Journal of Turkish Science Education, 2023, *20*(1), 189-210.
DOI no: 10.36681/tused.2023.011

Journal of Turkish Science Education
http://www.tused.org
© ISSN: 1304-6020

Scratch-Assisted Waves Teaching Materials: ICT Literacy and Students' Critical Thinking Skills

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ABSTRACT
The rapid development of technology requires education to provide learning that can improve students' critical thinking and ICT (information and communication technology) skills. One of the lessons that can be applied is ICT-based. The material is packed with state-of-the-art technology and computer programming. For this reason, a study was carried out which had the objectives of (1) developing Scratch-assisted Wave teaching materials, (2) testing their validity, (3) testing the practicality of using teaching materials, and (4) testing their effectiveness in improving students' ICT literacy and critical thinking skills. This research is an R&D that has 4D procedures, namely define, design, develop, and disseminate. The product trial used the pretest-posttest control group design. The research instruments consist of the gap test, ICT literacy test and critical thinking skills test. The data analysis technique used in the study are percentage and t-tests. The product in this research is in the form of ICT-based wave teaching materials. Programming applications in teaching materials are in the form of Scratch with a contextual learning approach, namely physical symptoms and phenomena that are closely related to life. The average percentage validity of teaching materials in terms of content is very decent category. The level of readability of teaching materials through gap tests and questionnaires is very easy-to-understand categories. The effectiveness of teaching materials is seen from the increase in ICT literacy and critical thinking skills of high school students who use Scratch-assisted Wave teaching materials are higher than those using ordinary teaching materials.

RESEARCH ARTICLE

ARTICLE INFORMATION
Received:
14.04.2022
Accepted:
08.11.2022

KEYWORDS:
ICT literacy, critical thinking, Scratch, waves.

To cite this article: Negoro, R.A., Rusilowati, A., & Aji, M.P. (2023). Scratch-Assisted Waves Teaching Materials: ICT literacy and students' critical thinking skills. *Journal of Turkish Science Education*, *20*(1), 189-210.

Introduction

Physics is a science that studies natural phenomena such as the basic characteristics and properties of matter, energy, and their interactions. Knowledge gained through learning physics is a form of concept (Aulia, 2018). A concept is a form of idea about an object or event that is used to understand the surrounding phenomena. Understanding the concept that is captured and understood by students is not always in accordance with the concept that has become a reference. This is one of the problems in learning physics which is commonly called a misconception (Jumini, 2017; Negoro, 2019; Sheftyawan, 2018; Thompson, 2006).

The problem of physics misconceptions is still an important subject. Several studies on teaching and learning physics, especially on wave material, show that there are still many students who have misconceptions about the speed of propagation of mechanical waves that are only influenced by the shape of the pulse, frequency and wavelength without considering the medium of propagation. (Barniol, 2016; Kogetsu, 2014;; Reyes, 2018). Problems in physical understanding of mathematical equations are also still found, including students having difficulty understanding the meaning of positive and negative signs in wave equations, using trigonometric forms (sin or cos), and so on. (Auli, 2018; Kennedy, 2011; Wheeler, 2017; Zaleha, 2017;). One solution to the current misconception problem is 21st-century learning by focusing on the formation of thinking skills that are relevant to the characteristics of students and current circumstances (Dewi, 2021; Oral & Erkilic, 2022; Rosdiana, 2019; Suana, 2019; Thohir, 2013).

Along with the problem of misconceptions about physics material, in the 21st-century, education is becoming increasingly important to ensure that students can learn and innovate, can use technology and information media, and can work, and survive using life skills. Three 21st-century education concepts have been adapted by the Ministry of Education and Culture of the Republic of Indonesia to develop the curriculum for Elementary School, Junior High School, Senior High School, and Vocational High School. The three concepts are 21st-century skills, scientific approach, and authentic learning (Details, 2016; Larson, 2011; Ormiston, 2010; Trilling, 2009; Wiggins, 2011).

Previous research has shown that high school, diploma and university graduates still lack competencies, including ICT literacy and critical thinking skills. (Kivunja, 2015; Lai, 2017; Mansour, 2017; Pinto, 2014a). Working in this knowledge age requires a new combination of skills, namely higher-order thinking and complex communication (Lai, 2017). This description shows the need for workers whom must-have 21st-century skills. This need urges various parties in the education sector so that education can produce students who can face the world of work.

Several studies show that many students are still unable to actively process information from various sources to form complete knowledge (Hakim, 2019; Mansour, 2017; Pinto, 2014b; Sumiaty, 2014). This shows the students' lack of ICT literacy even though the technology is currently developing rapidly. The wrong target of using technology is one of the causes of the low ICT literacy of students (Hakim, Widayati & Pratiwi, 2019). On the other side shows that technological developments change work procedures into ICT-based work so that the need for school graduates who master ICT literacy cannot be avoided (Dewi, 2015; Mustikawati, 2016; Syamsuar 2019; Wusqo, 2016).

Learning in schools is expected to be able to facilitate students to build ICT literacy through technology. An individual's ICT literacy is a relative measure of their capacity to utilize ICT materials to achieve educational and learning goals (Pinto & Escudeiro, 2014). ICT literacy is needed for students to form a complete knowledge of information that comes in parallel (Skryabin, Zhang & Liu, 2015). In addition, teaching ICT literacy will increase capacity in every field of human endeavor according to the demands of today's world of work (Lai, DiCerbo & Foltz, 2017). In line with the need for ICT literacy, there is a need for other abilities that cannot be separated from a thinking process, namely critical thinking skills. This need arises because the information processing aspect of ICT literacy is included in the cognitive domain so critical thinking is very important in the formation of new concepts (Gretter, 2016; Rahmatina, 2017; Susilawati, 2015; Wijayati, 2019; Wiyono, 2015).

