Thematic E-Modules Using the PjBL Model Based on STEAM to Enhance Science Literacy and HOTS

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Abstract

This research aims to develop a thematic E-module utilizing the Project-based Learning (PjBL) model based on STEAM (Science, Technology, Engineering, Arts, Mathematics) and to assess its effectiveness in improving science literacy and higher-order thinking skills among fourth-grade elementary school students. The development method utilized the Borg & Gall model. Research instruments included document analysis sheets, needs analysis sheets, and validation sheets. Data collection techniques involved document analysis, observation, questionnaires, and tests. Data obtained from product assessment sheets, test results, and questionnaires were analyzed both qualitatively and quantitatively. The results indicate that the developed E-Module has demonstrated high levels of validity and effectiveness in enhancing science literacy and higher-order thinking skills among fourth-grade elementary students. Material validity was evaluated using Aiken's V, with an average score of 0.90 (very valid), and a validator agreement rate of 0.92% (almost perfect). Language and design validity were also found to be high, with Aiken's V scores of 0.91 (very valid) and 0.88 (very valid) respectively, and validator agreement rates of 0.80% (almost perfect) and 0.73% (strong) respectively. Based on the calculation of gain scores, the experimental group achieved 0.47 (moderate) compared to the control group's score of 0.25 (low). Additionally, an independent sample t-test showed a significance value of 0.000 (sig <0.05) between the control and experimental groups, confirming the effectiveness of using this E-Module. This research provides a significant contribution to the development of innovative and effective learning materials aimed at enhancing science literacy and higher-order thinking skills among fourth-grade elementary students.

Keywords: Thematic E-Module, PjBL, STEAM, Science Literacy, Higher Order Thinking Skills

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INTRODUCTION

Era 4.0 has presented many technological innovations that make it easier to access information and communication. Era 4.0 is an era of digitalization which has a disruptive impact on human life. The impact of this disruption makes human life more efficient with the aim of improving the quality of life. Technological developments have brought fundamental changes to aspects of human life, including in the field of education (Susanti et al, 2023). With this, education increasingly plays a role in determining the progress of a country.

Learning in the 21st century with the education system and education management will change, relevant skills that need to face change. Related to the skills needed to face 3 changes in facing the demands of the 21st century. According to Supena et al (2021) it is necessary to master learning skills and innovation skills, which consist of 4C, namely Critical Thinking, Communication, Collaboration, and Creavity.

The demands of 21st century competency refer to students' high-level thinking abilities. According to Ennis in Winarni (2012), students' high-level thinking abilities consist of twelve indicators which are grouped into five aspects of high-level thinking. Through this aspect of high-level thinking skills, it is hoped that students can develop high-level thinking skills so that 21st century competencies and the demands of the 2013 curriculum can be achieved optimally.

Facing the challenges of 21st century learning, students need high-level thinking skills in an effort to prepare individuals who are able to compete in the era of globalization. Students really need high level thinking skills in the hope that they will be able to solve the problems they face in the future. According to Susanti et al, (2023) It is very important to train students' high-level thinking skills from elementary school age because high-level thinking skills are one way that can contribute to adjusting attitudes and behavior in dealing with various problems experienced in everyday life.

High-level thinking abilities as a result are related to High Order Thinking Skills (HOTS) which are part of high-level thinking abilities (Ariffiando et al, 2024). According to the Teaching Knowledge Test Cambridge English, The University of Cambridge (2015), HOTS is a cognitive skill which is analysis and evaluation that can be taught by teachers to their students. So that students can develop skills in thinking about things and making decisions about things in solving problems, thinking at a high level and thinking about the positive and negative things about something.

Teaching materials are materials or teaching materials that are prepared completely and systematically in accordance with the principles that the teacher will teach to students (Muktadir & Darmansyah, 2021). The teaching materials used in the learning process must have unique and interesting form, content and presentation methods so that they can foster students' interest in participating in the learning process (Puspitarini & Hanif, 2019). According to Darmansyah et al (2021) Teaching materials are a very important component in learning activities, especially in the implementation of learning. Teaching materials are developed according to the needs of teachers and students (Yuanita & Kurnia, 2019).

This is in line with research by Krissandi (2020) which found that one of the obstacles for elementary school teachers in implementing the 2013 Curriculum was the problem of the availability and shortage of books from the government. The book is a student's book which should be contextual and is considered to be very textual. Apart from needing to adapt to student needs, the development of thematic teaching materials also needs to adapt to curriculum demands.

