DEVELOPMENT OF STEM INTEGRATED ELECTRONIC LEARNING MATERIAL ON ELASTICITY MATERIALS TO IMPROVE STUDENTS' 21st-CENTURY SKILLS

UNDERGRADUATE THESIS

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STATEMENT

I hereby declare that:

1. My scientific work, the final project is in the form of a thesis with the title:" Development of STEM Integrated Electronic Learning Material on Elasticity Materials to Improve Students' 21st-Century Skills", is my original work.
2. This paper is purely my ideas, formulations, and research, without the help of other parties, except the supervisor.
3. In this paper, no work or opinion has been written or published by other people, unless it is clearly stated as a reference in the manuscript by mentioning the author and being included in the literature.
4. I made this statement in truth. If there are deviations in this statement, I am willing to accept academic sanctions in the form of revocation of the title obtained because of this paper and other sanctions following provisions of the applicable law.

Padang, November 2021

Vivi Mardian

ABSTRACT

Vivi Mardian, 2021: Development of STEM Integrated Electronic Teaching Material on Elasticity Materials to Improve Students' 21st-Century Skills. *Undergraduate Thesis*. Padang: Study Program of Physics Education, Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang.

The ease of internet access currently provides an excellent opportunity for the government to increase growth in all aspects of life. 21st-century skills include critical thinking, creativity, and communication skills. Based on preliminary data at SMAN 2 Padang, physics teachers have not applied STEM well to teaching materials. Student learning outcomes are still low, as evidenced by the acquisition of students' mid-semester exam results, namely 63.3. One of the right solutions to overcome these problems is to develop STEM-integrated electronic teaching materials to improve students' 21st-century skills. The method used in this research is Research and Development (R&D) by applying the Plomb research model. The object of this research is STEM integrated electronic teaching material on elasticity material. The data collection instruments used were questionnaires for validity, practicality, and effectiveness test instruments. Based on the research objectives and data analysis conducted, three research results were obtained. First, the average value of the validity of the STEM integrated electronic teaching materials is 0.87, which is in the very good category. Second, according to students, the average practical value of using STEM integrated electronic teaching materials is 83, in the good category. Third, the use of STEM integrated electronic teaching materials developed effectively improves students' 21st-century skills. The data analysis shows that the electronic teaching materials developed are valid, practical, and effectively used in online learning to improve students' 21st-century skills.

Keywords: Electronic Learning Material, STEM Integration, 21st – Century Skill

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Padang, October 2021

Writer

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CHAPTER 1
INTRODUCTION

A. Background of the Research Problem

The ease of internet access currently provides an excellent opportunity for the government to increase growth in all aspects of life. Medium and long-term growth can be achieved by realizing a smart society 5.0. Various problems in society can be solved by involving the development of the industrial revolution 4.0 (Fukuyama, 2018; Serpa & Ferreira: 2018). One of the most significant developments is the high level of community competition in improving quality education. Quality education can be seen from the quality of human resources produced by a country. Education is the spearhead of national change and creates a generation that can compete globally. These global competitions and challenges must be trained to students in line with the educational process to have 21st-century skills.

21st-century skills have become basic abilities that students must-have today. 21st-century skills can be grouped into ten abilities, namely skills in thinking (creative, innovative, critical thinking, problem-solving, decision making, metacognitive), skills at work (communicating and collaborating), skills in using tools (language, ICT), and skills in adapting (family, career, social relations) (Binkley et al., 2012). There are four essential skills to be mastered by students: critical thinking skills, creative thinking, and communication. This is following the demands of the 21st century, especially in education, where the learning system must lead to learning objectives. The learning objectives at each level of

education have at least one goal: a change in behavior, increasing knowledge and raising students' critical thinking skills. This goal can be achieved if one of the learning tools is equipped with good Learning material.

Learning material are a set of systematically arranged material that allow students to learn and are adapted to the existing curriculum (Depdiknas, 2006). Learning material make it easier for teachers to deliver subject matter so that all learning competencies can be adequately achieved. In addition, Learning material make it easy for students to learn actively, independently, or under guidance. This can be realized if the teacher packs Learning material with a systematic, unique, and interesting presentation of material. The existence of learning material is the main point for teachers and students in the continuity of learning. For this reason, teachers must provide learning material that are complete and easy for students to understand.

The government has made various efforts to improve the quality of education in Indonesia to face the challenges of the 21st-century. The government's measures include increasing teacher professionalism through teacher certification programs, subject teacher training, and Teacher Competency Examinations (UKG). Then the government continued to make curriculum changes until the applicable curriculum is 2013 revised 2021 curriculum. According to Permendikbud No. 36 of 2018, "the purpose of developing the 2013 curriculum is to prepare Indonesian people to have the ability to live as individuals and citizens who are faithful, productive, creative, innovative, and

effective and able to contribute to the life of society, the state and world civilization".

