DEVELOPMENT OF PROJECT-BASED LEARNING SCIENCE E-MODULE TO IMPROVE COLLABORATION SKILLS OF ELEMENTARY SCHOOL STUDENTS

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Abstract

The need for 4C competencies in the era of Industrial Revolution 4.0 and Society 5.0 is driving this research. Indonesia's low ranking in the PISA science category, placing 71st out of 80 countries, emphasizes the urgency of this study. Education has introduced 21st-century learning to meet these demands. In the science learning process, effective collaboration skills are crucial and require teachers to use suitable learning models. However, there is a shortage of relevant teaching materials, especially at the basic education level, in this digital era. This research aims to develop an effective project-based learning e-module that enhances collaboration skills in fifth-grade students. The development method follows the 4D model by Thiagarajan, involving the Define, Design, Development, and Dissemination stages. The research uses interviews, questionnaires, and observations as instruments. The results validate the project-based learning e-module for science, with media expert validation at 87%, linguist validation at 79%, and material expert validation at 80%. Moreover, student responses to individual, small group, and large group tests were 88%, 80%, and 83%, respectively. Using the independent sample t-test in SPSS 26 for Windows, quantitative analysis demonstrates a significant average difference in final observation scores between the experimental and control groups, with a difference of 2.381. This outcome yields a two-tailed p-value of 0.000 from the respondents in both groups. In conclusion, the use of e-modules in learning effectively improves students' collaboration skills.

Keywords: e-module; collaboration; project-based learning; science.

Abstrak

Penelitian ini dilatarbelakangi oleh kebutuhan akan kompetensi 4C yang penting di era revolusi industri 4.0 dan *society* 5.0. Rendahnya peringkat Indonesia pada hasil PISA kategori sains, berada di peringkat 71 dari 80 negara, menambah urgensi dari penelitian ini. Dalam upaya memenuhi tuntutan tersebut, pendidikan telah beradaptasi dengan memperkenalkan pembelajaran abad 21. Keterampilan kolaborasi yang baik diperlukan dalam proses penemuan pada pembelajaran IPA, hal ini menjadi tuntutan bagi para guru dalam menggunakan model pembelajaran yang dapat memenuhi kebutuhan tersebut. Namun, di era digital ini, terutama pada tingkat pendidikan dasar, masih terdapat kekurangan dalam ketersediaan bahan ajar yang sesuai dengan kebutuhan zaman. Penelitian ini bertujuan untuk mengembangkan e-modul pembelajaran IPA berbasis *project based learning* yang meningkatkan keterampilan kolaborasi siswa kelas 5 SD secara efektif. Metode pengembangannya menggunakan model 4D dari Thiagarajan, yaitu *Define*, *Design*, *Development*, dan *Dissemination*. Instrumen yang digunakan dalam penelitian ini adalah wawancara, angket, dan observasi. Hasil penelitian menunjukkan bahwa e-modul pembelajaran IPA berbasis *project based learning* ini valid dengan hasil validasi ahli media sebesar 87%, validasi ahli bahasa 79%, dan validasi ahli materi 80%. Selain itu, respons siswa pada uji perorangan sebesar 88%, uji kelompok kecil 80%, dan uji kelompok besar 83%. Analisis kuantitatif dengan uji *Independent Sample T-Test* menggunakan SPSS 26 *for Windows* menunjukkan adanya perbedaan rata-rata hasil observasi akhir antara kelas eksperimen dan kelas kontrol sebesar 2,381. Hasil ini diperoleh dari responden kelas eksperimen dan kelas kontrol, dengan *p-value sig (2-tailed)* sebesar 0,000. Dengan demikian, dapat disimpulkan bahwa penggunaan e-modul dalam pembelajaran telah meningkatkan keterampilan kolaborasi siswa.

Kata Kunci: e-modul; IPA; *project based learning;* kolaborasi.