These electronic teaching materials can also help teachers maximize the use of technology in the learning process. Apart from that, it can be used anytime and anywhere. The choice of electronic teaching materials for thematic learning is also supported by interviews with teachers at SDN 44 Bengkulu City that the teaching materials used by teachers in the learning process still use thematic books for teachers and students without any teaching materials that utilize technology. This often makes students feel bored during the learning process.

The STEAM approach was chosen to be integrated into teaching materials because it contains elements of science, technology, engineering, art and mathematics. Apart from that, the STEAM element was chosen so that when using this teaching material students and teachers do not feel unfamiliar with the demands that must be achieved, because the basic competencies used in the science, technology, engineering, arts and mathematics

learning content are in accordance with the demands of the learning being developed.

Teaching materials with a STEAM approach can provide active and interesting learning activities, help students understand teaching materials well, and develop high-level thinking skills and be creative in dealing with real-world problems in the environment (Afriana, Permanasari, & Fitriani 2016). Research conducted by Harjanty & Hardianti (2020) entitled "Analysis of the Application of STEAM-Based Learning". The simple result is that STEAM applications have appeared in learning activities that have been implemented but teachers still do not fully understand STEAM learning regarding its elements and aspects.

The learning process can be carried out through model stages that are integrated with approaches, one of which is the PjBL model with a STEM approach. PjBL with a STEM approach is integrated project-based learning in the STEM field which can provide opportunities for students to learn contextually such as exploring, planning learning activities, implementing projects collaboratively, and ultimately producing a product (Jauhariyyah, Suwono, & Ibrohim 2017). The PjBL-STEM model is project-based learning which has science, technology, engineering and mathematics criteria (Annisa & Damris 2018).

Learning with a STEM approach encourages students to have a positive attitude in the academic field. So it can be concluded that the relationship between science and technology and other knowledge cannot be separated in learning. Science requires mathematics as a tool for processing data, while technology and engineering are applications of science. The STEAM integrated PjBL learning model is a learning context designed by teachers to encourage students to be directly involved in learning activities (Siew et al, 2015).

Teachers' lack of understanding with STEAM-based PjBL learning also has an impact on students' scientific literacy. This is proven that Indonesia is still at level 1, which is a low level and Indonesia has a score of 396, while the standard for the average score is 489. In this case, Indonesia is in the 6th lowest of 78 countries. Based on this data, scientific literacy abilities in Indonesia are still behind other countries (Schleicher, 2019). This can also be seen from the low high-level thinking abilities of elementary school students.

An alarming fact was also revealed from the international literacy ranking, Most Literate Nations in the World, published by Central Connecticut State University in 2018. The literacy level of Indonesian society is very lagging behind. Indonesia is in 60th place out of a total of 61 countries. This is proven by the score which is still below the international average in 2018. The international average score for science at this level is in the bottom 5 of 77 countries, namely 371 (PISA, 2018).

The results of the 2022 Program for International Student Assessment (PISA) study show that Indonesia is ranked 68th with the following scores: mathematics (379), science (398), and reading (371) (OECD, 2023). The average results for these three subjects decreased by 12-13 points compared to 2018, indicating a decline (learning loss). Overall, the PISA 2022 results can be classified as low. The research results of Sari & Nurwahyunani (2016) revealed that one of the causes of students' low scientific literacy is teachers' lack of knowledge about scientific literacy.

One solution to improving scientific literacy skills is to develop teaching materials in the form of e-modules using the STEAM-based PjBL model for science learning content. The learning activities provided in the e-module use the STEAM approach, students are directed to the real world as a context for learning critical thinking and problem solving skills by identifying the purpose of the problem and finding solutions to the problem. This is in line with previous research which explains that Project Based Learning (PjBL) with integrated Science, Technology, Engineering, Art, and Mathematics (STEAM) is important to apply in science learning to help students improve problem solving abilities (Fathoni et al, 2020).

The results of research conducted by Chania et al (2020) show that the development of teaching materials using a STEM approach that focuses on Higher Order Thinking Skills (HOTS) meets quality criteria that are very suitable as a teaching material for student learning. From the research findings, it can be concluded that the characteristics of teaching materials developed through the HOTS-oriented STEM approach include questions that refer to Bloom's Taxonomy at levels C4, C5, and C6. This indicates that the teaching materials are in accordance with the high level of thinking expected in learning.

Based on the description of the problem above, the researcher felt motivated to develop teaching materials entitled "Development of Thematic E-Modules Using the STEAM-Based PjBL Model to Improve Science Literacy and Higher Level Thinking Abilities in Grade IV Elementary School Students".