Curriculum development can be achieved if the learning approach used is appropriate. The learning approach that has been developed by developed countries in the STEM approach. The STEM approach can be used to answer educational problems in Indonesia. STEM is developed by raising everyday issues into learning. The impact of education is more meaningful because students are more interested and feel the benefits of learning physics in real life. With the STEM approach, it is hoped that students will more easily understand the concepts that will be conveyed and apply them in everyday life and explore the potential that exists within themselves.

Although many efforts have been made by the government, schools, teachers, and other parties, there are still learning objectives that have not been achieved. Based on interviews with physics teachers at SMAN 2 Padang, the learning material used are still in printed form. The obstacles encountered when using these learning material are that students tend to be bored and have difficulty understanding the learning material. Besides that, printed learning material are pretty expensive to procure. Teachers need electronic learning material that are cheaper, more attractive, and more accessible for students to understand the learning material.

The learning material used by the teachers at SMAN 2 Padang have not been adequately integrated with STEM, as evidenced by the STEM analysis of the learning material. STEM aspects analyzed in learning material include the

integration of science, technology, engineering, and mathematics. The instrument used is the STEM integration analysis sheet on learning material. The percentage of the presence of STEM in the learning material is 48%. This shows a lack of STEM integration in learning material, so it is necessary to follow up in integrating STEM into learning material to improve students' STEM abilities.

Students' earliest skills are seen from the assessment instruments' results in the form of essay questions. The aim is to measure students' earliest skills, namely critical and creative thinking skills and communication skills through writing. critical and creative thinking skills were scored 57. Meanwhile, communication skills were scored 64. Based on the assessment results, it can be seen that the problems that students have are, there are still students who answer questions that do not match the facts. In addition, students have not been able to explain the information in the table well. Therefore, this is nicely ould be a concern for teachers to improve students' 21^{st} -century skills.

Students' knowledge can be seen from the acquisition of the Mid-Semester Examination (UTS) scores for students of class XI MIPA in the even semester of 2021. The average score obtained for the four classes was 63.3, which was in the sufficient category. The four classes got data that the highest and lowest scores of students were 92 and 52. From the data obtained, it can be concluded that students face difficulties in learning.

Physics is inseparable from the science that studies natural phenomena. Meanwhile, learning physics makes it easier for humans to understand nature because it discusses the forms of energy that exist in the semester. In this study,

one of the material applied in the trial is elasticity material. The selection of research material is based on several reasons. First, elasticity is one of the many physical material at the third level, analyzing at Bloom's taxonomy level. Second, the UTS assessment instrument used by the teacher on elasticity material was still low, namely 47%, which contains HOTS questions. If this problem is left unchecked, students will not compete academically and will not master 21st-century skills.

Preliminary study results obtained show a gap between actual and ideal conditions. Real conditions illustrate that teachers are still using old learning material. The learning material used are not complete, such as the table of contents, bibliography, and the author's identity and appearance are not yet attractive. If this problem is left unchecked, it will impact the students' 21st-century skills, such as students who are less skilled in critical thinking, finding solutions to problems, and communicating experimental data. Teachers need learning material that are practical, attractive, easy to understand, and economical to support the learning and learning process. For this reason, electronic learning material are one of the learning material that facilitate students and teachers in learning.

Electronic learning material are learning material packaged in electronic form. Electronic learning material are the transition of print-based learning material to learning material in electronic form accessed through technology (Oliver et al., 1996). Electronic learning material play an essential role in supporting online and offline learning. Students do not need to spend a lot of

money to print these learning material because they can be directly accessed via their android or computer. Electronic learning material can increase student activity in the learning process so that learning becomes more effective. Electronic learning material can contain very interactive material, questions, quizzes. The absence of interactive media in electronic learning material will make students quickly bored and cause student achievement to be wrong (Aina, 2013). Therefore, electronic learning material must be well prepared by teachers so that they can improve student achievement in the aspects of knowledge and skills.

Electronic learning material can be supported by loading material equipped with a STEM (Science, Technology, Engineering, and Mathematical) learning approach. STEM has developed in both developed and developing countries (El-Deghaidy & Mansour, 2015). The linkages between science and technology as well as other sciences cannot be separated in science learning. Science requires mathematical formulas to process data, while technology and engineering are real applications of science. STEM makes it easy for students to solve problems, especially science and mathematics (White, 2014; Stohlmann et al., 2012). Another benefit of STEM integrated is that it makes students better at solving problems, finding ideas, being independent and technology literate (Morrison, 2006). Based on research conducted by Kennedy (2014), as many as 87.3% of students who successfully passed the STEM integrated science exam compared to ordinary students who were only 84%. Thus, the integration of STEM in learning material can develop students' abilities more quickly.