It is difficult for high school graduates to have critical thinking skills due to three important factors. The first factor is that the model or method of teaching critical thinking has a functional conflict, namely between the need for a teacher to teach these abilities as well as his demand for high student achievement test results (Greenstein, 2012). The second factor is teaching and learning skills which are complex and require focused attention, energy and time to get the acquisition and application right. (Paul, 2007; Rosefsky, 2012; Sherblom, 2010). The third factor is the competence of teachers who must also have the ability itself so that they have a clear enough understanding to teach and form critical thinking skills (Negoro et al., 2020; Rusilowati et al., 2020).

The learning process in schools is expected to train students to think critically which is one of the main abilities in the 21st-century era (Ahmatika, 2016; Kaliky, 2018; Suci, 2019). Learning critical thinking is important because through critical thinking, students will be trained to observe the situation, raise questions, formulate hypotheses, make observations and collect data, and then provide conclusions (Anugraheni, 2018; Mujib, 2017; Nofi, 2018). Critical thinking also trains students to think logically and not to accept things easily. Critical thinking skills are a type of higher-order thinking that involves analytical thinking which will then be able to form thinking frameworks such as memory to metacognition (Dwyer, 2014; Munawaroh, 2015; Permana, 2016; Prayogi, 2017; Rachmawati, 2015; Rahmawati, 2016). Each student's critical thinkin skills are different, depending on the exercises that are often done to develop critical thinking. Furthermore, critical thinking skills are the basis that must be built to overcome students' inability to understand physical phenomena comprehensively which raises conceptual problems (Negoro, 2018).

In observations and interviews conducted by researchers at Senior High School 8 Semarang, Senior High School Teuku Umar Semarang, and Senior High School 2 Kesatrian Semarang, it was found that in studying Physics, especially in the Wave material every year, students did not develop ICT literacy and critical thinking skills. Access to technology in order to explore information as learning support is still on low level. The existence of technology in schools is not used optimally for the fulfilment of physics learning content; for example, computers are only intensely used during computer-based exams. The availability of computers in schools is currently quite increasing because the National Examination activities are held every year using computers (Busono, 2019; Santi, 2019; Supriyono, 2019). The increase in computer supplies that occurs along with the need for computers in schools is not utilized optimally to support learning. In addition, the enthusiasm of students in answering the questions asked by the teacher is still limited in theory (formulas), have not shown development that is in accordance with their potential and leads to conceptual understanding. In addition, 60% of students still have difficulty solving problems when a wave case is proposed, and have not been able to make decisions on the right solution to the problem. This emphasizes that problem-solving analysis requires critical thinking skills (Tibebu, 2018; Tiruneh, 2016). The availability of media and teaching materials are still limited. This was shown through learning that only uses one book which is a summary of the material and a short formula. The lack of media and teaching materials that support active and independent learning makes it difficult for teachers to build an understanding of students' concepts. Student learning activities can be increased when supported by learning that is relevant to the availability of facilities such as computers, gadgets, and the internet. Students also have hopes that physics learning can be packaged as more fun like a game that is relevant to technological developments.

Students' abilities are the result of school culture, where students have a subjective view of the ideal teaching model in a model that features a teacher-led approach according to the times (Ma, 2011; Häkkinen, 2016; Schratzenstaller, 2010). Based on this, the up-to-date tradition or culture affects the ideal learning model needed in life. Now, there is a need to develop new teaching methods and assessment tools to suit the needs of the environment function in the next life (Häkkinen, 2016; Krokfors, 2011; Välijärvi, 2011;). The use of renewable technology can be a relevant solution in addressing learning needs that have a culturally sophisticated basis.

One way to overcome the existing problems is to provide teaching materials that can facilitate learning to build ICT literacy and critical thinking skills. Research results from Skryabin (2015), Hakim (2019), and Navis (2019) show that teaching materials packaged and filled with content relevant to the times will support the learning process to improve ICT literacy. In addition, the results of Errington (2015), Wahyuni (2015), and Nurbaiti (2016) show that teaching materials filled with inquiry or discovery learning content, and interactive and contextual approaches are able to build students' critical thinking skills. Based on this, teaching materials must have content that comprehensively meets the need to build ICT literacy and critical thinking skills. These abilities can then be used as capital to reduce students' misconceptions (Kazmi, 2000; Kim, 2013; Negoro, 2018).

The utilization of technological developments as learning support will provide students with the capital to have ICT literacy. The term ICT literacy is similar to digital literacy which became popular around 2005 and means the ability to relate to hypertextual information in the sense of non-sequential or non-sequential reading with the help of a computer (Bawden, 2001; Davis, 2011). This ability is very influential in the process of using computers in various contexts and learning content (Syarifudin, 2014).

Along with technological developments, innovation can be carried out in the form of integrating teaching materials with other media so that they are able to fulfill the necessary functions to build critical thinking skills in learning. Computer programming is one of the materials to support efforts to build critical thinking skills. Although computer programming is done with computers, programming is also close to thinking skills. Learning how to program provides many benefits including gaining computer knowledge, critical thinking skills and problem solving skills (Barr, 2011; Choi, 2013; Tasneem, 2012). This utilization requires the ability or mastery of technology to access information and communication (ICT literacy). It is based on three components; content, pedagogy and technology, plus the relationships between components that are at the heart of teaching (Ariani, 2015; Imam, 2019; Quddus, 2019; Wiguna, 2017;). Several studies have shown that teachers design technology-based lessons, one of which is a spreadsheet, which is able to accommodate the provision of material (Agyei & Voogt, 2012). Seeing this side, the use of technology is important to facilitate material accommodation.

