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Development of Scratch Assisted E-Learning Teaching Materials on Wave Materials

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Abstract

This study aims to produce e-learning teaching materials that can be used to improve students' conceptual understanding. Teaching materials were made using scratch, which are integrated into web with the subject of physics subject waves for class XI. The type of research was Research and Development. The teaching materials developed have been implemented on a small scale, which was class XI students at MA Uswatun Hasanah Semarang. Data collection was carried out by giving the teacher a feasibility sheet for teaching materials. Data on students' conceptual understanding abilities were obtained from the results of pretest and posttest on a small scale, namely students of class XI MA Uswatun Hasanah Semarang and by looking for student or teacher responses to the teaching materials developed. Based on the experts and teachers' assessment, the teaching materials developed were feasible. The implementation of teaching materials in physics learning on wave materials showed that the increase in students' conceptual understanding in the experimental class by using scratch-assisted e-learning teaching materials got a score of 0.52 (medium) better than the control class which used student worksheets to get a score of 0,34 (medium). In addition, students and teachers responded well to the developed teaching materials.

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INTRODUCTION

The 21[st] century brings a popular change, which is the rapid development of Science and Technology resulting in a change in the learning paradigm indicated by changes in curriculum, media, and technology. Curriculum changes can be in the form of changes in objectives in accordance with the demands of scientific developments, community developments and the times (Siregar & Nara, 2014). Information and Communication Technology (ICT) based learning cannot be separated from the demands of 21st century learning. One of the demands of 21st century learning is the integration of technology as a medium of learning to develop learning skills. In the world of education, technology has a strong influence and vice versa (Gardner, 1992). Tambade & Wagh (2011) staded that the use of computers learning using computers is more effective than using traditional learning. Computers as one of the technological developments can create a renewal in increasing creativity to problem-solving skills (Barr & Stephenson, 2011).

Science and technology are basic needs in improving the quality of human resources, while the quality of human resources is formed from the education they take. In addition, one of the advantages of information technology is that it can make multimedia more attractive, visual and interactive (Choi, 2013).

Teachers needed in the 21st century are teachers who are able to teach concepts in a student-centered manner and use an interactive approach in accordance with contemporary technology (Kapucu et al., 2014). In addition, the skills that must be prepared for students include collaboration skills, communication skills, creativity, critical thinking skills, skills in using information technology, problem-solving skills and self-regulation skills. Student skills are the result of school culture, where students have a subjective view of the ideal teaching model in a model that displays a teacher-led approach according to the times (Häkkinen et al., 2017; Mäkitalo-Siegl et al., 2011). Knowledge and skills must be followed by the formation of attitudes and behaviors that remain grounded in Indonesian culture. This is stated in Law No. 20 of the National Education System of 2003 that students actively develop their potential to have competencies rooted in religious values, Indonesian national culture, and are responsive to the demands of changing times (Charalambidis, 2014). However, the facts on the ground are teachers tend to deliver learning materials directly so that students become passive and less creative. The material is still packaged in the form of student worksheets amid the demands of the 2013 curriculum to be skilled in using technology. In addition, based on the observation of the need identification questionnaire given to the physics teacher, it was found that the teaching materials used were only books and worksheets. A number of studies on physics learning, especially on wave material, it was found that there are still many students who have misconceptions, including the understanding that the speed of mechanical waves is influenced by the shape of the pulse, frequency, and wavelength regardless of the propagation medium. (Barniol & Zavala, 2016; Kogetsu & Taniguchi, 2014). Problems in physical understanding of mathematical equations are also still found, including students who have difficulty to understand the meaning of positive and negative signs in the wave equation, differences in the trigonometric forms used (sin or cos), and so on (Kennedy & De Bruyn, 2011).

Students need to be actively involved in learning activity so that they have the opportunity to develop creative thinking skills (Hardyanto & Milah, 2018). Familiarizing students to be involved in the learning process conceptually and mathematically will be better at understanding the physical meaning of concepts, so that skills are considered to be part of generic science skills and 21st century skills (Lahra et al., 2017). Therefore, active learning is a positive alternative so that students are able to build knowledge on their own and properly with the assistance of instructor guidance and feedback from other students (Buitrago et al., 2017). In addition, to see students' creativity, teaching methods are needed (Deta & Widha, 2013). Media-assisted learning is very helpful for students in mastering concepts and increasing student creativity.

