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Development of E-Modules Oriented by A Science, Technology, Engineering, Art, and Mathematics (STEAM) Approach to Improve High Level Thinking Ability

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Abstract: Standards for 21st century learning for educators and students relate to the application of technology learning. One of the ways teachers use to optimize digital learning activities is by creating teaching materials in the form of e-modules. The aim of this research is to develop an electronic module oriented towards the STEAM learning approach. This e-module is used to improve elementary school students' high-level thinking abilities. This research uses the Research and Development research method with the ADDIE development model. The subjects of this research were grade IV elementary school students in Pariaman Tengah, Pariaman City, namely SDN 17 Kampung Baru, SDN 04 Rawang, and SDN 02 Karan Aur. There are three instruments for this research, namely validation instruments in the form of validation sheets, practicality instruments and effectiveness instruments. The results of this research areThe average validation result for the three aspects of media, language and material is 85.65, which is included in the very valid category. The paired sample t-test results were obtainedsignificance value of Sig. 0.000 <0.05so the data shows that there are differences significant difference between before using modules and afterwards, so it is stated that modules can increasing the high-level thinking abilities of high-class students.

Keywords: E-Module; Higher Order Thinking Skills; STEAM Approach

Introduction

Information and communication technology advancements have altered human lifestyles, including those related to employment, socializing, and education (Husain & Kaharu, 2020). In the 21st century, both educators and students must possess teaching and learning skills. To thrive in this knowledge-based, information-technology-driven society, a variety of obstacles and possibilities must be overcome (Sole & Anggraeni, 2018). The "4C" competencies—Critical Thinking, Communication, Collaboration, and Creative Thinking—are the four components of 21st-century talents (Indarta et al., 2021; Muhali, 2019). The "4C" competencies—Critical Thinking, Communication, Collaboration, and Creative Thinking—are the four components of 21st-century talents (Dewi et al., 2023; R. Rahayu et al., 2022). One way that educators may help students get ready for the digital age is to use their subject-matter expertise, technological know-how, and facilitation skills to support advanced learning experiences, creativity, and innovation in digital learning contexts (Gjelaj et al., 2020; Marnita et al., 2023). The assumption behind 21st century skills is that people today live and work in a technologically dependent environment with an abundance of information, a high rate of technical advancement, and novel patterns of communication and collaboration (Nouri et al., 2019; Resti, 2018; Teo, 2019). Success in this digital world actually depends on having the necessary skills, which include critical thinking, problem-solving, communication, and teamwork abilities (Afandi et al., 2019; Zubaidah, 2019). Currently, the world of education is required to always and always adapt to technological developments, especially adapting its use to the world of education, especially in the learning process

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(Kumbara & Rodliyah, 2021; Meletiou-Mavrotheris et al., 2022). Thus, 21st century skills must be mastered and possessed by every student in order to face the Industrial Revolution 4.0 (Budiman, 2017; Haifaturrahmah et al., 2020). Technological advances have brought various improvements in education policies throughout the world, including Indonesia. National education policies continue to experience renewal and innovation following current developments in learning technology because more and more developed countries have utilized technological developments in educational innovation platforms (Budiman, 2017; Zen, 2019).