Scratch is one of the results of the development of computer programming-based technology in the form of simulation media that can help complement teaching materials to support interaction (Gretter, 2016; Lopez, 2015; Pinto, 2014a; Rusilowati, 2020). The Scratch application has the feature of making simulations according to the wishes of the maker with the principle of programming algorithms. This feature can facilitate active student learning by involving high-level thinking processes, one of which is critical thinking. Scratch has advantages in terms of practicality to create simulations by users actively through algorithmic methods that are arranged with the box/puzzle principle (Maloney, 2010; Resnick., 2009). Scratch facilitates users to better understand the material through simulation creation activities compared to other simulation content that only provides ready-made simulations (Husna, 2019; Syah, 2016). The excellence of Scratch programming implies that learning activities will require students to learn to actively build thinking skills (Rush, 2012).

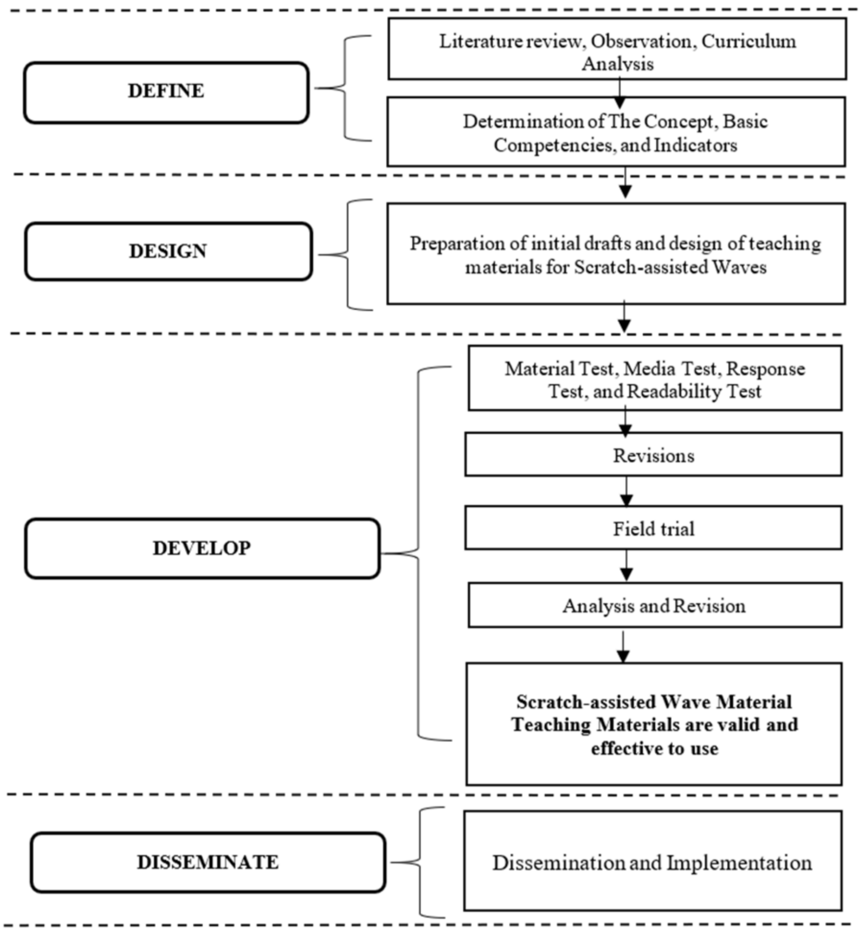
Based on the description above, we need something that provides a variety of content to support the development of critical thinking skills for effective learning of physics material. Researchers considered one of these things, namely in the form of teaching materials. Teaching materials are systematically arranged in language that is easily understood by students according to their level of knowledge and age, which can help them to learn independently with minimal assistance or guidance from educators (Budiman, 2008; Hasruddin, 2009). This study chose teaching materials because the teaching materials currently available in schools are only textbooks and worksheets that have not been integrated, so it is necessary to develop teaching materials to invite students to learn independently. As students' critical thinking skills develop, it is hoped that they can form good thinking patterns so that in the future they have a good understanding of the concept of Wave material. Based on the description above, this study aims to (1) develop Scratch-assisted Wave teaching materials, (2) test its validity, (3) test the practicality of its use, and (4) test its effectiveness in improving ICT literacy and critical thinking skills.

Methodology

This research is categorized as Educational Research and Development or commonly abbreviated as R&D. This type of research R&D is a process for developing and validating a product (Sugiyono, 2010). The learning device developed is Scratch-assisted teaching materials on Wave material. This research was conducted from January 10th, 2020 to December 9th, 2021. The research procedure adopted the Thiagarajan (4D) stages, namely Define, Design, Develop and Disseminate. The four stages have specifications as shown in Figure 1 below.

Figure 1

Stages of Development of Scratch-Assisted Wave Teaching Materials



The definition stage in this study began with observing schools to find out the learning process, the use of learning media, and the condition of students, teachers and schools. The results of this stage are used to identify needs that will be used in planning and developing learning media. The needs that are focused on include (1) critical thinking skills and ICT literacy which are one of the main 21st-century skills; (2) students' basic competencies, namely students can analyze the physical quantities of standing waves and traveling waves in various real cases according to the curriculum in Indonesia; (3) ICT-based teaching materials containing wave content with contextual presentation.

The design stage is the stage of designing or thinking to get an effective and efficient way of teaching materials for scratch-assisted Wave materials in accordance with the criteria. This stage produces an initial draft of material and product design which is then developed into a teaching material that will be used in research data collection. The drafts prepared in this step include basic competencies, instructional materials instructions and concept maps. These three will be the basis for a complete teaching material.