Utilization of technology and information in the world of education can be used in Physics subjects, namely presenting microscopic study objects that cannot be reached by the five human senses. According to Sinaga et al (2014) in teaching physics concepts, the majority of high school physics teachers teach using text representation models and mathematical equations. In addition, there is a lack of media and teaching materials that support active and independent learning in accordance with student characteristics and student learning difficulties. This makes students feel that physics is a difficult subject, especially to understand the object of microscopic physics study so that it influence the learning outcomes. If physics concepts are taught very well with the help of software, then no one will call them abstract objects anymore (Aina, 2013). According to Adegoke (2011) multimedia can improve student learning outcomes.

To increase interest, much effort has been made to develop learning tools, activities and materials, both for younger children and for secondary schools and universities (Meerbaum-Salant et al., 2013). The development of the world of technology provides more and more applications that offer various conveniences for creating and designing a modeling or simulation. The use of simulation in physics learning is very effective in simplifying concepts and increasing students' understanding of the material (Intana *et al.*, 2018). One of them is Scratch, a program developed by the Massachusetts Institute of Technology (MIT). Scratch is one of the results of the development of computer programming-based technology in the form of simulation media (Ortiz-Colón & Romo, 2016). In addition, scratch can help complement teaching materials to support interaction (Gretter & Yadav, 2016). The Scratch application has the feature of making simulations according to the wishes of the maker with the principles of programming algorithms. This feature can be an active student learning facility by involving thinking processes, one of which is creative thinking. Hardyanto's research (2014) shows that studying various physical phenomena can be done using Scratch programming.

Scratch has advantages in terms of practicality to actively create simulations by the users themselves through an algorithmic method that is based on the box/puzzle principle (Maloney *et al.*, 2010). Scratch facilitates users to better understand the material through simulation creation activities compared to other simulation content that only provides ready-made simulations (Husna *et al.*, 2019). The implication of the advantages of scratch programming is that learning activities will require students to actively learn to build thinking skills. In addition, scratch can improve problem-solving skills and creative thinking skills (Lu, 2021).

The advantage of the scratch software is that it is freeware so that it does not burden the user or the makers of its derivative programs and can be embedded in an HTML file, which is the programming language used on the internet. Another advantage of scratch is the ability and compatibility on various operating system platforms such as Windows, Mac, and Linux. In addition, scratch is designed to develop creativity, the ability to think systematically and work in groups, which are basic skills that must be possessed in the 21st century.

Researchers consider the form of teaching materials. Teaching materials are systematically arranged in language that is easily understood by students according to their level of knowledge and age, can be accessed anytime and anywhere, and can help them to learn independently (independently) with minimal assistance or guidance from educators. Rusilowati et al (2020) stated that scratch-assisted teaching materials provide opportunities for students to develop material concepts into animation and involve students in every use of Scratch. This teaching material is integrated with the internet, which is expected to be able to facilitate learning to build mastery of concepts and increase students' creativity. This study chose teaching materials because the only teaching materials currently available in schools are textbooks and worksheets that have not been integrated, therefore it is necessary to develop teaching materials to encourage students to learn independently and creativity. The purpose of the study was to determine the level of feasibility, teacher and student responses and to determine the effect of e-learning teaching materials on students' understanding of concepts.

METHODS

Design used in this study was *Research and Development* (R&D) based on the design according to Sugiyono (2016) which covers: (1) identification of potential and problems, (2) collecting data, (3) product design, (4) design validation, (5) design revisions, (6) small-scale trials, (7) product revisions, (8) large-scale trials, (9) product revisions, (10) final products. The product developed is in the form of web teaching materials that can be accessed via the link http://sainsunnes.rf.gd/. The web has a menu button containing home, profile, material, animation and how to make animation, and questions.