E-modules are digital reproductions of printed modules with accompanying software that may be read on a computer or other electronic device. An electronic module is a tool or facility for learning that includes content, approaches, constraints, and methods of evaluation that are planned methodically and engagingly to acquire the desired competences in accordance with the degree of complexity (T. Rahayu & Pertiwi, 2022; Zulhelmi, 2021). Students will acquire the subject more readily if they use e-modules because the learning process involves using a variety of approaches in addition to reading in a textbook-style format (Nopiani et al., 2021; Yadav et al., 2014). Learning that uses e-modules will direct students to carry out learning independently because e-modules are a tool for learning (Rahmadhani et al., 2021). E-Modules can support independent learning and allow students to gauge their own comprehension. The learning activities in e-modules have an end goal so that students can know what they need to master or comprehend in order to reach the goal (Ardianti & Amalia, 2022; S. Sirate & Ramadhana, 2017). The anticipated topic competencies/subcompetencies are achieved through the use of e-interactive modules, which are learning resources with content, methods, limitations, and evaluation methods that are developed methodically and engagingly in accordance with the level of complexity (Risma Mutmainah, Ghullam Hamdu, 2020; Sotiriou & Bogner, 2020). Students can benefit from independent and traditional learning with the help of e-modules (electronic modules). Additionally, it may make learning more engaging, interactive, and capable of communicating historical ideas through images and videos to make the offered information simpler to absorb (Kuncahyono & Aini, 2020).

Considering the importance and benefits of the existence of E-Modules, a preliminary study was carried out in the form of observations at elementary schools to see how e-modules were developed in the field.Researchers found that in this school there were no teaching materials that could make students enthusiastic in participating in the learning process. Furthermore, researchers also found that there are still many students who do not have good scientific attitudes, such as being embarrassed to ask questions, embarrassed to express opinions and so on. This can be proven when the teaching and learning process takes place, where it can be seen that students' scientific attitudes such as curiosity are still low, which is proven when students are given questions by teachers that stimulate students' curiosity about the subject matter being studied, only a few students respond while other students choose to sit, be quiet, listen and take notes on the material being studied. Apart from curiosity, attitudes of responsibility, discipline, honesty and cooperation are still very low. Furthermore, researchers also found that there are still many students who do not have good scientific attitudes, such as being embarrassed to ask questions, embarrassed to express opinions and so on. This can be proven when the teaching and learning process takes place, where it can be seen that students' scientific attitudes such as curiosity are still low, which is proven when students are given questions by teachers that stimulate students' curiosity about the subject matter being studied, only a few students respond while other students choose to sit, be quiet, listen and take notes on the material being studied.

Through teacher interviews, information was also gathered that each school had received government aid in the form of computers and tablets to make it simpler for instructors to carry out instruction, but that these tools were not actually used in the instruction process and were instead merely kept in the teacher's room. The learning process also underutilizes other technology-based resources such school Wi-Fi, Infocus, and learning programs, which would actually make things easier for teachers. This is a compelling reason to create teaching materials that are technologically integrated and employ student-oriented methods, based on curriculum analysis, analysis of student characteristics, and analysis of needs, so that teachers can efficiently carry out the teaching and learning process and achieve the highest levels of student learning. Researchers are creating instructional materials, notably e-modules, because they have discovered a number of issues at the school and via teacher interviews. This will help kids become excited about studying and help them adapt to modern technology advancements. STEAM-focused E-module teaching resources are one approach that is extremely appropriate to adopt to enhance critical thinking abilities and scientific attitudes in primary schools.

In this research, researchers chose to use an application Kvisoft flipbook maker. According to (Suri et al., 2020) Kvisoft Flipbook Maker is a program that can aid in the learning process because it allows for the inclusion of motion animation, audio, and video, allowing for the expansion of the learning process beyond purely written instruction and creating an

engaging, interactive learning environment for students. Because the Kvisoft flipbook maker application is a soft file that can be viewed both online and offline, using it doesn't have to be expensive. Through online access, this program is freely or cost-free to download. Because it may integrate motion animation, Kvisoft Flipbook Maker is a learning tool that can support and aid the process of learning (Junaidi, T., Hidayat, MT, Effendi, DI, Rizki, A., & Nuriana, 2022; Triwahyuningtyas et al., 2020). Because the Kvisoft flipbook maker application may be used both online and offline and is available as a soft file, using it doesn't have to be expensive (Chen et al., 2019; Wibowo & Pratiwi, 2018). Through thinking and investigating activities in problem-solving based on five integrated scientific disciplines, students can develop ideas or major ideas based on science and technology using the STEAM learning approach (Cook et al., 2020; Hasanah, A., Hikmayani, A. S., & Nurjanah, 2021). Additionally, STEAM encourages kids to observe, research, and ask questions in order to learn more about the world around them. The advantages of STEAM education include fostering independent thought, as demonstrated by the fact that teachers explain fundamental concepts and that most students work alone or in small groups for their undertaking (Hsiao & Su, 2021; Malele, V., & Ramaboka, 2020; Nurhikmayati, 2019; Suganda et al., 2021).

