to facilitate media manipulation for novice programmers. Fig. 2 shows the scratch user interface that develop by the authors.

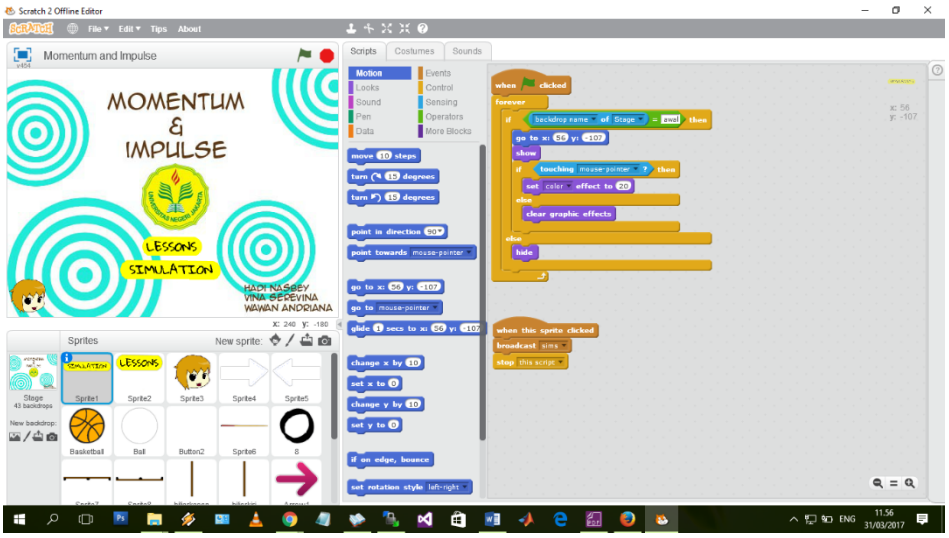

Figure 2. The scratch user interface

A scratch project consist of a fixed *stage* (background) and a number of moveable *sprites*. Each object contains its own set of images, sounds, variables, and scripts. This organization enables easy export and exchange of sprites. Programming is done by dragging command block from a palette into the scripting pane and assembling them, like puzzle pieces, to create "stacks" of blocks. Scratch has a number of control structures, including conditionals (*if, if-else*), loops (*repeat, forever, repeat-until*), and event triggers (*when-cliked, when-key-pressed*) [11].

3. Methodology

A learning material is developed using research and development method (R & D) with ADDIE (Analysis, Design, Development, Implementation and Evaluation) model as a framework to develop the software.

Five processes are conducted according to the ADDIE model which describes with following phases;

1. Analysis phase: in this phase, the problems that exist in the learning process is identified. The questionnaire is given to students to gathering information about a learning material that student needs, a subject that become a constraint in learning process of physics, and a possible solution that can cope the problems.
2. Design phase: in this phase, the planning is constructed to cope with the problems. The scratch programming language is chosen as the software to develop a learning material. A learning material is designed according the result of analysis phase.
3. Development phase: in this phase, the software of a learning material is developed. During this phase, the software is validated by a competent people such as the researcher on educational physics and the high school teacher which teach physics.
4. Implementation phase: in this phase, the software is implemented by using it on the learning process. The students at Bani Saleh high school Bekasi Indonesia is chosen as the subject of implementation. The implementation phase took six-session time, each time consist 45 minute.
   The software is used in the learning process in the classroom. The physics phenomenon which shown the linear momentum in the daily life experience is shown through an animation and a simulation in the software.
5. Evaluation phase: in this phase, the pre-test and the post-test are conducted by the student. The pre-test and the post-test consist the question about subject momentum in physics. The normalized gain, **G**, is used to analyzed the performance of the learning material [12].
   The normalized gain, **G**, is calculated using following equation;

$$G = \frac{postscore\ \%-prescore\ \%}{100-prescore\ \%} \qquad (1)$$

   The interpretation of the normalized gain value is classified to three groups.
   (1) $G \geq 0{,}7$ is very good performance, (2) $0{,}7 > G \geq 0{,}3$ is good performance, (3) $G < 0{,}3$ is bad performance.

4. Results

4.1.Analysis phase

20 students of second grade at Bani Saleh high school Bekasi Indonesia is given a questionnaire consist a question about a learning material that student needs, a subject that become a constraint in learning process of physics, and a possible solution that can cope the problems.

The information about a learning material consist a visualization a subject which being learn was needed by student, the most difficult subject in physics lesson to visualized by the student is

momentum subject, and the student don't interests the lesson because the physics lesson was taught monotony, are obtained based on the questionnaire. The scratch programming language is chosen as the software to developing a learning material.