From the problems found, STEM integrated learning material have not been implemented optimally at SMAN 2 Padang. Researchers feel it is essential to develop STEM integrated electronic learning material at this time. Therefore, the researcher proposed the title "Development of Integrated Electronic Learning Material STEM on Elasticity Materials to improve Students' 21st Century Skills".

B. Identification of the Problem

In the background, the main problem was found, namely: the learning outcomes of physics at SMA Negeri 2 Padang are still low. The results of the analysis obtained several factors that are estimated to cause the problem, namely:

1. The learning material used in the learning process at SMAN 2 Padang are still relatively low in content presentation.
2. 21^{st} -century skills of students are included in the low category seen from the scores obtained through the 4C skills test.
3. Physics learning outcomes are still relatively low, seen from the average UTS value of class X science students, 63.3.

C. Limitation of the Problem

For the research to be more focused and directed, it is necessary to limit the problem. The limitation of the problem is limited based on the identification of the issues described above, the boundaries of the problem in this study are as follows:

1. 21st -century skills, namely critical thinking, creative, and communication skills proposed by Saavedra & Opfer, 2012; Kivunjav, 2015.

2. The structure of electronic learning material developed based on guidelines for developing ICT-based electronic learning material.

D. Formulation of the Research

Based on the research problems that have been proposed, it can be formulated as follows:

1. How is the validity of the STEM integrated electronic learning material on elasticity materials?

2. What is the practicality of using STEM integrated electronic learning material on elasticity materials?

3. How effective is using STEM integrated electronic learning material on elasticity materials to improve the 21st-century skills of XI high school students?

E. Purpose of the Reserach

Based on the formulation of the problem proposed, the objectives of this study are to:

1. Determining the validity of STEM integrated electronic learning material on elasticity materials.
2. Determine the level of practicality from the use of electronic learning material, STEM integrated on elasticity materials.
3. Determine the effectiveness of using STEM integrated electronic learning material on elasticity materials to improve the 21st-century skills of class XI high school students.

F. Benefits of the Research

Based on the research objectives above, the expected benefits of this research are:

1. For researchers, as a condition for obtaining a bachelor's degree at the Department of Physics, Padang State University.
2. For teachers, as a reference to improve the quality of physics learning by adjusting the learning material used to overcome students' learning difficulties.
3. For students, as a learning resource in supporting the learning process.
4. For other researchers, as a reference to continue and develop research in the future.

CHAPTER II
THEORY

A. Literature Review

1. Defenition of Electronic Learning Material

Technological developments allow teachers to design learning material in electronic form. Electronic learning material are learning material that are contained in electronic form, be it visual, audio, or audio-visual (Jeung et al., 1997; Jety, 2016; Yachina, 2016). Electronic learning material consist of learning material that are systematically arranged to achieve learning objectives that are presented or published in electronic format (Ramadayanty, 2021; Misbah, 2020). Electronic learning material are designed to realize the curriculum and stimulate as many student perception components as possible (Klementa et al., 2014). Learning material presented electronically provide more flexible and student-centered learning opportunities (Tóth et al., 2004). Thus, electronic learning material greatly facilitate students both in repeating learning material and doing structured tasks.

Electronic learning material have several characteristics. According to Dewi & Eveline (2008: 199), some of the elements of electronic learning material are as follows, (1) utilizing electronic devices so that there are no boundaries between teachers and students, (2) utilizing the advantages of computers, such as sophisticated applications, (3) the learning material developed are independent, and can be accessed anytime and anywhere, (4) the learning process can be monitored at any time on a computer device. Therefore, the use of electronic learning material supports students in both direct and online learning.

Interactive electronic learning material have several advantages. According to Simamora et al. (2018: 53), the benefits of electronic learning material are (1) e-modules can be accessed via smartphones, laptops, and computers, (2) the use of electronic learning material allows students to study independently anywhere and anytime, (3) not easily weathered or damaged like printed modules, (4) electronic learning material can be presented with audio, video, and interactive questions, and (5) improve students' skills in critical thinking, problem-solving, developing positive attitudes, and self-confident.

The development of electronic learning material must pay attention to several criteria. According to the Ministry of National Education (2017: 7), several basics must be considered in developing an electronic learning material including, (1) learning material must be able to foster student interest in learning, (2) written and designed for students so that they must pay attention to the use of language must be communicative, interactive. And semi-formal, (3) explain the learning objectives, (4) the pattern of preparation using "flexible learning," (5) the practice of learning material tailored to the needs of students and learning objectives, (6) learning material should be focused on providing exercises for students, (7) accommodate students' learning difficulties, (8) at the end of the material is given a summary, (9) packaged to be used in learning activities, (10) the preparation of learning material must have an introduction, presentation, and closing section, (11) have a mechanism to collect feedback, (12) to support self-assessment, and (13) there is a mechanism on how to use it as well as instructions before and after using it take electronic learning material.