Method

The research and development methodology is being used in this study. A research technique called "research and development" is used to create and test goods that will eventually be used in the field of education. Development research is research conducted to create specific items and evaluate their efficacy (Sugiono, 2022). Development research seeks to generate goods by taking into account the degree of need in order to create an efficient good (Desyandri & Vernanda, 2017). In order to address issues that were discovered during observations at the Central Pariaman District Elementary School, researchers conducted this Research and Development study. The end result of this research and development will be a STEAM approach-focused e-module that will help fourth grade pupils in elementary schools build their high-level skills and scientific attitudes. The development model used in this research is the ADDIE (Analyze, Design, Development, Implementation, Evaluation) model. This ADDIE model can be used in various forms of product development, one of which is E-module development. The ADDIE model is a model that is still very relevant to use because this model can adapt very well to various conditions and there are revisions and evaluations at each stage.(Kurnia et al., 2019). The application of the five ADDIE development steps in this research can be seen in the concept map below (Figure 1).

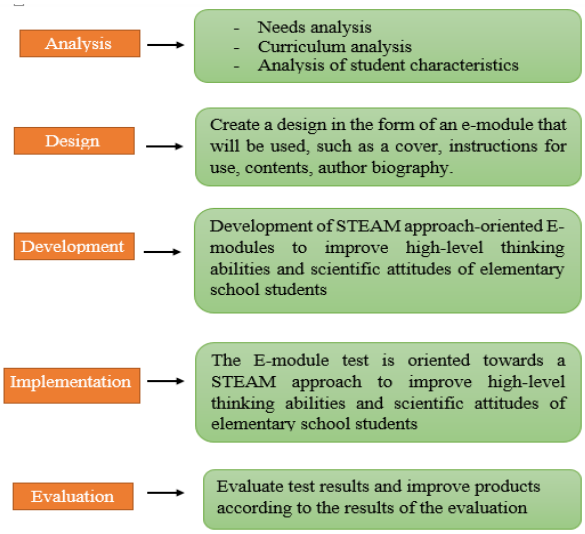

Figure 1. Research Procedures

The subjects of this research were grade IV elementary school students in Pariaman Tengah District, Pariaman City, namelySDN 17 Kampung Baru, SDN 04 Rawang, and SDN 02 Karan Aur. The reasons for choosing this research subject are that students have conditions that are in accordance with research needs, the school's external and internal environment supports the implementation of research, school facilities and infrastructure are sufficient for carrying out research, teachers are able to carry out the designed learning development and there is a positive response and support from the school community.

There are three instruments for this research, namely a validation instrument in the form of a validation sheet to test the validity of the development of a STEAM approach-oriented E-module to improve students' high-level thinking skills and scientific attitudes for fourth grade elementary school students. The practicality instrument is a module questionnaire oriented towards an integrated STEAM probing probing approach using a Likert scale with five alternative answers, namely very practical, practical, quite, not very practical, very not practical. The effectiveness instrument is in the form of test items to determine the level of effectiveness of the development product, in terms of how much the STEAM approach-oriented e-module is able to provide results as expected.

Result and Discussion

When conducting a needs analysis, data is obtained from interviews with teachers and students as well as a

review of previous research literature. At this stage, results were obtained regarding various problems in the application of learning, including the learning process not running properly because there were still many teachers who had not integrated subjects according to established principles and carried out activities in accordance with real life. In general, learning in class only implements low-level thinking aspects including remembering, understanding and applying. Meanwhile, aspects of higher level thinking such as analyzing, synthesizing and evaluating are rarely applied.