METHOD

This research uses a research and development (R&D) approach. Development research is a method for developing a new product or improving an existing product and can be accounted for. According to Borg and Gall (1988), Research and Development is a research method used to develop or validate products used in education and learning. According to Gay at al (2009) Research and Development is the process of finding out consumer needs and developing products that suit their needs. The aim of research and development is not to formulate test theories but to create products that are effective for use in schools.

This research is educational research and development which aims to develop thematic e-modules using the STEAM-based PjBL model. Educational development research includes the development process, product validation, and product testing. Through development research, researchers strive to develop a product that is effective for use in learning

The e-module development design in this research refers to the Borg & Gall research model. Borg & Gall (1983: 772) state that there are two main objectives in research and development procedures, namely: 1) producing products, and 2) testing the effectiveness of products in achieving goals.

This research and development refers to the Borg & Gall model, so the research implementation uses the ten R&D steps of the Borg & Gall model. The ten steps include: research and information collecting, planing, develop Preliminary form of product, preliminary field testing, main product revision, main field testing, operational product testing, operational field testing, final product revision, and dissemination and implementation. To make it easier, here is a chart that shows the flow of research and development using the Borg & Gall model.

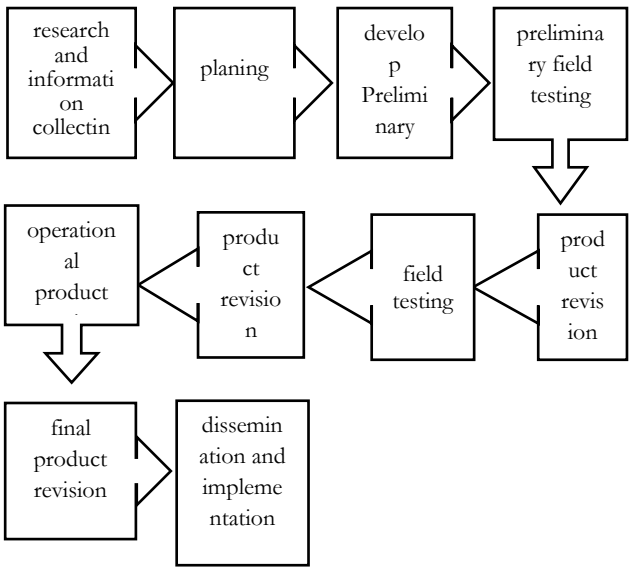

Figure 1. Chart of product development steps according to the Borg and Gall development stages

The initial field trial subjects were conducted at SDN 55 Kota Bengkulu, involving 26 fourth-grade students. The field trial subjects at SDN 41 and SDN 05 Kota Bengkulu consisted of two fourth-grade teachers and 50 students. The operational research subjects were fourth-grade students at SDN 44 Kota Bengkulu, with 29 students in class IVA as the experimental group and 29 students in class IVB as the control group. The research objective was the development of thematic e-modules using PjBL Based on STEAM to enhance the science literacy and higher-order thinking skills of fourth-grade students.

The operational trial was conducted with one class at SDN 44 Kota Bengkulu using a One Group Design. The experimental design is outlined as follows.

Groups	***Pretest Meassure***	***Treatment***	***Posttest Meassure***
One group	O_1	*X*	O_2

Explanation:

O_1	=	*Pretest for control and experimental groups*
O_2	=	*Posttest for control and experimental groups*
X	=	Treatment using the STEAM-based PjBL e-module product.

The operational field test of this research involves one experimental class using the STEAM-based PjBL e-module product. The steps for the operational field test are as follows:

1. Conducting the operational field test with different students from those involved in the previous stages. This activity involves one class.
2. Administering a pretest on science literacy and high-level thinking skills to the fourth-grade students initially.
3. Providing the experimental class with treatment by using the PjBL-based STEAM e-module product during the learning activities.
4. Administering a final test (posttest) to all students in the experimental class to measure the learning outcomes of science literacy and high-level thinking skills.
5. Analyzing the results of the final test (posttest).
6. After analysis, comparing the results of the pretest and posttest.

The data collection techniques used in the research on developing thematic e-modules using the PjBL-based STEAM model include observation, interviews, questionnaires, product assessment scales, and tests. The data obtained from product assessment sheets, test results, and questionnaire sheets are analyzed using both qualitative and quantitative statistical methods.

1. Qualitative data, such as comments and suggestions obtained from subject matter experts, language experts, presentation experts, evaluation experts, practitioners, and colleagues, are analyzed and qualitatively described to revise the developed product.
2. Quantitative data, including scores from subject matter experts, design experts, language experts, responses from teachers and students regarding the e-module, as well as pretest and posttest results, are analyzed quantitatively.