According to the Directorate of High School Development (2010), the preparation of ICT-based learning material must meet the established rules, including:

a. Planning Stage

The planning stage in the preparation of ICT-based learning material aims to determine the characteristics of the KI-KD of a subject whether learning can be developed using ICT-based learning material or not.

b. Preparation phase

The preparation stage consists of determining the material, the type of software, the type of ICT-based learning material, and compiling storyboards.

c. Compilation Stage

The activity of preparing ICT-based learning material depends on the characteristics of the material to be developed in learning activities. In general, learning material contain:

1) Title, class, semester, and identity of the authors;
2) Core Competencies and Basic Competencies;
3) Achievement indicators;
4) Learning material;
5) Practice questions;
6) Competency test;
7) Reference.

d. Assessment Stage

The assessment stage of learning material is an evaluation of the learning material prepared, whether they meet the requirements or need improvement.

e. Shipping Stage

The development of science and technology has brought many positive impacts in various aspects of life, including education. Learning tools made by utilizing ICT can increase students' creativity and motivation (Hori & Fujii, 2021). This is in line with Alobaid (2021) opinion that in the learning process, the integration of various information and communication technologies can create, improve, and optimize a better learning environment. One of the technologies that can be used in learning activities is Flipbook (Mandal et al. l, 2017). This application is used to design electronic books that can display videos, images, animations, writings, etc. This program can also be opened on an Android phone. By using Flipbook, teachers can display learning material that will be delivered in a more attractive form.

2. STEM

The term STEM was first recognized in the 19990s. At that time, the US office of the NSF (National Science Foundation) used the term "SMET" as an abbreviation for "Science, Mathematics, Engineering, & Technology." However, an NSF employee reported that "SMET" almost sounded like "smut" in pronunciation, so it was replaced with "STEM (Science, Technology, Engineering, and Mathematical). So in the Indonesian context, STEM refers to four fields of science, namely science, technology, engineering, and mathematics (Sanders, 2009).

STEM has been applied in several developed countries such as the United States, Japan, Finland, Australia, and Singapore. STEM is recognized as a discussion material in the field of education, namely STEM Education. But its meaning cannot be distinguished because STEM can be defined separately based on the four disciplines integrated into STEM. In the United States, STEM integration has been described in three dimensions (Kilty et al., 2013). The first dimension emphasizes the concept of science in STEM. The other two dimensions are the practice of science and engineering, which highlights the application of interdisciplinary relationships, and the core ideas of the discipline, which emphasize the basic concepts needed to understand each STEM discipline. The grouping of STEM integration levels is as follows (Vasquez et al., (2013):

Table 1. STEM Integration Grouping

Typed	General Description
Disciplinary	Content studied in separate discipline classrooms.

Multidiscipnary	Content is studied separately but connected through a common theme or issue.
Interdisciplinary	Focus on interdisciplinary content and practice from two or more disciplines connected through a common theme or issue.
Transdisciplinary	Content from two or more disciplines is applied to real-world problems, with a learning focus on real-world problems.

STEM integration is a transfer of technology and engineering fields to a science and mathematics standard curriculum. However, STEM integration is an approach to learning that extends beyond its academic role. Interestingly, the STEM approach can predict learning for the future or career. Students' experiences at the elementary and secondary levels can form the "competence" that students already have as a provision in science and mathematics abilities. In addition, the STEM approach can increase student interest in fields related to science (Ainley et al., 2008). Therefore, the integration of STEM is a new challenge for teachers in understanding various fields of science.

Learning with the STEM approach provides students with practical experience in the form of projects so that students experience the learning process directly, following the nature of science. The results of research by Kelly et al. (2021) show that students who do STEM learning get great experiences because they are allowed to collaborate with students from other disciplines. So far, the application of STEM in Indonesia has not been popular compared to developed countries such as the United States and Japan. Judging from Indonesian students'

achievements in mathematics and science, there are predictions that science teachers' ability, especially in integrated STEM subjects, is still low (Oktavia et al., 2021). This shows the importance of developing STEM in learning, especially in science and mathematics.

The STEM approach can be developed if it is associated with phenomena in the natural environment to realize learning that presents facts experienced by students. The four fields of science in STEM can be explained as follows:

a. Aspect of Science: is a lesson about the natural world, including natural laws associated with physics, chemistry, and biology and the treatment or application of facts, principles, concepts, and other provisions related to these disciplines (Torlakson, 2014). Science plays an essential role in informing the engineering design process.

b. Technology aspect: although not a scientific discipline in the true sense, the technology aspect consists of the entire system, people and organizations, knowledge, processes, and devices that create and operate technology, as well as their own. Humans make technology to fulfill their needs and wants. Most of the two are combined by technology.

c. Engineering aspect: knowledge to operate or design a procedure to solve a problem. Engineering can apply the concepts of science, mathematics, and technological tools.

d. Aspects of Mathematics: learning about patterns and relationships between space, numbers, and equations. Skills used to analyze, reason,

communicate ideas creatively and interpret solutions based on calculations and mathematical data.