The electronic module or E-Module developed contains IPAS (Independent Curriculum) class IV semester 1. This material is based on the STEAM learning approach where each material described contains projects which contain STEAM components. The storyboard design is designed to be a reference in developing STEAM-based electronic modules for high-class learning. Some of the software used in developing this electronic module is Kvisoft Flipbook Maker. At the develop and select instructional materials stage, researchers develop teaching materials that are appropriate to the learning strategy. The teaching materials chosen are STEAM-based e-modules in the form of flipbooks. Furthermore, the STEAM-based E-module will be validated by experts which includes media validation, language validation and material validation. Below are presented the results of the average percentage of validation from validators.

Table 1. Media Expert Validation Results

Aspect	Average (%)	Category
Product content design	81	Valid
Product sample design	84	Valid
Product size	86	Very Valid
Average of all aspects	83.6	Valid

In the table above it is shown that the average percentage of overall media expert validation is 83.6% with the valid category. When carrying out validation, there is input and criticism from the validator which is used as material to perfect and revise the e-module before it is tested on students. Next, the media validator's input and suggestions are to change the background color to make it look brighter, replace the background in the initial display with a more attractive image, make all designs in changing themes the same, change the type and size of the font to be larger. The researcher followed the input from the validators well and found media expert validation results as shown in the table above.

The next stage is linguist validation which is reviewed in terms of straightforward, communicative, diagnostic and interactive aspects, suitability to student development, conformity to language rules, and use of terms and symbols. The results obtained from the linguist validation can be seen in Table 2.

Table 2. Linguist Expert Validation Results

Aspect	Average (%)	Category
Straightforward	88.2	Very Valid
Communicative	86.7	Very Valid
Diagnostic and interactive	85	Valid
Suitability of language to student development	87.1	Very Valid
Conformity with Indonesian language rules	84	Valid
Use of terms and symbols	86	Very Valid
Average Overall aspect	87.21	Very Valid

The table above shows that the average percentage of overall validation results for linguists obtained was 87.21%, which is classified as very valid. When carrying out validation, there is input and criticism from the validator which is used as material to perfect and revise the e-module before it is tested on students. Input and suggestions from the language validator are the layout of symbols, the use of good Indonesian spelling, eliminating words that contain double meanings and adjusting capital letters, writing the source on each image entered, writing for English or foreign words in italics. The next stage is material expert validation in terms of aspects of material content and presentation. The results obtained from material expert validation can be seen in Table 3.

Table 3: Material Expert Validation Results

Aspect	Average (%)	Category
Suitability of material to learning objectives	85.8	Very Valid
Material accuracy	83	Valid
Update of Material	88.1	Very Valid
Create students' curiosity	85	Valid
Supporting the presentation of material	85	Valid
Material presentation techniques	87.4	Very Valid
Correspondence and continuity of thought flow	86	Very Valid
Presentation of learning	89	Very Valid
Overall Aspect Average	86.16	Very Valid

The table above shows that the average percentage result for the overall validation of material experts was 86.16%, which is classified as very valid. When carrying out validation, there is input and criticism from the validator which is used as material to perfect and revise the e-module before it is tested on students. The results of the material validator's input and suggestions are to adapt to the learning objectives, pay attention to class assessments, complete the material indicators listed, pay attention to word choice so that students can understand

the meaning conveyed, adjust instructions to the material and search for research material at school.

The calculation of the shift in the average validation value for each aspect obtained a very valid category. This means that the product being developed or e-module can be used in class IV elementary school learning because it has a very valid status. Below is a diagram of the overall results of e-module validation in this research.