RESULT AND DISCUSSION

1. Development of Thematic E-Modules PjBL Based on STEAM

a. Field Study

The field study was conducted to explore the problems in the field, in this case, elementary schools, followed by a needs analysis for the development of e-modules using the PjBL model based on STEAM. Several activities conducted during the field study are as follows.

1. Observation

Observations were carried out to gather information about the problems occurring in schools. The observation activity was conducted at SDN 44 Kota Bengkulu.

The first observation was conducted in Grade IV at SDN 44 Kota Bengkulu on February 19, 2024. Based on the observation results, several problems were identified in the classroom, as follows.

a) Students appeared active in answering questions posed by the teacher, but they struggled to develop answers to follow-up questions from the teacher.
b) Learning activities seemed to only train students to think at the knowledge and comprehension levels. Students had difficulty providing solutions to problems presented by the teacher.
c) Interactions among students in the classroom lacked effective collaboration. Students appeared to learn individually.
d) Both teachers and students in learning activities were still fixated on the main theme book as the primary source. The use of learning modules that could stimulate higher-order thinking skills had not been incorporated into the teaching. Learning resources appeared inadequate in supporting students' science literacy.

Based on the observations conducted, initial conclusions can be drawn regarding the lack of students' skills in addressing problems posed by the teacher, the insufficient availability of science literacy module reading materials in the classroom, and the limited use of learning modules that could support and develop higher-order thinking skills.

2. Teacher Interviews

Interviews were conducted with a source who is a fourth-grade teacher at SDN 44 Kota Bengkulu. The interview conducted on February 21, 2024, yielded several points as follows:

a) Teaching materials in the form of learning modules are more abundant for Mathematics subjects, while teaching materials supporting science learning, particularly for topics related to

environmental balance and natural resource conservation, consist mainly of pictures depicting forests, tree felling, reforestation, etc.

b) The high-level thinking skills of students are still lacking. Teachers mentioned that the demand for high-level thinking skills is still very challenging to teach to elementary school students. Students are still at the level of knowledge acquisition and have not reached the level of understanding. They still struggle to answer questions that require high-level thinking skills.

c) Student scientific literacy is still inadequate. According to the teachers, some students struggle to understand basic concepts of Natural Sciences. They find it difficult to apply these concepts in real-life situations or understand their practical implications.

d) Teachers expressed the need to develop learning modules that can support student scientific literacy and high-level thinking skills.

e) There is a need for the development of e-modules using a PjBL-based STEAM model. Teachers agree that e-modules using a PjBL-based STEAM model are highly needed to be developed as learning support in schools.

3. Needs Analysis Questionnaire

The needs analysis questionnaire was used to assess the requirements for developing thematic e-modules using the PjBL-based STEAM model from a broader subject pool.

a) Teacher Needs Analysis Questionnaire

The distribution of the needs analysis questionnaire containing 15 statements was conducted to determine the requirements for developing thematic e-modules using the PjBL-based STEAM model. The questionnaire was given to 11 elementary school teachers in Bengkulu City, and the results are presented in Table 2.

Table 2. Results of Teacher Needs Analysis Questionnaire

No	Statement	Percentage (%)
1	Teachers agree that the instructional materials used in the module are sufficiently varied.	63.64%
2	Teachers believe that instructional materials in the form of modules are highly needed in the schools where they teach.	72.73%
3	Teachers agree that the instructional materials should be electronic.	100%
4	Teachers express interest if there are e-module instructional materials available.	72.73%
5	Teachers express interest if there are e-module instructional materials available.	72.73%
6	Teachers agree that digital-based learning is needed.	100%
7	Teachers sometimes implement Higher Order Thinking Skills (HOTS)-based learning.	54.55%
8	Teachers agree that the development of e-modules using the PjBL-based STEAM model is needed.	72.73%
9	Teachers agree that student literacy in science in science learning is needed.	100%
10	Teachers state that the instructional materials used so far have not been able to improve students' scientific literacy and higher-order thinking skills.	54.55%
11	Teachers state that the development of thematic instructional module materials to improve scientific literacy is needed.	81.82%
12	Teachers state that the media used so far have not been effective in providing stimulus for students to be proficient in science learning.	54.55%
13	Teachers state that the instructional module materials used so far have not been effective in providing stimulus for students to skillfully solve problems with appropriate solutions.	63.64%
14	Teachers agree that the development of thematic instructional	72.73%

	module materials is needed to improve higher-order thinking skills.	
15	Teachers agree that the development of thematic e-modules using the PjBL-based STEAM model is needed.	81.82%

b) Student Needs Analysis Questionnaire

The needs analysis questionnaire consists of ten statements given to students to understand the needs for developing thematic e-modules using the PjBL-based STEAM model from the students' perspective. The questionnaire was administered to 29 fourth-grade students. Based on the questionnaire, the results are presented in Table 3.