3. 21st-Century Skills

In the era of society 5.0, various skills must be mastered by students. These skills are often known as 21st-century skills. According to Scott (2015), 21st-century skills are essential skills such as communication, collaboration, critical thinking, and creativity. Meanwhile, Kayange & Msiska (2016) revealed that students need 21st-century skills to participate effectively and succeed in obtaining academics, communicating, and filtering detailed information. Another opinion was also conveyed by Schleicher (2012) regarding 21st-century skills, including critical thinking skills, creative thinking, problem-solving, decision making, collaboration, and communication. Thus, the main skills that must be mastered by students are critical thinking skills, creative thinking, and communication.

Critical thinking skills are skills that must be mastered by the younger generation in the face of increasingly complex global competition with the development of science and technology. Critical thinking is the ability to analyze an idea based on logical reasoning to consider using specific measures or standards (Lambertus, 2009). According to Watson (1980), critical thinking skills are: (1) an investigative attitude that involves the ability to find out the truth that already exists; (2) natural, abstract, and general knowledge that can be proven logically; and (3) skills in applying and applying the acquired knowledge.

Critical thinking skills are essential for students in solving problems. Some factors hinder the integration of necessary thinking skills in students: (1) lack of practice, (2) little information, (3) preconception, and (4) time constraints (Snyder, 2008). The first obstacle is that the teacher has not provided critical thinking exercises to students properly. The second obstacle, students are still not used to finding sources of information or knowledge in other sources independently. The third obstacle is that teachers and students experience preconceptions about the material to be studied because, in physics, students have found their concepts in everyday life. Finally, time constraints are an obstacle to integrating critical thinking skills. Sometimes, teachers often deliver topics to be discussed in a short time.

Critical thinking skills are trained by providing opportunities to comment, criticize, expand and enrich explanations. Researchers use several characteristics of necessary thinking skills in cognitive knowledge, namely interpretation, analysis, evaluation, inferring, and explaining (Facione, 2011). There are six indicators of critical thinking skills developed by Fascione, which are further divided into six skills sections, as shown in Table 2.

Table 2. Indicators of Critical Thinking Skills

Skills	Sub-Skill	Description
Interpretation	Categorization Coding Classification meaning	Understand and express the meaning or meaning of various experiences, situations, data, events, judgments, conventions, beliefs, rules, procedures, or broad criteria.

Analysis	Review of ideas Argument Analysis Argument	Identify inferential relationships between statements, questions, concepts, descriptions, data, or other forms of representation intended to express
Evaluation	Assessing Claims Judging Arguments	Assess the credibility of any statement or other representation that provides an explanation or description of a person's perceptions, experiences, situations, judgments, beliefs, or opinions and assess the logical strength of actual or purported inferential relationships, including statements, descriptions, questions, or other forms of representation.
Inference	Questioning the evidence Guess the alternative Draw a conclusion	Identify and define the elements needed to draw reasonable conclusions, formulate conjectures and hypotheses; consider relevant information, and derive consequences that flow from words, reports, principles, evidence, judgments, beliefs, opinions, concepts, descriptions, questions, or other forms of representation.
Eksplanation	Declare results Justify the	State the reasoning results, justify the reason based on considerations of evidence,

	procedure Presenting arguments Self correction	concept, methodology, criteria, and context; Presenting reasoning in the form of convincing arguments.
Self-Regulation	Self-assessment Self correction	Consciousness helps one's cognitive activities, the elements involved, and the results obtained, especially by applying self-analyzing and self-evaluating skills.

Creative thinking is a skill in finding new and original things, developing various solutions to problems, involving ideas to create new things, and being varied and unique (Leen et al., 2014; Abdullah & Osman, 2010; Nussbaum et al., 2021). Meanwhile, creativity is creative thinking (within the framework of cognitive processes, as thoughts that aim to create new knowledge or work) and produce innovative products (something original and qualitatively new) (Simkova et al., 2021). So, creative thinking is a thinking activity so that creativity appears in students or thinking to produce new things for themselves.