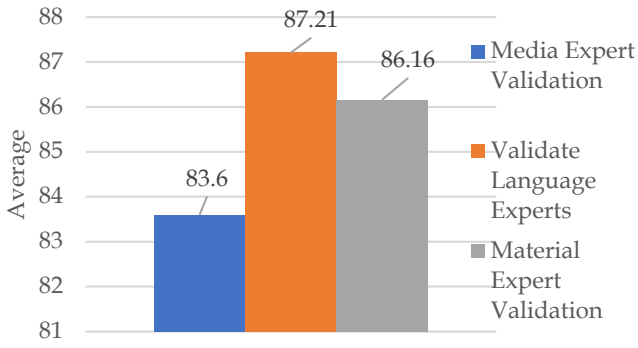

Figure 2. E-Module Validation Results

The image above explains that the product developed is good and can be used in elementary school learning. The average validation result for these three aspects is 85.65, which is included in the very valid category. This means that the e-module developed in this research follows the applicable rules in terms of media, language and learning materials.

The testing stage comes next, and it tries to gauge how well and how positively students react to the e-module being created. One-on-one, small-group, and field trials were conducted at this point. Three students conducted one-on-one trials, five students conducted small group trials, and thirty students conducted outdoor trials. The table below displays the findings from one-to-one and small group experiments.

Table 4: Results of One To One and Small Group Trials

Aspect	One To One Trial (%)	Small Group Trials (%)
Learning Design	84	90
Operational	86	89
Visual Communication	83	86
Average	84	88.3

Based on the table above, the average percentage calculation results at the one to one trial stage were 84, this shows that the electronic module product in the form of a flipbook that has been developed very well. As for the input obtained when the one to one test was that there were several sentences that were unclear so it was difficult to understand and the choice of background color in the material was not quite right so it was a little annoying. From the previous stage, namely one to one testing, input from students became revision material for the next e-module product. Then the revised product is tested in a small group. At this stage, the trial was carried out by five students who were selected based on different levels of knowledge using a questionnaire with a total of 11 questions. The results of the small group trial can be seen above, with an average value of 88.3. This proves that the development of this e-module product is getting better as proven by the results of the increasing average value. This also shows that the electronic module product in the form of a flipbook that has been developed is good. The input obtained during the small group trial was adding cartoon animation to the electronic module and there were questions that confused students and had to be clarified.

The next stage is the field trial. The data obtained from the results of the field trial are student learning outcomes which include the cognitive domain which includes evaluation scores and competency tests with the C4-C6 question domain, namely analysis, evaluation and creation which is part of improving level thinking abilities. tall. In this field trial, the tests are in the form of pretest, posttest and project. According to Kim and his team, project-based learning allows students to realize concrete projects by developing their creativity and respecting their learning style (Kim et al., 2019). Before the electronic module is implemented in the learning process, students are given a pretest first. The pretest questions consist of 5 essay questions. After carrying out the pretest, a learning process was carried out in the form of STEAM project activities. And after learning at the final stage, students are given a posttest. The following is the appearance of the e-module after it has been improved based on validator input and suggestions.