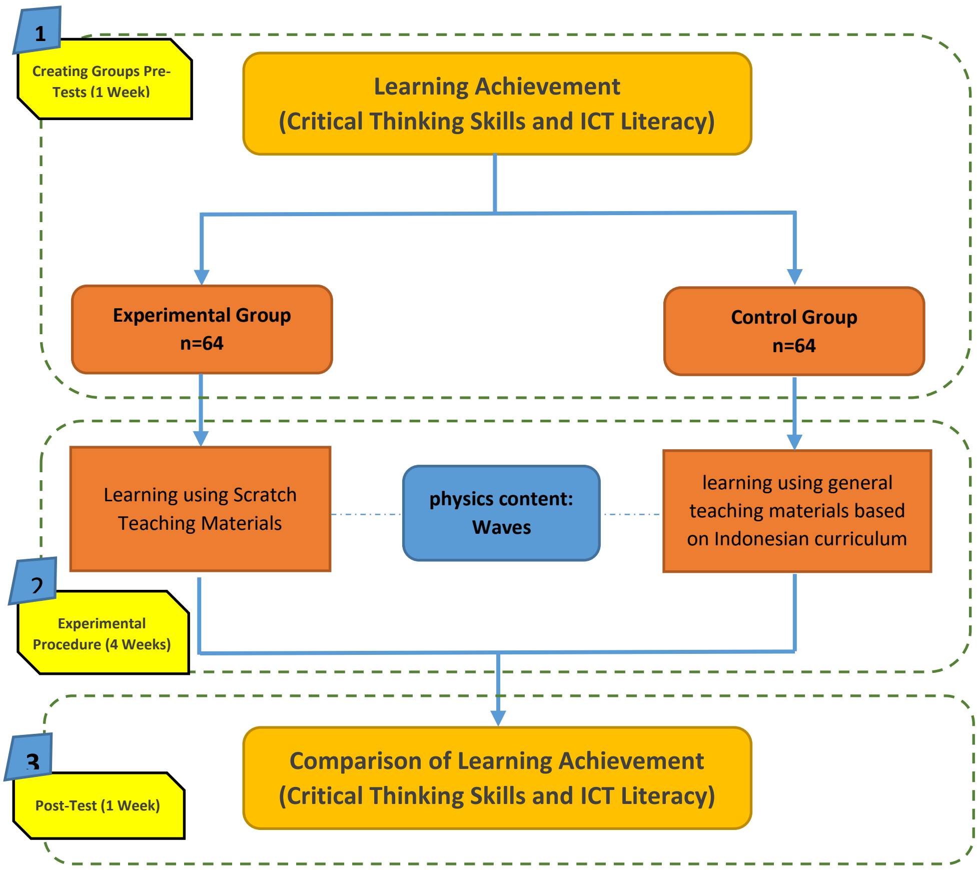
The development stage is the implementation stage of the design stage. The initial draft, namely the material and product design from the results of the planning stage, began to be developed. At this stage, there is the development of scratch-assisted wave teaching materials. The feasibility test at this stage was carried out by media experts, while the response test was carried out by expert practitioners or people who have expertise in high school physics. Meanwhile, the literacy test was carried out by high school students. The feasibility test, response test and readability test of teaching materials were carried out to find out whether the scratch-assisted Wave teaching materials were appropriate or not.

Teaching materials that have been tested for validity and practicality, were tested on class XI students of Senior High School 2 Kesatrian Semarang with a total of 34 students for each experimental class and control class. The sampling technique used in this study is purposive sampling where this technique determines the sample with certain considerations. The considerations are (1) Students are part of a group that has not studied physics material, namely waves; (2) Students are part of a group that has studied physics material, namely motion kinematics, particle dynamics, circular motion, and simple harmonic motion; (3) Students are part of a group that has mastered basic computer use.

The trial used the experimental method with a pretest-posttest control group design to be able to see differences in the achievement of critical thinking skills and ICT literacy in students where the experimental class was given Scratch-based wave teaching materials and the control class was given conventional wave 2013 curriculum in Indonesia. The illustration of the experimental design can be seen in Figure 2 below.

Figure 2

Pretest-Posttest Control Group Design



The research instruments were in the form of validation sheets, interview guidelines, observation sheets, gap tests to determine the readability of teaching material texts, critical thinking skills tests, and ICT Literacy tests. Before being used, the instrument was tested first and the reliability coefficient of the critical thinking ability test was 0.597 and ICT literacy was 0.571 both in the medium category. The construct validity of the test was tested using second-order confirmatory factor analysis (CFA) by calculating the estimated value of the indicator on the latent variable. The results of the analysis show that the critical thinking test meets the valid criteria seen from the Goodness of Fit. The calculated chi-square value is 1.285. This value is lower than the cut-off value of 5.25. This means that there is no significant difference between the covariance matrices so that the model is categorized as fit. In addition, the values of GFI, AGFI, CFI, TLI, NFI, and RMSEA have values that meet the cut-off value limits, so it can be said the model is fit. The results of the construct validity analysis can be seen in Table 1.

Table 1

Kriteria Goodness of Fit Instrumen Tes Berpikir Kritis

Goodness of fit Index	Cut off Value	Results	Category
X^2 Chi square	$\leq \alpha$.df	1.285	FIT
Significance probability	$\geq$ 0,05	*all items are classified as significant*	FIT
GFI	$\geq$ 0,90	0,91	FIT
AGFI	$\geq$ 0,90	0,96	FIT
CFI	$\geq$ 0,95	0,93	FIT
TLI / NNFI	$\geq$ 0,95	0,98	FIT
NFI	$\geq$ 0,95	0,96	FIT
RMSEA	$\leq$ 0,08	0,01	FIT

The dissemination stage in this study was carried out through the publication of scratch-assisted wave teaching materials packaged in books. Several school teachers in Semarang City, Indonesia, use this book to support learning in the class. The results of this stage are an inference of the entire research process which can then be taken into consideration in the field of Education and references for new related research in the future.