Creative thinking skills in students can be measured by paying attention to the characteristics they have. The characteristics of students who have creative thinking skills can be seen from the following descriptions, 1) fluency (igniting many ideas in problem-solving, providing many answers in answering a question, providing many ways or suggestions for doing things, and working faster doing more). Than other students), 2) flexible thinking (producing variations of

problem-solving ideas or answers to a question, being able to see a problem from different perspectives and presenting a concept in different ways), 3) original (providing relatively new ideas in solving problems or answers other than the usual ones in answering a question, making unusual combinations of parts or elements), 4) elaboration (developing or enriching other people's ideas and adding, organize or detail an argument to increase the quality of the idea call it), 5) Assess (can find the truth of a question or fact or problem-solving plan, can spark the idea of solving a problem and can carry it out correctly and have justifiable reasons to reach a decision (Moma, 2017).

Another skill that is very important to be mastered by students is communication skills both orally and in writing. Communication skills are skills in expressing ideas, ideas, knowledge, or information obtained logically (NEA, 2010). Skills can be done in various ways; in short, communication skills are the ability to articulate thoughts, ideas using oral, written, nonverbal communication skills in multiple contexts (Roekel, 2011). Based on the above opinion, it can be concluded that these communication skills will help students express or show the results of teamwork to others in oral form or other scientific writings.

Communication brings together the communicant with the communicator. The communicant is the person who receives, while the communicator is the person who conveys the message. Communicating does not have to be done with direct interaction but can also mimic body movements such as smiling, winking, waving hands, and using feelings in one's heart. Effective communication if the information conveyed can be accepted by others (Lundeberg, 2016).

Various factors cause students to tend to be passive in conveying an idea or opinion. There are four factors or barriers to communication: barriers to the delivery process, physical barriers, semantic barriers, and psychosocial barriers (Lunenburg, 2010). Process barriers are caused because the teacher does not fully understand the message in the form of learning material delivered to students, whether accepted. Physical barriers include the distance between the teacher and students who communicate, the atmosphere being too crowded, and interference with the communication media. Sematic barriers are language barriers. The choice of different words between teachers and students can cause differences in understanding. Psychosocial barriers are psychological and social barriers that include empathy, habits, customs, expectations, needs, perceptions, and culture.

Communication skills include delivering messages from teachers to students or vice versa, willingness to accept communication (reading, listening, arguing, and using many sources) to express ideas (Greenstein, 2012). Indicators of communication skills that can be measured are: (1) seeking information; (2) listening and observing; (3) scientific writing; (4) representing information; and (5) presenting knowledge (Handayani, Sulisworo, & Ishafit, 2021). While the indicators of scientific communication skills are: (1) compiling and submitting reports systematically and clearly; (2) explaining the experimental results; (3) classifying data and compiling data; and (4) describing the data in the form of graphs, tables or diagrams (Wangsa et al., 2017).

4. Elasticity

Elasticity is the ability of an object to return to its original state when the force applied to the object is removed (Sunardi et al., 2016). Elasticity is an object that can be compressed and stretched to a certain extent (Radi & Rasmussen, 2013: 306; Halliday, 2011: 306). We will discuss the elastic properties of solids by introducing the concepts of stress and strain. Clay cannot return to its original state if the force is removed (Ruwanto, 2017). Some other examples, such as platysin and flour dough, are plastic objects (Supriati, 2019).

Stress is the ratio of the force to the cross-sectional area, so mathematically, it can be written (Halliday, 2010):

$$\tau = \frac{F}{A} \quad \text{.....(1)}$$

The SI unit for stress is the Pascal (Pa). Equation 1 shows that 1 pascal = 1 Pa = 1 (Kane, 1986). Strain is the ratio between the increase in length and the initial length of an object (Juliastuti, 2001). Mathematically it can be written in the equation:

$$\varepsilon = \frac{\Delta l}{l_0} \quad \text{.....(2)}$$

Strain is a comparison of two length quantities so that strain is a dimensionless pure number (it has no units) (Ruwanto, 2017). The experimental results show that for small tensile forces, the stress is proportional to the strain. The modulus of elasticity, also known as Young's modulus, is written as follows:

$$Y = \frac{tegangan}{regangan} = \frac{F/A}{\Delta l/l_0} \quad \text{.....(3)}$$

Since strain has no units, the units of Young's modulus are the same as stress, i.e., or Pascal (Kane, 1986).

The elasticity property is beneficial in everyday life. Examples of the application of elasticity properties such as:

(1) Spring mattresses are more comfortable than regular mattresses (Supriati, 2019). Why is that? When sleeping, the force of body weight pressing on the bed is supported by springs. Because the spring is elastic, the spring mattress will maintain its thickness.

(2) Shock breaker, spring can also be used in motor vehicle suspension. With the spring in the shock breaker, motorized vehicle passengers become comfortable sitting in the seat even when driving on uneven roads.

(3) Balances, various types of scales or balances also use a lot of springs. The balance sheet can facilitate buying and selling transactions in the market.

(4) Fast wings are required to be flexible or elastic and must not be too rigid. Airplane wings must be able to handle vibrations from the propellers and air pressure while flying. When tested, branches with good elasticity will bend like a bow but are not damaged and return to their original shape.