The experimental design form was *True Experimental Design* with the type of *Pretest and Posttest Control Group Design*. In this experimental design, the experimental class and control class students were given a *pretest* (O_1) then the experimental class would be given the treatment, which was learning by using scratch-assisted e-learning teaching materials, while the control class was given using student worksheets teaching materials. Then, the experimental class and control class students were given a *posttest* (O_2) to determine the increase in understanding of the concept. The subjects of this study were media validators, material validators, physics teachers and students of XI MIPA MA Uswatun Hasanah. The aspect of assessing the feasibility of teaching materials refers to the assessment indicators by the National Education Standards Agency (2006), which are content feasibility, linguistic feasibility, presentation feasibility, and graphic feasibility.

RESULTS AND DISCUSSION

The results of making animation using Scratch are integrated into the web. Then in the web section there are menu button containing home, profile, material, animation guides, and practice questions. The design view of e-learning teaching materials is presented in Figure 1. The web developed using supporting software such as HTML, PHP and xampp. Web teaching materials can be accessed by students anytime and anywhere via the link http://sainsunnes.rf.gd/.

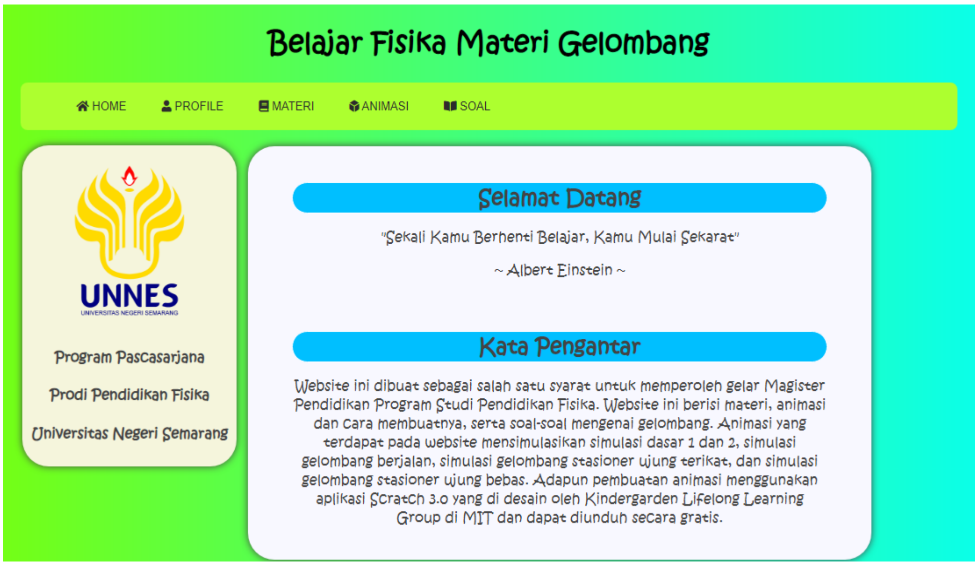

Figure 1. Teaching Material Design

After the teaching materials was ready, expert validation was carried out. The validation of teaching materials was carried out by media experts (2 lecturers) and material experts (2 physics lecturers). From the results of the media expert validator's assessment in Table 1, the value obtained for all aspects is 82.52 which is categorized as good criteria. This means that the product of e-learning teaching materials with the help of scratch was valid so that it was feasible for the next stage of research. Table 2 material expert validation results.

Table 1. Media expert validation results

No.	Aspects assessed	Number of Statements	Value
1.	Presentation	4	78.12
2.	General Appearance	7	83.93
3.	Language or legibility	3	79.17
4.	Use of scratch-assisted e-learning teaching materials	9	88 ,89
	Average rating		82,52

Table 2. Results of material expert validation

No.	Aspects assessed	Number of Statements of	Value
1.	Feasibility of content	20	72.66
2.	Feasibility of presentation	13	68.67
3.	Language	13	70.14
4.	Use of scratch	4	78.12
	Average rating		72 ,39

From the results of the material expert validator's assessment in Table 2, the value obtained for all aspects is 72.39 which is categorized as good criteria. This means that the product of e-learning teaching materials assisted by scratch was valid so that it was feasible for the next stage of research. Furthermore, the feasibility test was carried out by 3 teachers in the field of physics. The feasibility test was carried out to get input from the teacher regarding appropriate teaching materials for students. Feasibility assessment by looking at the eligibility criteria for teaching materials according to the National Education Standards Agency (2006) which has been developed by researchers. The results of the feasibility test are presented in Table 3.