Findings and Discussion

The results of the development of this research are scratch-assisted wave teaching materials, along with the results of testing their validity, practicality, and effectiveness in improving ICT literacy and critical thinking skills.

Characteristics of Scratch-Assisted Wave Teaching Materials

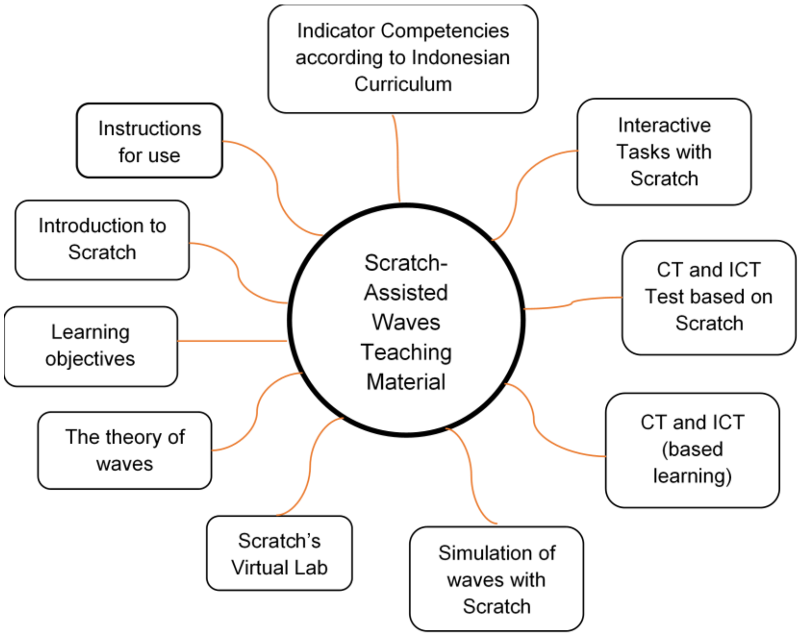
The teaching materials that developed were based on the curriculum, 21st-century education, and 4-0 education. Core competencies, basic competencies and indicators of achievement of material competence Waves become the starting point for the development of teaching materials. The use of the Scratch program focuses on adjusting content that can improve 21st-Century skills, namely critical thinking skills and education 4.0 ICT literacy. This teaching material is suitable for being used by high school students in class XI.

The characteristics of teaching materials developed based on ICT are (a) teaching materials utilizing the advantages of computers (in the form of digital media) for access and use of Scratch (b) teaching materials utilizing multimedia technology as interactive materials to build student motivation, (c) teaching materials utilizing electronic technology to reduce printed products and (d) teaching materials which are independent and can be stored on electronic devices so that they can be accessed anytime and anywhere.

Teaching materials were prepared with a contextual approach aimed at helping students understand the Wave phenomenon that occurs in the environment. The contextual approach packaged in the content of teaching materials also supports learning to improve critical thinking skills. ICT-based teaching materials and a contextual approach have some content that is intended to make teaching materials materially complete and easy to use. The outline of the content can be seen in Figure 3.

Figure 3

Scratch-Assisted Waves Teaching Material Content



The teaching materials that developed were based on ICT-based wave materials. This is based on a preliminary study that many students have misconceptions about wave material, low interaction during learning, and lack of use of technology.

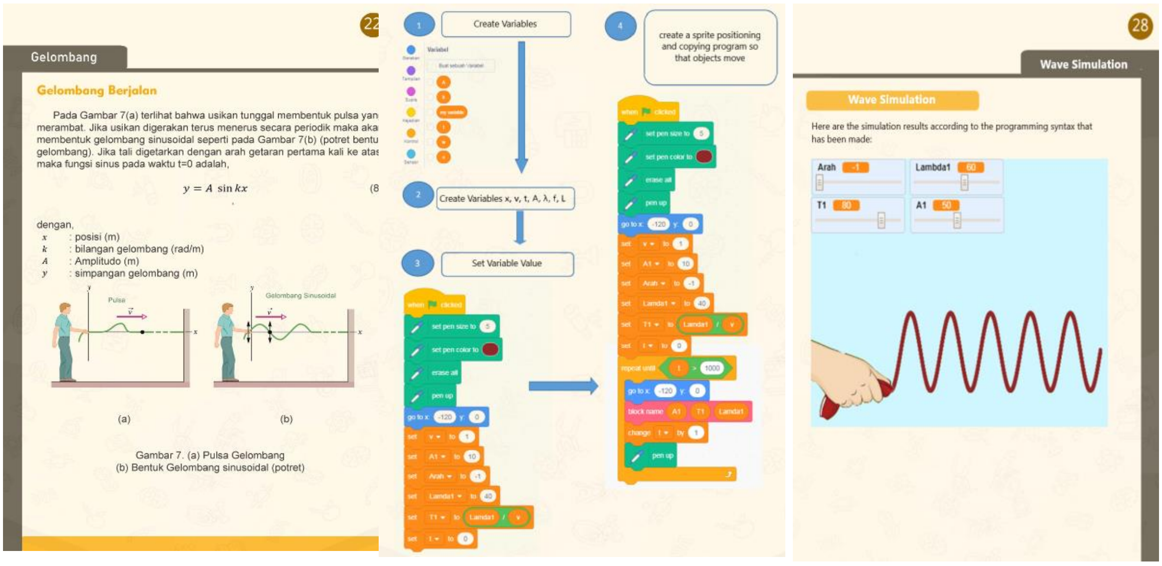
Wave teaching materials have programming content via Scratch programming software. ICT-based teaching materials include ICT components including definition, access, management, evaluation, creation and communication. The ICT component was packaged in learning activities in general and in simulation activities in particular. This approach is able to make students more meaningful in learning through packaged learning, so that students learn more actively. This ICT-based wave of teaching materials has the use of computers through teaching materials in accordance with the characteristics of the new millennium learner. Students with new millennium learner characteristics have a learning style that relies on technology and information skills (Hakim, 2019; Pratiwi, 2017; Yuan, 2017).