(5) Steel frame roofs made of building material in earthquake-prone areas must be slightly flexible so that the building does not easily collapse when an earthquake occurs (Juliastuti, 2001).

Two springs arranged in series will have characteristics such as (1) The tensile force on the series replacement spring is equal to the tensile force experienced by each spring, (2) The increase in the length of the series

replacement spring is equal to the sum of the lengths of each spring. (Supriati, 2019). While two or more springs arranged in parallel have the following characteristics (1) The tensile force on the parallel replacement spring is equal to the sum of the tensile forces on each spring, (2) The increase in the length of the parallel replacement spring is equal to the increase in the length of each (Supriati, 2019).

B. Preview of the Studies

Previous studies relevant to this research include the first research conducted by Nailu (2020) entitled The Effect of the Science, Technology, Engineering and Mathematics (STEM) approach on students' cognitive abilities in a fluid material. This study uses a pre-experimental method with a one-group pretest-posttest design. The results showed that the STEM approach affected students' cognitive skills, as evidenced by the difference in the average cognitive skills of students in the experimental class and control classes.

The second research was conducted by Rasmi (2020) entitled Implementation of STEM learning using the slingshot toy project on elasticity and Hook's law. The type of research used is a non-equivalent experimental research pretest-posttest control group design with a quasi-experimental research design. The results showed that learning using STEM assisted by the slingshot toy project was better than conventional learning on elasticity and Hooke's law. It can be seen from the results of data analysis that the differences in the pretest and posttest scores of each class are obtained. In addition, STEM learning can make students more creative and active in the learning process.

The third research was conducted by Lestari (2018) entitled Implementation of Student Worksheets with STEM Approach (Science, Technology, Engineering, and Mathematics) to improve students' critical thinking skills. The research method used is an experimental method consisting of preparation, implementation, and data processing. The results of the research carried out are the results of the performance of the LKS with the STEM approach in class VIIIA on critical thinking skills, an increase in n-gain on the posttest, and pretest values of 0.5 on the moderate criteria. This shows that the worksheets developed with the STEM approach can improve students' critical thinking skills.

The fourth study was conducted by Mu'minah and Aripin (2019) entitled Implementation of ICT-assisted STEM-based Science Learning to improve 21st-century skills. This research is pre-experimental research with a one-group pretest-posttest design. The results showed that the increase in students' creative thinking skills was 87.97%, communication and collaboration skills were 66%, while the effectiveness level was 72.63%. So it can be concluded that ICT-assisted STEM-based science learning can improve students' 21st-century skills.

The previous research was conducted by Lolanessa (2020) entitled The Effect of problem-based learning model using the STEM approach in improving the problem-solving skills of junior high school students. This study used a pre-experimental method with one group pretest-posttest design. The results showed that the application of the PBL learning model could improve students' problem-solving abilities with an n-gain value of 0.62, which was included in the medium category.

The research conducted is different from some previous studies. Previous research examined the implementation of STEM-based worksheets and the effect of STEM. Previous research only looked at the impact of using learning with a STEM approach. In comparison, the study was conducted in the development of electronic learning material. Development of STEM integrated physics electronic learning material on elasticity material to improve students' 21st- century skills. This research was conducted based on earliest observations; the 21st-century skills of students, such as solving problems, creative thinking, and communication, are still low. One of the causes of the low ability of these students is the unavailability of electronic learning material that contain STEM indicators to support 21st-century skills students' skills such as critical thinking, creativity, and communication.

C. Conceptual Framewrok

The main components of learning are learning objectives, students, teachers, curriculum, learning material, methods, learning facilities, and learning evaluation. Based on this, it can be interpreted that learning material as a part of the learning process are an essential part of the factors that determine student learning outcomes. Therefore, it is necessary to have learning material that can support students to obtain optimal learning outcomes in the learning process and improve students' 21st-century skills.

One example of learning material is electronic learning material. Electronic learning material were developed by integrating STEM. Learning using STEM integrated electronic learning material can be directed to improve students'

21st-century skills. In enhancing the 21st-century skills, these students need guides who can lead students to activities related to 21st-century skills. The 21st-century skills include critical thinking, creativity, and communication skills. Based on the theory described, the framework of thinking in this study can be described as follows.