Table 3. Product feasibility test results

No.	Aspects assessed	Number of Statements of	Value
1.	Feasibility of content	20	76.9
2.	Feasibility of presentation	13	83.77
3.	Feasibility of language	13	76.62
4.	Feasibility of Graphics	19	84.92
	Average rating		80.55

Assessment on the feasibility aspect of the content of teaching materials consists of four aspect indicators, namely the suitability of the material with the competency standards and basic compentencies, the accuracy of the material, supporting learning materials, and the up-to-date of the material. As presented in Table 3, the e-learning teaching materials contain the content of the material, getting a score of 76.9 with proper criteria. This will greatly assist students in mastering concepts and materials in accordance with the competencies that students must possess (Nurichah et al., 2012). Thus, the material presented in the teaching materials has supported the achievement of competency standards and basic competencies on the subject of waves and has been in accordance with the education level of students, which is SMA/MA.

The assessment on the feasibility aspect of presenting teaching materials consists of four aspect indicators, namely presentation technique, presentation support, learning presentation, and completeness of presentation. As presented in Table 3, e-learning teaching materials were arranged in a presentation and get a score of 83.77 with proper criteria. This is because e-learning teaching materials were presented with a coherent and consistent presentation organization in 3 main parts, namely the beginning, the content, and the end in accordance with the provisions of the Ministry of National Education (2008). These teaching materials were also arranged in a consistent systematic so that they can improve the thinking skills of students.

Assessment on the feasibility aspect of presenting teaching materials consists of six aspect indicators, namely straightforward, communicative, dialogical and interactive, conformity to the level of student development, coherence and integration of the flow of thought, and the use of terms, symbols or icons. As presented in Table 3, e-learning teaching materials in the linguistic aspect got a score of 76.62 with proper criteria. This is because e-learning teaching materials were presented in a language that is easy to understand and in accordance with the level of development of students, namely SMA/MA. In addition, the language used in this teaching material also follows the rules of Indonesian and good and clear terminology.

This is in line with the research of Nugraha et al (2013) which states that the use of language in teaching materials in accordance with the rules of the Indonesian language, the choice of words that are easy to understand, and the use of simple sentences will facilitate the delivery of the author's intent so that it will be easily understood by students. In addition, the information contained in these teaching materials has also been presented clearly to make it easier for students to understand these teaching materials as a whole (Rianatha & Sawitri, 2015). Effective, standard, and not too long sentences have also been included in these teaching materials to facilitate the delivery of material information in teaching materials to students (Rahmawati *et al*., 2016).

The assessment of the feasibility aspect of teaching graphic material consists of three aspect indicators, namely the presentation of teaching materials, the general appearance or design and the use of scratch. Researchers try to make graphic teaching materials that are interesting and easy for students to understand. As presented in table 3, teaching materials in the graphic aspect got a score of 84.92 with proper criteria. The display of e-learning teaching materials is simple and easy to use. Teaching materials have a menu button containing home, profiles, materials, animations, practice questions. When using e-learning teaching materials in class, students use computers to access e-learning teaching materials then the teacher and students together create wave animations with the help of scratch software, according to research conducted by Kalelioğlu & Gülbahar (2014) that students are more happy and interested in technology-based physics learning. For people who have never used Scratch, the main features of Scratch are very interesting (Nikou & Economides, 2014). In addition, if someone wants to make wave animations with Scratch software, the teaching materials have provided steps for making animations along with their descriptions.