Wave teaching materials have various multimedia formats such as images, photos and Scratch-assisted which include interesting audio, visuals, simulations and animations so that student boredom during learning will be reduced. The use of multimedia devices in teaching materials in the form of simulations can make learning more effective. This is in accordance with the submission of several studies including research by Kumar (2017), Yuan (2017) and Chabay (2020). The developed ICT-based teaching materials are combined with a contextual approach. The contextual approach to teaching materials has several principles, namely constructivism, inquiry, questioning, learning community, modeling, reflection and authentic assessment. The following is a sample of teaching materials that are in accordance with the modeling aspect of the contextual approach. One sample of teaching materials that match the aspects of the contextual approach can be seen in Figure 4.

Figure 4

Contextual Aproach: (a) Contextual Phenomenon (b) Procedure for Compiling Scratch Programming (Modeling); (c) The result of Scratch Programming (Modeling)

(a) **(b)** **(c)**



A contextual approach combined with ICT can help students gain knowledge in a fun, interactive learning in the form of analyzing surrounding phenomena through information technology. This is in accordance with the results of research from Akmam, Amir, & Asrizal (2016) in which teaching materials were able to make subject matter more quick, fun and improve the expected learning outcomes. In addition, the use of technology in the form of computer access on the use of Wave teaching materials assisted by Scratch can facilitate a way to solve a problem contextually assisted by ICT which is a demand for 21st-century skills according to research results by Amin (2013), Sari (2017), and Khikmawati (2018). Teaching materials through a contextual approach will make it easier for students to understand physical concepts and will prevent just memorizing theories in the form of formulas (Majid, 2019; Muhammad, 2016; Oktaviani, 2017; Pratiwi, 2017; Rizki, 2017; Yunawati, 2017).

Wave teaching materials are arranged with a combination of various languages, namely a variety of written language and a variety of spoken language. It is intended that the material in teaching materials can be delivered communicatively so that teaching materials can attract students' interest in learning. This is in accordance with the delivery of previous research where the oral variety will give a dynamic impression on the reading and be able to arouse students' interest in reading (Nurlaila, 2016; Sihong, 2018; Sudarto, 2019).

In the learning process using Scratch-assisted teaching materials, students have a high probability of making mistakes in compiling programming syntax during the simulation process. The causes of errors in the preparation of this syntax can be caused by (1) students do not understand the function of the feature blocks for the preparation of Scratch programming syntax; (2) students are not able to compose functions and mathematical equations of wave phenomena into syntax; (3) students have not mastered the algorithmic principles to construct simulation syntax according to existing phenomena. As an anticipation of mistakes made by students, the teaching materials provide content in the form of a scratch introduction. In this content, there is a way of making basic simulations that students can learn first.

Validity of Scratch-assisted Wave Teaching Materials

The feasibility of the Scratch-assisted wave teaching materials was assessed by 3 validators who are lecturers of Physics Education in State University of Semarang. Validation of teaching materials was carried out in terms of material, media, and content base of critical thinking skills and ICT literacy. The feasibility of the material was seen in terms of content and in terms of language. The feasibility of the media was seen in terms of graphics and practicality. Based on the validation carried out by the validator, there are several suggestions and inputs that can be used for improvement before being tested on a limited scale. The results of the validation of the Scratch-assisted wave teaching materials are presented in Table 2.

Table 2

Teaching Material Validation Results

Aspects	Percentage of Validation Results (%)		
	V1	V2	V3
Content Expert			
1. Content Eligibility	98,08	-	82,69
2. Language Eligibility	90,38	-	80,76
Average of each validator	94,23	-	81,73
Average overall content		87,98	
Media Expert		92,85	
Rerate total		90,26	
Category		Very Valid	

Based on Table 2, it can be concluded that the Scratch-assisted Wave teaching material is very valid in terms of material with an average of 87.98% with a very valid category. Teaching materials also have a very valid validation level in terms of media with an average of 92.85%. Based on the percentage of achievement, overall, scratch-assisted wave teaching materials are suitable for use in learning.

Readability of Scratch-assisted Wave Teaching Materials

Teaching materials that had been validated by the validator were tested on a limited scale and then tested for readability. The readability test was carried out through a fill-in-the-blank and a readability questionnaire. The fill-in-the-blank test was composed of 20% of the reading parts of teaching materials or as many as ten pages by eliminating every fifth word in the reading sentence. If the fifth word is a conjunction or preposition, the next word is superimposed. This test was tested on 15 students who were students who had already received the wave material. The results of the test given to students showed that the percentage of correct answers was 87.22%. If you refer to Bormuth's criteria for teaching materials, the results of the gap test can be categorized into very easy-to-understand criteria. The results of the readability questionnaire given to students showed that the average percentage of readability was 84.97%, which means that Scratch-assisted wave teaching materials have very easy-to-understand criteria.

Student and Teacher Responses to the Practicality of Scratch-Assisted Wave Teaching Materials

After the learning was done, a response questionnaire was given to students and teachers in order to give an idea of how the impression from a practical point of view was during the use of scratch-assisted wave teaching materials. The results of giving a questionnaire to determine the responses of students and teachers to the practicality of the draft of teaching materials developed can be seen in Table 3.

Table 3

Results of Student and Teacher Responses to the Practicality of Teaching Material Drafts

Respondent	Percentage (%)
Student	86,29
Teacher	91,67

Table 4

Results of Student and Teacher Responses to Teaching Materials on Large-Scale Trials

Respondent	Percentage (%)
Student	93,57
Teacher	93,33

The results of the percentage of student and teacher responses in Table 3 show the average value with very good criteria. However, there were still things that needed to be improved on the draft teaching materials according to suggestions from students and teachers, such as improving the color theme and appearance in order to further increase reader interest. After being revised, the teaching materials were used in a large-scale trial. The results of the percentage of student and teacher responses on the wide-scale test, according to Table 4 have an average with a very good category.