Table 3. Results of Student Needs Analysis Questionnaire

No	Statement	Percentage (%)
1	Students feel that the presentation of thematic e-module learning materials used is less engaging.	55.91%
2	Students believe that the learning process using thematic e-module learning materials is necessary.	88.17%
3	Students prefer electronic-based thematic e-module learning materials.	84.95%
4	Students prefer thematic e-module learning materials in the form of descriptions and illustrations.	83.87%
5	Students prefer thematic e-module learning materials in the form of books with application technology.	70.97%
6	Students state that e-modules using the PjBL-based STEAM model are interesting.	73.12%
7	Students state that the development of e-modules using the PjBL-based STEAM model is needed.	69.89%
8	Students agree that STEAM-based learning is needed in science subjects for scientific literacy skills (context, knowledge, competence, and attitude).	92.47%
9	Students say that the implementation of learning trains high-order thinking skills (HOTS) is sometimes done.	62.37%

2. Feasibility of STEAM-Based PjBL E-Module

The validation results from subject matter experts, language experts, and designers are as follows:

Table 4. Expert Validation Results

NO	Validation	Value V	Category
1	Subject Matter Expert	0.90	Very Valid
2	Language Expert	0.91	Very Valid
3	Design Expert	0.88	Very Valid

The recapitulation of the assessment results of the PjBL-based STEAM e-module product can be seen in Diagram 1.

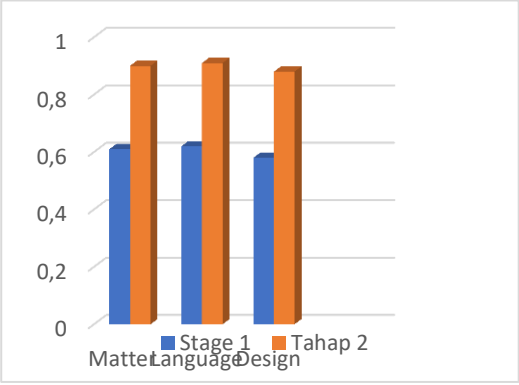

Diagram 1. Product Assessment Results by Validators

Based on Diagram 1, it can be concluded that the product evaluation by experts in the aspects of content, language, and design has improved. In the first stage, the content aspect had a score of 0.60, while in the second stage, this score increased to 0.90. Similarly, the language aspect had a score of 0.62 in the first stage, which increased to 0.91 in the second stage. As for the design aspect, the score was 0.58 in the first stage

and increased to 0.88 in the second stage. The evaluation results by the experts indicate that the e-module using the PjBL-based STEAM model is highly suitable for use as learning material in Grade IV elementary school, with some revisions needed based on feedback and suggestions from the experts regarding content, language, and design.

Product of Revision Results

a. Cover Page of the E-Module with Android Studio Application

On the cover of the e-module, there are features such as developer profiles (about us), content, integration points, module instructions, and evaluation. The text and images in this e-module have been developed according to the suggestions from design experts. The illustrations used on the cover are tailored to the thematic learning topics.

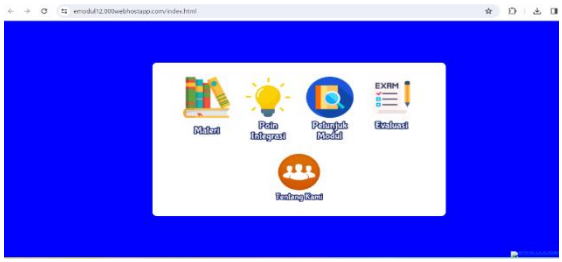

Figure 2. Cover Page

b. STEAM Integration Points

Integration Points contain elements of STEAM integrated into thematic learning. Integration points have undergone several changes after revision. The revised results can be seen in Figure 3.

Figure 3. STEAM Integration Points

c. Module Instructions (KI, KD, Indicators, Learning Objectives)

In the module instructions feature, there are KI (Competence Standard), KD (Basic Competence), Indicators, and Learning Objectives, which have undergone several revisions. The revised results can be seen in Figure 4.