Figure 3. Material in the E-Module

Figure 4. Project Creation 1

Figure 5. Material in the E-module

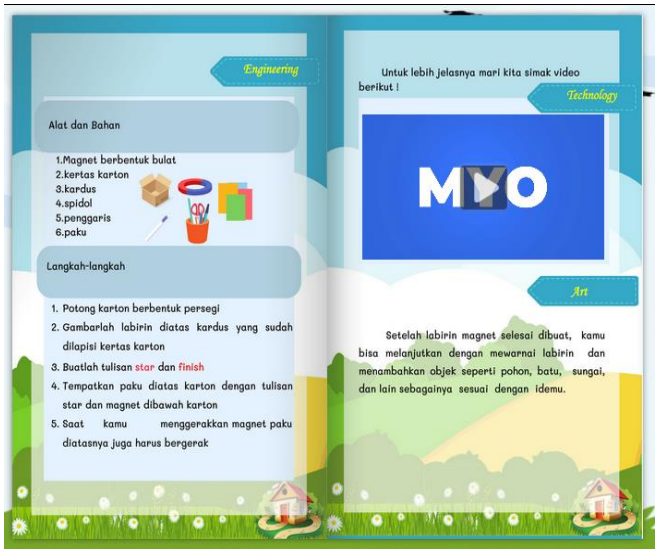

Figure 6. Creation of Project 2

Before designing a project, students are given a stimulus first. The stimulus given is a field trial in the form of a project assignment in which students are formed into 6 groups of 5 students each. Class IV was formed into five groups to complete the projects contained in the e-module. Before working on the project, researchers provide stimulus to students by showing pictures, then students are assigned to observe the pictures and prepare materials and plan for the project. After that, students write down ideas and designs after observing the picture. During project activities, students write down the problems they find and then discuss solutions to these problems.

During the project activities, the researcher observed the students' performance and asked questions to build students' understanding of the project being carried out. From the observations, there was one group that was unsuccessful in working on the project, students had difficulty dividing tasks within their group and also had difficulty using and creating the project. Students are directed to evaluate the problems contained in the product*And*The results found were that there was an error in the installation of the wheels which caused an imbalance in the movement of the car loaded with used bottles. To increase knowledge about the project being carried out, the researcher provides a STEAM-based module for students to read it and then summarize the material that has been read on an observation sheet or post test in working on the student's project using tools and materials that can be found at home such as markers, rulers, cardboard. , scissors and others. Tools also include crayons, pencils, rulers, and scissors. Technology includes all toys children use for play, from basic to sophisticated designs, as well as commonplace simple devices, thus it is important to make sure the technology is age-appropriate (Estrianto, 2020; Quigley et al., 2020). After completing the STEAM project, students are given post test questions consisting of 5 essay questions.

To analyze the increase in students' high-level thinking abilities, a prerequisite test is carried out first, namely the normality and homogeneity test. If the data is normally distributed and homogeneous, then the next test uses the*paired sample t-test*. The results of the calculation of the posttest data description are as follows (Table 5).

Table 5. Analysis of Pretest and Posttest Descriptions

Mark	Test	
	Pretest	Posttest
Number of Students	30	30
Mean	69.74	92.07
Standard Deviation	7.28	7.93
Minimum Value	58	61
Maximum Value	79	96

Based on data from students' pretest and posttest results, it is known that the average student learning outcomes before implementing learning with STEAM-based e-modules was 69.74 and the minimum score obtained was 58 and the maximum score was 79. The average obtained after implementing learning with STEAM-based electronic modules, it was 92.07 and obtained a minimum score of 79 and a maximum score of 96. Based on the pretest and posttest scores, it can be used to determine the effectiveness of learning using STEAM-based electronic modules with the normalized N-gain formula. The normalized N-gain results of student learning outcomes obtained an average of 71.08 according to Hake's criteria (1998: 1) The average achievement shows that learning outcomes using STEAM-based electronic modules are categorized as high. After getting the normalized N-gain results, the learning results are then subjected to a prerequisite test. Prerequisite tests are carried out before the paired sample t-test is tested. Results of analysis of pretest and posttest scores for high-level thinking abilities.

Table 6: Paired Sample T-Test results

Test type	Normality	Homogeneity	Paired Sample T-Test
Pretest	0.081	0.103	0.000
Posttest	0.172		