Improving Students' ICT literacy

The improvement of students' ICT literacy using Scratch-assisted wave teaching materials is known from the results of a wide-scale trial in class XI of Senior High School 2 Kesatrian Semarang, totaling 68 students. The magnitude of the increase in ICT literacy in the control class and experimental class can be seen in Table 5.

Table 5

N-Gain ICT Literacy Test Results

Class	Average		N-Gain
	Pretest	Postest	
Control	47,67	71,32	0,45
Experiment	47,79	90,14	0,81

Based on Table 5, it appears that the results of N-Gain in the experimental class are greater than the control class. Independent t-test was conducted to test the significance of the difference in the

average increase in students' ICT literacy, this is based on the results obtained where the distribution data is normal and homogeneous. Research hypothesis:
H_0: The increase in ICT literacy in the experimental class is smaller than or equal to the control class,
H_1: The increase in ICT literacy in the experimental class is higher than the control class.

Table 6

t-Test Results for Improving ICT Literacy

Class	N	$\bar{X}$	${S_x}^2$	S	t_{hitung}	t_{tabel}
Control	34	0,45	0,0046	0,0868	17,0925	1,997
Experiment	34	0,81	0,0105			

Based on Table 6, it can be seen that the results of t-count for critical thinking skills are 17.0925 while t-table for a significance level of 0.05 is 1.997. This shows that t-count is in the rejection area of Ho, so it can be concluded that the increase in ICT literacy in the experimental class is significantly higher than the control class. When analyzed further, the achievement of ICT lieracy for each aspect, obtained results as presented in Table 7.

Table 7

Achievement of ICT Literacy in Every Aspect

Aspects	Precentage (%)
Access	90.79
Manage	78.41
Integrate	84.23
Evaluate	78.88
Create	68.46

Based on Table 7, it can be seen that the highest percentage of ICT literacy achievement is in the access aspect and the lowest percentage of achievement is in the creating aspect. This shows that students have no difficulty accessing IT, but their creativity is still not well mastered. The factor causing the increase in students' ICT literacy after using Scratch-assisted teaching materials is learning that creates an active atmosphere in problem-solving challenges. In the learning process, some students were faced with challenges such as difficulty in compiling syntax. This difficulty was then solved through discussion among students. This shows that learning using Scratch-assisted teaching materials is not only fun, interesting, and educational but also helps them to develop communication. This is in line with what was revealed in other studies, such as Lewis (2016) dan Wan (2018). Interesting findings can be seen from the sources they refer to while working on the project. Students in this study were given the freedom and empowerment to complete their assignments, while the teacher did not intervene much in decision-making with their critical thinking skills. The teacher only acted as a facilitator for students.

The other side shows that the creating aspect in achieving ICT literacy is the lowest aspect compared to other aspects. This aspect requires a deepening of mastery of scratch programming in the script processing process. The realization of students' ideas to create a complete simulation is constrained by scripting skills which are relatively new to students. Therefore, it is necessary to get used to using IT, especially the Scratch program.

Overall, students took advantage of various other sources around them, such as the internet, friends and teachers. This happens because of the demands of learning to use Scratch-assisted wave teaching materials which require students to actively access, find and process various information, one of which is used to build a complete simulation project. Learning through a process like this will make students build their own knowledge in accordance with constructivist learning theory (Asyrofi, 2016; Mulyati, 2016; Siagian, 2016). Students will specifically have information, communication, and mastery of technology skills because students directly build experience (insight) and will then form complete knowledge.

This finding shows that, through learning using Scratch-assisted teaching materials, high school students can cultivate their independence and create their own learning. This is in accordance with several previous studies which revealed that learning using Scratch attracts students' attention and interest more than conventional learning so that students will be more active and independent in discovering new knowledge (Kelleher, 2019; Wan, 2018).

Improving Student Thinking Skills

The improvement of students' critical thinking skills using Scratch-assisted wave teaching materials was known from the results of a large-scale trial in class XI of Senior High School 2 Kesatrian Semarang, totaling 68 students. The magnitude of the increase in critical thinking skills in the control class and experimental class can be seen in Table 8.

Table 8

N-Gain Test Results of Critical Thinking Skills

Class	Average		N-Gain
	Pretest	Postest	
Control	7,67	37,08	0,32
Experiment	13,68	76,98	0,73

In Table 8 it can be seen that the increase in critical thinking skills in the experimental class is higher than the control class. Based on the results obtained, the distribution of data is normal and homogeneous so that the hypothesis test is carried out by parametric statistical analysis or the significance of the difference in increasing critical thinking skills is shown through the independent t-test. The research hypothesis is as follows:

H_0: The increase in critical thinking skills in the experimental class is smaller than or equal to the control class,
H_1: The increase in critical thinking ability of the experimental class is greater than that of the control class.

Table 9

t-Test Results for Increasing Critical Thinking Skills

Class	n	$\bar{X}$	${S_x}^2$	S	t_{hitung}	t_{tabel}
Control	34	0,32	0,00413	0,08931	18,9276	1,997
Experiment	34	0,73	0,01182			

Based on Table 9, it appears that the results of t-count > t-table. This shows that t-count is in the rejection area of Ho, so it can be concluded that the significant increase in critical thinking ability of the experimental class is greater than that of the control class. In other words, the improvement of students' critical thinking skills using Scratch-assisted wave teaching materials is better than students using ordinary teaching materials.

Further analysis related to the achievement of critical thinking skills in terms of every aspect. The results of the analysis can be seen in Table 10.