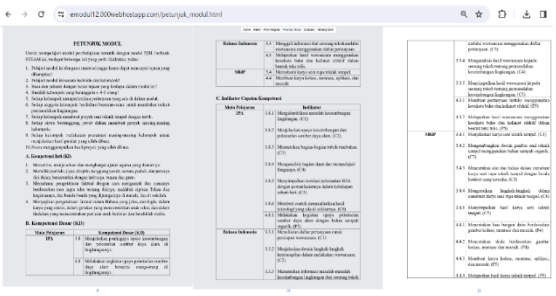

Figure 4. Module Instructions

d. E-Module Content

The content of the e-module includes three thematic learning subjects: Science, Indonesian Language, and Art. The content activities are supplemented with activity identification, questions, and project activities. This content has undergone several revisions. The revised results can be seen in Figure 5.

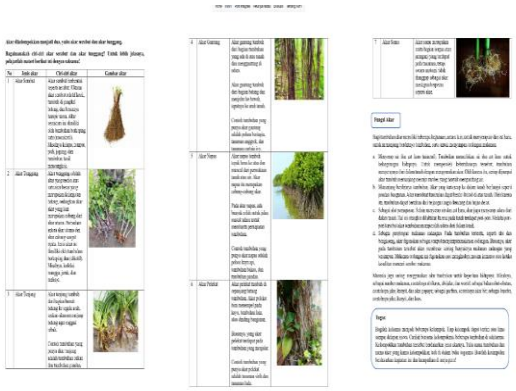

Figure 5. E-Module Content

e. Evaluation

The developed evaluation questions consist of 30 items for testing fourth-grade elementary school students. Each thematic learning subject contains 10 questions. The evaluation questions are conducted using Google Forms. The revised results can be seen in Figure 6.

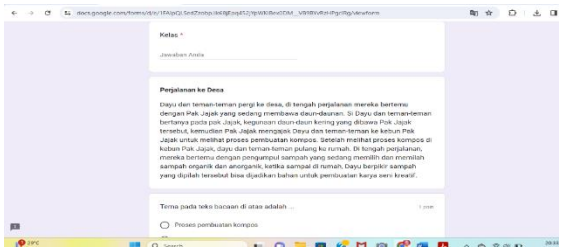

Figure 6. Evaluation Questions

3. Effectiveness of STEAM-Based PJBL E-Module

Student evaluation tests were conducted to assess the effectiveness of the STEAM-based PJBL E-Module in enhancing the scientific literacy and higher-order thinking skills of fourth-grade students. The effectiveness of the E-Module using PJBL based on STEAM can be observed from the hypothesis testing results of the students' pretest and posttest scores. To view the summary of the pretest and posttest results, the student test results are presented in Table 5.

Table 5. Summary of Pretest and Posttest Learning Outcome Data

No	Class	Pretest Average	Postest Average	Gain	Criteria
1	Experiment	57.47	76.18	0.47	Sedang
2	Control	58.73	68.23	0.25	Rendah

Based on Table 5, it can be observed that the average pretest score for the experimental class was 57.47, which increased to 76.18 in the posttest. Based on these pretest and posttest results, a gain score of 0.47 was obtained, falling into the moderate category. Similarly, for the control class, the average pretest score was 58.73, which increased to 68.23 in the posttest. The gain score for this group was 0.25, falling into the low category.

The research by Zulvira & Desyandri (2022) indicates that thematic interactive teaching materials using the STEAM approach are highly valid and practical in thematic learning. STEAM provides an approach to achieving STEAM by integrating the principles of each discipline with art as interdisciplinary learning into critical areas together through new technology and design thinking with investigative processes (Stroud & Baines, 2019). As an educational approach, STEAM motivates students to expand their knowledge of the world around them through observation, experimentation, and asking questions. Additionally, the benefits of STEAM education include stimulating independent thinking, teachers introducing basic concepts, and students having the opportunity to work independently or in small groups to explore their projects (Malele & Ramaboka, 2020). Involving art in the STEAM approach provides children with the opportunity to creatively and imaginatively depict STEM concepts (Wahyuningsih et al., 2020).

The use of interactive teaching materials is highly recommended in classroom contexts as it can enhance joy in the learning process. This is consistent with the research by Putri & Ardi (2021), which shows that interactive teaching materials can create a fun and comfortable learning environment for students. This is due to the diversity of components in interactive teaching materials such as animations, images, and interactive exercises, which can attract students' interest to participate (Setyaningsih & Farida, 2020). The combination of these components allows teaching materials to clarify abstract concepts into more concrete ones (Diyana et al., 2019). When using interactive teaching materials in the classroom, excessive verbal delivery can also be reduced because the material can be presented with static as well as dynamic/animated visualizations (Maria et al., 2019). This means that interactive teaching materials can assist teachers in delivering material without expending excessive energy and can enhance the effectiveness of the learning process.