Introduction

In the 21st century, the fourth industrial revolution and society 5.0 highlight the importance of developing the potential and skills of human resources to keep up with the times. This is particularly relevant in education, which plays a critical role in producing high-quality human resources (Teknowijoyo &; Marpelina, 2021: 182). Education, as defined by Ki Hajar Dewantara, involves developing children's character, thinking abilities, and physical well-being through a holistic approach that balances their lives. Educators, also known as teachers, play an important role in encouraging students to actively develop their potential and serve as role models. To achieve this, teachers must stay updated with the current trends in education and create an inclusive environment where both teachers and students can learn together (Febriyanti, 2021: 1633; Hasibuan & Prastowo, 2019: 28).

In the present times, 21st century skills are essential for lifelong learning. They enable students to adjust to evolving living conditions and become more adaptable (OCDE, 2005:4). The 21st Century Partnership Learning Framework emphasizes the importance of education in developing 21st century skills. These skills include critical thinking, communication, creativity, and collaboration, collectively known as the 4Cs (National Education Standards Agency, 2010: 44). Numerous researchers have emphasized the significance of collaboration as a crucial ability for students to obtain prior to entering the workforce in the 21st century (Andersen &; Rustad, 2022: 1). According to a personnel report from Indonesia, collaboration, communication skills, and teamwork are the most crucial abilities required in the workforce. However, these skills are not yet fully mastered in Indonesia (Reni, Praherdiono &; Soepriyanto, 2021: 273). It is crucial for educators to possess the skill of collaboration during the learning process. This enables students to work together and avoid individualistic tendencies (Syurbakti, 2020: 4).

Every individual needs to possess a basic understanding of science and mathematics in the 21st century (Shafarina &; Erviana, 2022: 41). Despite advancements in science education, it still leans towards theoretical knowledge and lacks practical application. This approach emphasizes theory over real-life applications (Khoerunnisa, Triwoelandari &; Arif, 2022: 239). The process of learning science involves systematically observing and logically thinking to find sources of information about nature. This not only helps students master knowledge, facts, and concepts but also enables them to understand the process of discovery. Therefore, good collaboration skills are essential in science learning as it involves not just acquiring knowledge about facts and principles, but also learning through the process of discovery (Sufajar & Qosyim, 2022: 254). Elementary school science learning aims to engage students in utilizing scientific concepts in their daily lives, while also encouraging their participation in maintaining and developing these concepts (Mawaddah, Triwoelandari &; Irfani, 2022: 3). Studying science has several benefits, including nurturing curiosity, enhancing the ability to ask questions and find answers, and developing scientific thinking skills. Through science learning, individuals can gain hands-on experience in creating and refining products and processes while fostering scientific attitudes (Kelana &; Pratama, 2019: 1).

According to the recently released PISA 2018 assessment on December 3, 2019, the current state of education in the field falls short of expectations. The assessment evaluated three competencies, including science, and Indonesia ranked 9th from the bottom with an average score of 396 (Tohir, 2019: 1). According to the most recent TIMSS results in 2015, Indonesia ranked 44th out of 49 countries. TIMSS measures achievement levels in four categories: low (scores below 400), medium (scores between 475 and 549), high (scores between 550 and 624), and advanced (scores above 625). Based on Indonesia's average score of 397 in the latest study, the country's achievement level is considered low (Hadi &; Novaliyosi, 2019: 1)

Based on observations and interviews with teachers and fifth-grade students at SD Insan Kamil Bogor, it has been found that students' collaboration skills in science learning are still not optimal. In forming a study group, some students struggle to divide tasks among group members, work together effectively, complete tasks on time, express opinions, make decisions about group activities, and lack confidence in making presentations in front of the class. This is due to the fact that interactive learning models are not being used, which results in suboptimal learning implementation. In a study by Latifah, Triwoelandari &; Irfani (2023: 34) it was explained that the use of interactive media by teachers is still inconsistent. Not all teachers possess sufficient knowledge about interactive learning media (Sari, Novitasari & Miftah, 2020: 32). A major reason why students may become disengaged from learning is due to a lack of diverse teaching methods. This can hinder the successful transfer of knowledge and lead to boredom during the learning process (Asmahasanah &; Rahmani, 2019: 2).