The research subjects for the small-scale trial were MA Uswatun Hasanah students of class XI A (experimental class) which consisted of 21 students and 3 teachers. The results of the response scores to each aspect of teaching materials for small-scale trials on students are presented in Table 4. Small-scale showed the students obtained an average value of 82.44. The highest rating was obtained in the aspect of benefits, which is 85.71 with very good criteria. This shows that e-learning teaching materials could motivate and assist students in understanding learning materials and could train students' creative abilities. Scratch programming software allows most people to participate in a wide variety of creative projects (Peppler & Kafai, 2007). Scratch program projects can be made online. Users can access the project anywhere and anytime. In addition, the benefits of scratch in learning are as a means of delivering material or it can also be used as a game. Submission of material on scratch media uses animation (motion pictures). This causes students to be interested and students become easier to understand the description of a material. Meanwhile, the small-scale trials on teachers obtained a value of 82.14. This value is categorized as strongly agree, and product improvement was not so that the product could be used for the next stage. The results of the scores for each criterion are shown in more detail in Table 5.

Table 4. Student responses to small-scale teaching materials

No	Aspects assessed	Number of Statements	Value
1.	Display	6	83.33
2.	Presentation of material	13	78.29
3.	Benefits	6	85.71
	Average assessment		82.44

Table 5. Teacher's response to small-scale teaching materials

No.	Aspects assessed	Number of Statements of	Value
1.	Display	6	83.33
2.	Presentation of material	7	78.57
3.	Benefits	7	84.52
	The average assessment is		82.14

The teacher's highest assessment of teaching materials was obtained in the aspect of benefit, which is 84.52 with good criteria. This shows that these teaching materials make it easier for teachers to convey material to students, as well as streamlining teaching and learning activities in class and online learning. Suteja (2008) stated that the use of e-learning teaching materials provided e-moderating facilities, where teachers and students could communicate easily through these facilities whenever the communication activity was carried out without being limited by distance, place and time(Abadi, 2015). In addition, both teachers and students can conduct discussions via the internet which can be followed by many participants, thereby adding to knowledge and broader insight. In small-scale trials conducted by teachers and students, no significant obstacles were found regarding e-learning teaching materials, therefore e-learning teaching materials could be used subsequently on a large scale.

Furthermore, the N-Gain test was carried out to determine the increase in students' conceptual understanding abilities before and after being given or treatment in the experimental class and control class. The increase in students' conceptual understanding ability can be calculated from the results of the analysis of the pretest and posttest scores that have been carried out by students.

Table 6. Experimental and Control N-Gain Test Results

Class	Average Pretest Score	Average Posttest Score	Normalized Gain	Upgrade Category
Experiment	30	66.9	0.52	Medium
Control	30.23	55	0.34	Medium

Based on Table 6 the experimental class has a better understanding of concepts than the control class. The ability to understand concepts is an absolute requirement in achieving success in learning physics. Only by mastering the concept of physics, all physics problems can be solved, both physics problems that exist in everyday life and physics problems in the form of physics problems at school. This shows that physics lessons are not rote lessons but more demanding understanding of concepts and even application of concepts (Sugiharti, 2005). With a good conceptual understanding of the concepts and principles of physics, students' skills in solving physics problems will also be better. A formula in physics is basically a derivation of a concept. Solving physics questions without formulas at the junior high or high school level can be done and is even easier if students understand the concept better (Tampang et al., 2016). In the experimental class, it required students to discuss concepts and apply concepts by making wave animations using scratch software. Making animation using basic concepts and wave formulas. Students can develop the knowledge gained independently from teaching materials through the making of the wave animation, this is in accordance with the research conducted by O'Day (2007) that the animation developed can provide long-term memory for students, so that students do not easily forget of the concepts being taught. In the control class, students get the freedom to interact with each group member, exchanging information obtained from student worksheets or books. However, students in the control class did not take full advantage of the discussion to exchange information, ideas or opinions with other students. In addition, waves are abstract material so they need visualization. This has an impact on the understanding the concept of control class students.

CONCLUSION

Based on the results, it can be concluded that the scratch-assisted e-learning teaching materials got an average rating of 80.55 with categories suitable for use in learning. On average, teachers and students gave an assessment of 82.14 (good) and 82.44 (good) on the teaching materials developed. In addition, Improved understanding of students' concepts in the experimental class using e-learning teaching materials assisted by Scratch got a score of 0.52 (medium) better than the control class using student worksheets which scored 0.34 (medium).

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