4.2.Design phase.

The storyboard of the learning material is made which consist of the detail information of the content of a learning material. The collision of a billiard ball and the bouncing of a basketball are chosen as the simulation of physics phenomenon which shown the linear momentum in the daily life experience.

4.3.Development phase.

The learning material has the two main features that are a lessons feature and a simulation feature. The lesson feature consist a learning material of momentum subject. In the lesson feature, the information about the momentum subject shows in detail including an animation of linier momentum phenomenon (Fig. 3). The simulation feature consist a simulation of the collision of billiard ball and the bouncing of basketball that can show the linear momentum phenomenon. In the simulation of the collision of billiard ball, students can modify a quantity of the force that will hit the ball then the software will calculate the velocity, impulse and time collision of the ball. In the simulation of the bouncing of basketball, students can modify quantities of elastic coefficient of bouncing and a high of the ball will drop then the software will calculate the high of the bouncing of the ball (Fig.4).

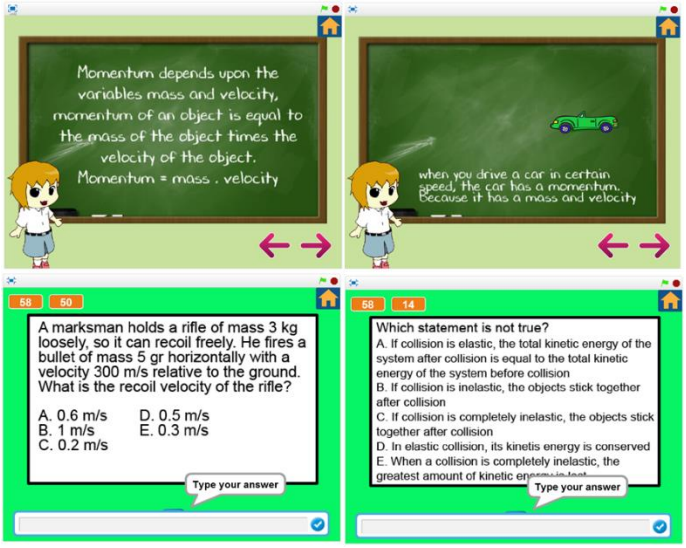

Figure 3. The scratch user interface

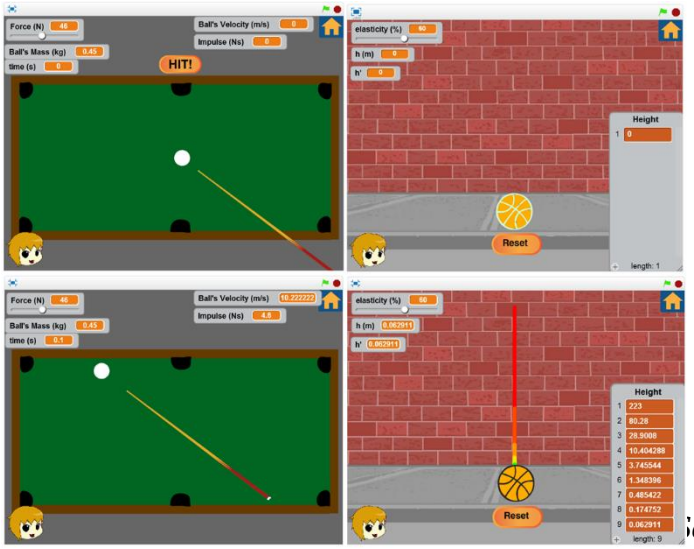

Figure 4. The scratch user interface

As a learning material, the software is validated by a competent people such as the researcher on educational physics and the high school teacher which teach physics. The mean score from the validator approximately 8.6 from 10 for the software. Which mean the software is appropriate as a learning material for helping students to learn a linear momentum.

4.4.Implementation phase

The learning material is implemented in teaching process at Bani Saleh high school Bekasi Indonesia.
The implementation phase took six-session time, each time consist of 45 minute duration.
The student also can copy the software and install it at their own PC.

4.5.Evaluation phase

The normalized gain, **G**, is used to analyzed the performance of the learning material.
The pre-test and post-test are given to student.
The tests consist of the questions about momentum subject that student being learn.
After pre-test and post-test resulted in the normalized gain value, G, approximately 0.53 which shown the performance of the software was good to increasing a comprehensive understanding in a student.

5. Conclusion

A software consists an animation and a simulation of physics phenomenon which shown the linear momentum in the daily life experience has been developed. The final product is appropriate as a learning material for helping students to learn a linear momentum. The performance of the software was good to increasing a comprehensive understanding in a student when it used in the teaching and learning process.

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