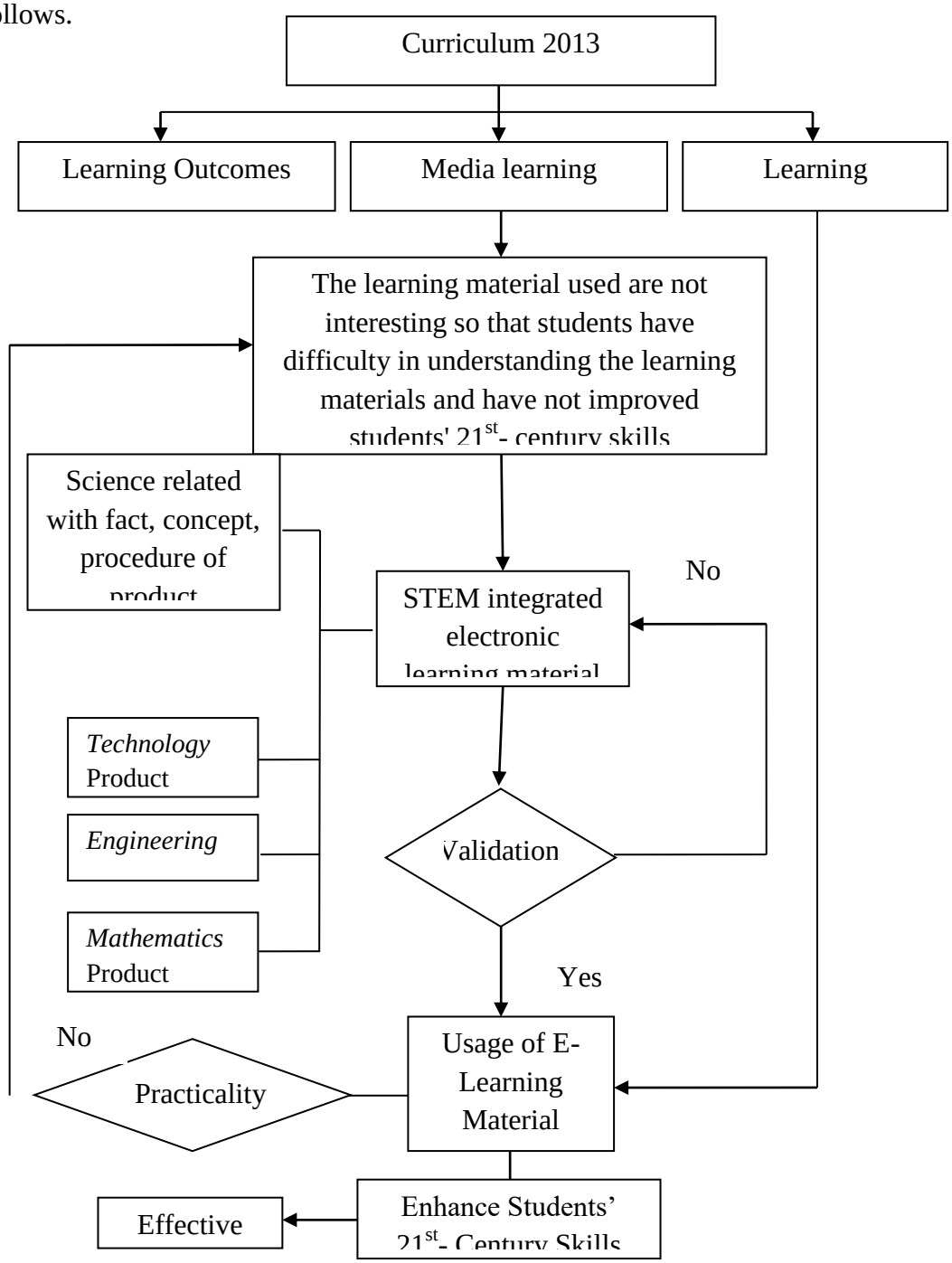

Figure 1. Conceptual Framework

CHAPTER V
CONCLUSION

A. Conclusion

Based on the research that has been done and the results of data analysis, the following conclusions are obtained:

1. The validity value of STEM integrated learning material was 88, which was in the very good category. This shows that STEM integrated electronic learning material are valid and can be used in physics learning to improve students' 21st-century skills.
2. The practical value of using STEM integrated electronic learning material was 83, which was in the very good category.
3. The use of STEM integrated learning material was effective for improving students' critical thinking, creative, and communication skills.

B. Suggestion

Based on the research that has been done and the obstacles faced in the field, some suggestions can be put forward as follows.

1. Teachers can use STEM integrated electronic learning material to support the physics learning process.
2. Students can use STEM integrated electronic learning material to improve students' mastery of 21st century material and skills in learning physics.
3. Other researchers can develop STEM integrated electronic learning material on all material for high school students in class XI semester 1 or semester 2.

Other researchers can also integrate students' 21st century skills in addition to critical thinking, creative, and communication. Thus produced learning material that are more complete than before.

4. The learning material in this study is limited to simple harmonic vibrations. Therefore, other researchers can develop research on other learning material.
5. The trial of learning material that has been carried out in this study is only a product trial. Other researchers can conduct trials of use so that maximum results can be obtained.

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