The STEAM approach in the development of interactive teaching materials aims to support teachers and students during the learning process. As the

learning process takes place, the material taught by the teacher is supported by images contained in interactive teaching materials. This aims to clarify material that is difficult for students to understand and increase interest and learning outcomes (Geni et al, 2020). By providing interesting learning material, students will find it easier to understand the material and increase their motivation to learn, which ultimately will impact the improvement of student learning outcomes.

CONCLUSION

Based on the research and development of the PjBL-based STEAM e-module, it can be concluded that: (1) The development process of the STEAM-based PjBL e-module includes curriculum analysis, needs analysis, and product design with content in Science, Indonesian Language, and Social Studies. This e-module is developed using the Android Studio application, involving stages such as compiling teaching materials, selecting formats, initial designs, research instruments, and implementation using Chromebooks in elementary schools. (2) The STEAM-based PjBL e-module has been assessed for its suitability for use by fourth-grade elementary school students through a validation process in three main aspects: content, language, and design. The validation results indicate that the content suitability has an average Aiken's V score of 0.90 (Very Valid), language suitability obtained an Aiken's V score of 0.91 (Very Valid), and design suitability validation results show an Aiken's V score of 0.88 (Very Valid). Thus, from the validation results of these three aspects, it can be concluded that this e-module is suitable for use as thematic learning material for fourth-grade elementary school students. (3) The STEAM-based PjBL e-module developed in this research has proven to be effective in improving the higher-order thinking skills and science literacy of fourth-grade elementary school students. The assessment of the effectiveness of the e-module is based on the calculation of the gain score, which shows a significant increase from the control group (0.25) to the experimental group (0.47), and the results of an independent sample t-test which yield a low significance value (0.000, sig <0.05).

REFERENCES

Afriana, J., Permanasari, A., & Fitriani, A. (2016). Penerapan Project Based Learning Terintegrasi STEM untuk Meningkatkan Literasi Sains Siswa Ditinjau dari Gender. *Jurnal Inovasi Pendidikan IPA*, 2(2), 202-212.

Annisa, R., Hsb, M. H. E., & Damris, M. (2018). Peningkatan Kemampuan Berpikir Kreatif Siswa dengan Menggunakan Model *Project Based Learning* Berbasis STEAM *(Science, Technology, Engineering, Arts and Mathematic)* Pada Materi Asam dan Basa di SMAN 11 Kota Jambi. *Journal of the Indonesian Society of Integrated Chemistry*, 10(2), 11-19.

Ariffiando, N.F., Susanti, A., Darmansyah, A., Wulandari, S., & Rahman, A.A. (2024). The Foldable Comic Based on Bengkulu Folktales to Enhance Elementary Students' HOTS and Social Awareness. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 9*(1), 4373-4391. https://doi.org/10.23969/jp.v9i1.12988

Chania, D. M. P., Medriati, R., & Mayub, A. (2020). Pengembangan Bahan Ajar Fisika Melalui Pendekatan STEM Berorientasi HOTS Pada Materi Usaha dan Energi. *Jurnal Kumparan Fisika,* 3(2), 109–120.

Darmansyah, A., Muktadir, A., & Anggraini, D. (2021). Pengaruh Penerapan Metode Outdoor Learning Dengan Memanfaatkan Barang Bekas Terhadap Hasil Belajar Siswa Pada Pembelajaran Tematik. *JURIDIKDAS: Jurnal Riset Pendidikan Dasar, 4*(2), 179–189.

https://doi.org/10.33369/juridikdas.4.2.179-189

Diyana, T. N., Supriana, E., & Kusairi, S. (2019). Pengembangan Multimedia Interaktif Topik Prinsip Archimedes Untuk Mengoptimalkan Student Centered Learning. *Jurnal Inovasi Teknologi Pendidikan*, 6(2), 171–

Fathoni, A., Muslim, S., Ismayati, E., Rijanto, T., Munoto, & Nurlaela, L. (2020). STEM: Inovasi Dalam Pembelajaran Vokasi. *Jurnal Pendidikan Teknologi Dan Kejuruan,* 17(1), 33-42.

Gay, L. R., Mills, G. E., & Airasian, P. W. (2009). Educational research: competencies for analysis and applications (9th ed.). Upper Saddle River, N.J.: Merrill/Pearson.

Geni, K. H. Y. W., Sudarma, I. K., & Mahadewi, L. P. P. (2020). Pengembangan Multimedia Pembelajaran Interaktif Berpendekatan CTL Pada Pembelajaran Tematik Siswa Kelas IV SD. *Jurnal Edutech Undiksha*, 8(2), 1–16.