Based on the table above, the results of the pretest and posttest analysis of students are known The data is normally distributed because the sig value. > 0.05. The normality of the data was tested using Shapiro-Wilk to obtain a significance level amounting to 0.081 for the pretest score and 0.172 for the posttest score. The results of the homogeneity test with a significance level of 0.103 > 0.05 indicate that the data variations are homogeneous. After the prerequisite tests were carried out, the pretest and posttest data were analyzed using the paired sample t-test. The paired sample t-test results were obtainedsignificance value of Sig. 0.000 <0.05so the data shows that there are differences significant difference between before using STEAM-based e-modules and afterwards, so it is stated that STEAM-based electronic modules can increasing the high-level thinking abilities of high-class students. In line with research Kimianti and his team revealed that the development of e-modules can improve student learning outcomes(Kimianti & Prasetyo, 2019). Other research conducted by Kuncahyono revealed developmentsThis e-module is said to be effective as a teaching material because it changes the learning style of children who used to learn so monotonously centered on the teacher. With the use of this electronic module, children learn to be more flexible, communicative and independent.(Kuncahyono & Aini, 2020). Thus, the development of electronic modules can improve problem solving and high level thinking abilities.

Therefore, the STEAM approach is suitable for students in the 21st century which requires students to have high-level thinking abilities. High Order Thinking Skills or higher order thinking skills are ways of thinking that equip students with the deep conceptual understanding needed to use their knowledge to solve problems in the real world. When students are engaged in learning activities, they are able to expand the knowledge they have learned and generate new ideas, which allows them to think more critically (Ramdani et al., 2019; Susanti et al., 2022). Students who have higher-order thinking abilities are better prepared to express their thoughts, make informed decisions, and conquer challenges. Higher-order thinking skills, on the other hand, demonstrate how students reason, including the development of knowledge and the ability to group complex concepts. The thinking ability required is not the ability to think in solving ordinary problems, but students are also required to be active in the learning process. Because in this era and in future eras the problems that each individual will face will be more complex. This is what educational institutions must develop in the learning process at school (Fauziah & Fitria, 2020). The aim of this research is to develop an electronic module oriented towards the STEAM learning approach. This e-module is used to improve elementary school students' high-level thinking abilities. This development will produce a product in the form of an e-module that is valid, practical and effective for use in elementary schools.

The goal of STEAM-based education is to develop students' knowledge and comprehension of science, technology, engineering, art, and mathematics so that they can utilize this information to solve issues and make decisions for advancement (Saddhono et al., 2020). The STEAM technique offers many benefits, including 1) Promoting an awareness of the connections between the concepts, principles, and techniques of a specific scientific subject, 2) Getting children interested in learning, fostering their imaginations and critical thinking, and 3) Encouraging them to comprehend and try out relevant processes (Estrianto, 2020). Getting pupils habituated to problem-solving in a creative approach is one of the other objectives of STEAM learning, in addition to enhancing students' capacity for critical, creative, and communicative thought. assisting in educating the future generation to deal with developments (Boice et al., 2021). Teachers have identified pedagogical, technical, facility, STEAM learning resource, and time constraints as obstacles to implementing STEAM learning. It is evident that the teacher has integrated STEAM-related learning activities. E-Modules can help students study

independently and using traditional methods, and they can also make the learning process more engaging,interactive, and capable of communicating historical messages through images and videos. To make the information offered more understandable (Zulhelmi, 2021). The use of e-modules in education has the following benefits: (1) It can increase student motivation. (2) The existence of an evaluation enables instructors and students to determine which sections are incomplete or completed. (3) Study materials can be split up to be provided more equitably across a semester (Wibowo & Pratiwi, 2018).

Conclusion

Based on validation findings from media, language, and material specialists, the STEAM e-module teaching materials generated were deemed adequate and valid for use in the learning process. In addition, the outcomes of one-on-one and small group trials done on students with this STEAM-based electronic module teaching material were positive. The presentation of STEAM-based electronic modules is made appealing by include projects and animations in addition to detailed explanations of each STEAM discipline, which encompasses science, technology, engineering, art, and mathematics. Based on the outcomes of field tests, this STEAM-based electronic module can help students become better at high-level thinking and can be a tool for independent study.

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Author Contributions

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Conflicts of Interest

This research did not have a conflict during the completion of writing this research. All parties can work together very well.

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