Table 10

Achievement of Critical Thinking Skills in Every Aspect

Aspects	Percentage (%)
Hypothesis testing	79,64
Argument analysis	66,39
Reasoning	80,64
Likelihood and uncertainty analysis	80,37
Problem-solving and decision-making	73,04

Table 10 shows that the argument analysis aspect has the lowest percentage achievement. The low achievement of the argument analysis aspect is caused by the lack of use of teaching materials that demand these abilities. Students were still not able to explore various forms of one's interpretation of a wave phenomenon that is packaged in an argument. As an improvement, it is necessary to change the mindset of students in such a way as to be logical, rational and systematic so that students have better argumentation skills.

One of the efforts to build critical thinking skills is through analysis of wave phenomena to be made into a simulation through Scratch programming. Aspects of Hypothesis testing, Argument Analysis, Likelihood and uncertainty analysis were built through the process of analyzing variables that are related to a wave phenomenon for the basic material of simulation syntax. Then, after the simulation is successfully made, the aspects of hypothesis testing, reasoning, problem-solving and decision-making were formed by providing problems with reference to the simulations that have been made. This process provides opportunities for students to develop their thoughts and ideas using critical thinking skills.

One of the reasons ICT-based Scratch-assisted wave teaching materials are able to improve critical thinking skills better than conventional teaching materials is one of the reasons the learning process utilizes programming or computing activities. Making this computational-based simulation can stimulate critical thinking processes in students. Students are required to actively analyze how the simulation is built with their critical thinking skills in the form of analysis of wave phenomena variables. This is in accordance with the results of previous studies where programming is close to higher order thinking skills, including critical thinking skills. In addition, learning by programming provides many benefits, including acquiring computer knowledge, problem-solving skills, and skills (Barr, 2011; Choi, 2013; Rodriguez, 2021; Rouhani & Jørgensen, 2022; Tasneem, 2012;). The other side shows that scratch supports wave learning by providing a variety of shape representations. This is an effort to make it easier for students to achieve a good understanding of the abstract conception of waves. This section is in accordance with several previous studies which raised various approaches to learning abstract conceptions with various representations (Abdurrahman et al., 2019; Dewi et al., 2019; Prayogi et al., 2018).

Scratch programming offers fun conditions in its use because the base of its use is identical to the game. This pleasant condition will build students' interest and motivation in learning which is needed in critical thinking learning, so that students actively discover new knowledge. Several research results are consistent with this, namely computational-based learning using Scratch has had a wide impact in the world of education, including the last two decades, in which more than tens of thousands of students around the world are highly motivated and interested in computational-based learning activities and learning that builds critical thinking (Kafai, 2018; Jiang & Li, 2021; Sabila & Gunawan, 2022; Zamin, 2018).

Overall, the research results show that the use of wave-assisted Scratch teaching materials in general has advantages in improving ICT literacy and critical thinking skills compared to printed teaching materials that are commonly used. However, there are still deficiencies in the achievement of several aspects of ICT literacy and critical thinking skills. However, the use of Scratch-assisted wave teaching materials in learning is more dominated by critical thinking activities than activities to acquire and use ICT. This is reinforced by the description that during the learning process, students tend to carry out activities to analyze hypotheses, arguments and data, and try to solve problems with multiple solutions.

Conclusion and Implications

Scratch-assisted wave teaching materials that were developed meet the criteria of being valid, easy to understand, practical to use, and effective as teaching materials to improve ICT literacy and critical thinking skills of high school students. The increase in ICT literacy and critical thinking skills of students who used teaching materials assisted by Scratch is higher than students who use teaching materials without Scratch. The create aspects of ICT literacy and argument analysis on critical thinking skills still need to be improved. As input for future research, it is necessary to develop teaching materials for other Physics materials with the help of Scratch, so that ICT literacy, especially the aspect of creating and critical thinking skills, especially argument analysis of students can be better.

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APPENDIX 1

Teaching with Scratch-assisted Wave Teaching Materials

The lesson plan for the use of Scratch-assisted Wave Teaching Materials broadly aims to make students can analyze the physical quantities of standing waves and traveling waves in various real cases. Learning is focused on a contextual approach by applying an inquiry learning model with several methods including lectures, experiments (computing projects with scratch), discussions, questions and answers, demonstrations. The learning steps in outline can be seen in Table.

Step	Activity	Time
Preliminary	**Phase 1. Problem orientation** • Teacher gives apperception and motivation • Teacher introduces Scratch Programming to Students • Teacher reviews the learning of Simple Harmonic Motion which is one of the basic concepts of Waves through making simulations with Scratch with Students	**20 minutes**
Core activities	**Phase 2. Formulate the problem** • Students interactively explain and guess how waves can occur. • Students interactively explain and predict physical quantities that affect waves. • The teacher divides students into groups of max one group of 3 people to use the available computers. **Phase 3. Collecting data** • Students collect a variety of supporting literature and references • Students discuss information from various data sources obtained • Students analyze information from various collected data **Phase 4. Processing data** • Students make a wave simulation with the materials/data that have been collected. • Students confirm the accuracy of the simulation to the teacher **Phase 5. Proving data** • Several groups show and explain the simulation made • Students discuss the results of the simulation • Students analyze the correspondence between information from literature and references with simulation results	**50 minutes**
Closing	**Phase 6. Formulating Conclusion** • Students conclude learning outcomes • Students prepare reports • The teacher gives group assignments to find materials/data for further simulations according to the available teaching materials • The teacher closes the learning activities by providing an evaluation of the learning process that has been implemented	**20 minutes**

Structured learning in 4 meetings where each meeting has 90 minutes. Learning is carried out for about 4 weeks where every week there is 1 meeting. Each meeting contains identical learning steps as in the table above.