Jauhariyyah, F. R., Suwono, H., & Ibrohim. (2017). *Science, Technology, Engineering and Mathematics Project Based Learning* (STEM-PjBL) pada Pembelajaran Sains. *Pendidikan IPA Pascasarjana UM*, 2, 432–436.

Krissandi, A., D., S. (2020). Kendala Guru Sekolah Dasar Dalam Implementasi Kurikulum 2013". *Jurnal Cakrawala Pendidik*, 3 (3), 457–467.

Maria, U., Rusilowati, A., & Hardyanto, W. (2019). Interactive Multimedia Development in The Learning Process of Indonesian Culture Introduction Theme for 5-6 Year Old Children. *Journal of Primary Education,* 8(3), 344–353

Malele, V., & Ramaboka, M.E. 2020. The Design Thinking Approach to students STEAM projects. Procedia CIRP, 91(1):230-236.

Muktadir, A., & Darmansyah, A. (2021). Pengembangan Bahan Ajar Komik Berbasis Cerita Rakyat Bengkulu di SD. *Jurnal PGSD: Jurnal Ilmiah Pendidikan Guru Sekolah Dasar, 14*(2), 153–159. https://doi.org/10.33369/pgsd.14.2.153-159

OECD. (2023). *PISA 2022 Results (Volume 1): The State of Learning and Equity in Education, PISA*. Paris: OECD Publishing.

Putri, A.A., & Ardi. (2021). Meningkatkan Hasil Belajar Siswa Melalui Multimedia Pembelajaran Interaktif Berbasis Pendekatan Saintifik. *Edutech Undiksha*, 8(1), 1–7.

Puspitarini, Y. D., & Hanif, M. (2019). Using Learning Media to Increase Learning Motivation in Elementary School. *Anatolian Journal of Education,* 4(2), 53-60. https://doi.org/10.29333/aje.2019.426a

Sari, K. & Nurwahyunani, A. 2016. Profil Literasi Sains Siswa SMP Negeri Se Kota Semarang. *Jurnal Pendidikan IPA*. 6(2), 249-361.

Setyaningsih, T., & Farida, S. (2020). Analisis Pemanfaatan Macromedia Flash 8 Sebagai Upaya Pengembangan Media Pembelajaran Tematik Terpadu di Sekolah Dasar. *E-Jurnal Inovasi Pembelajaran SD*, 8(9), 132–149

Siew, N. M., Amir, N., & Chong, C. L. (2015). *The perceptions of pre-service and in-service teachers regarding a project-based STEM approach to teaching science*. Springer Plus, 4(1), 1-20.

Stroud, A. & Baines, L. 2019. Inquiry, investigative processes, art, and writing in STEAM. In M.S. Khine & S. Areepattamannil (Eds.), STEAM education: Theory and practice (pp. 1-18). Springer.

Supena, I., Darmuki, A., & Hariyadi, A. (2021). The Influence of 4C (Constructive, Critical, Creativity, Collaborative) Learning Model on Students' Learning Outcomes. International Journal of Instruction, 14(3), 873-892. https://doi.org/10.29333/iji.2021.14351a

Susanti, A., Yuliantini, N., Prabowo, A., Melisa, M., Andini, T., & Darmansyah, A. (2023). The Development of Totor Gala Traditional Game Learning Video Using Nearpod Application for 4th Grade Elementary School Students. *Kinestetik : Jurnal Ilmiah Pendidikan Jasmani, 7*(1), 248–257. https://doi.org/10.33369/jk.v7i1.25284

Susanti, A., Tarmizi, P., Wulandari, S., & Darmansyah, A. (2023). Peningkatan Pengetahuan Konseptual Berorientasi HOTS Pada Mata Kuliah Pendidikan PKn SD Melalui Penerapan *Case Method* Berbantuan *Quizizz* Mahasiswa PGSD Universitas Bengkulu. *Inovasi Sekolah Dasar: Jurnal Kajian. 10*(2), 75-85. Pengembangan Pendidikan https://doi.org/10.36706/jisd.v10i2.22554

Wahyuningsih, S., Nurjanah, N.E., Rasmani, U.E.E., Hafidah, R., Pudyaningtyas, A., Syamsuddin, M. (2020). STEAM learning in ece a literature review. *International Journal of Pedagogy and Teacher Education (IJPTE),* 4(1), 33-44.

Winarni, E. W. (2012). *Inovasi dalam Pembelajaran IPA*. Bengkulu: FKIP UNIB.

Zulvira, R., & Desyandri. (2022). Pengembangan Bahan Ajar Interaktif Tematik Terpadu Menggunakan Steam Berbasis Lectora di Kelas III SD. *Jurnal Cakrawala Pendas*, 8(4), 1273–1286.