To improve science study results and better collaborate with students, it's important to use teaching materials that meet their needs. Collaborative and learner-centered learning is both effective and enjoyable (Rahmatullah, Inanna & Ampa, 2020: 319). A teacher needs to create creative teaching materials that may come in print, audio, audiovisual, interactive form, or models/mockups. These materials should align with the curriculum and cater to the needs of students, keeping up with the advancements in information technology (Prastowo, 2016: 6). Ministry of Education and Culture (2017: 3) explained E-modules are a form of self-directed learning material that is structured into distinct units and delivered electronically. Navigation is integrated with each learning activity to facilitate student engagement with the program. Through the use of instructional videos, animations, and audio, e-modules aim to enrich the learning journey. They are thoughtfully crafted to lead students through the learning process, enabling them to develop their knowledge at a pace that suits them (Tambunan & Tambunan, 2023:1029). E-modules can also explain scientific material that makes it easier for students to understand material that is very difficult to understand, so that using E-modules will be interesting, and can increase student interest and motivation (Ulfa &; Ngabekti, 2022: 43).

To optimize the learning experience with electronic modules, it is paramount to employ effective learning methodologies. Project-based learning, a cutting-edge model, can prove to be highly beneficial for students as they work on scientific projects, enhancing their problem-solving, collaboration, and argumentation skills. This approach has gained significant traction in recent times due to its emphasis on efficient learning (Ismanto, Vitriani & Anshari, 2022:18). Project-Based Learning is an instructional approach that engages students in addressing real-world challenges through inquiry-based methods. This approach emphasizes the creation of meaningful projects that encourage knowledge construction (Santos et al., 2023: 1714). Project-based learning is an innovative teaching approach that fosters students' curiosity and inquiry skills by engaging them in complex problem-solving activities. By working together on collaborative projects that integrate multiple subjects, students can explore content in more meaningful ways and experiment as a group. This method helps students develop critical

thinking and teamwork skills while also deepening their understanding of the subject matter (Zen et al., 2022: 2).

Project-based learning is different from problem-based learning. Problem-based learning involves students handling real-life situations by coming up with solutions. On the other hand, project-based learning goes a step further, requiring product development. This requires extensive research, collaboration, and utilizing technology to explore and create the final product (Marnewick, 2023: 2). Wiartis (2021: 50) argues that project-based learning involves the use of activity projects to achieve competencies, attitudes, knowledge, and skills. The focus of learning is on student activities, which involve researching, analyzing, creating, and presenting learning products based on real experiences. These products can take many forms, such as designs, schemes, written works, artwork, technological works, and more. In the end, the resulting product is the result of a project undertaken by the student. The process of creating a product requires students to work together to find solutions to authentic problems in the process of integrating knowledge, application, and construction (Guo et al., 2020: 2).

Success in the workplace demands more than just basic knowledge and skills. At PjBL, students gain a thorough understanding of the content while also developing responsibility, confidence, problem-solving abilities, collaboration skills, communication skills, and creativity (Saidova &; Ergasheva, 2019: 210). PjBL also includes questions that direct collaboration among students, use of scaffolding technology, strong emphasis on critical thinking and communication skills, and interdisciplinary learning (Santos et al., 2023:1715). Incorporating project-based learning in the classroom encourages students to become independent learners by involving them in practical projects that seek to solve real-life problems. This approach is comparable to challenge-based learning (Organ et al., 2022: 181). In addition, several studies show that students' knowledge, skills, and academic motivation increase after PjBL (Guo et al., 2020: 2).

The novelty in the development of Project Based Learning (PjBL) based science learning e-modules for grade 5 elementary school students lies in an approach that combines modern technology with project-based learning. These e-modules not only present science content in a more engaging and accessible way, but also emphasize the development of students' collaboration skills. By utilizing interactive features, such as online discussion forums and virtual collaboration tools, students are invited to work together to explore scientific concepts through their research projects. As such, this e-module is not just a digital learning tool, but one that combines technology with PjBL, creating an innovative learning experience and supporting the development of significant social and collaborative skills of grade 5 primary students.

Based on the description above, the purpose of this study is to evaluate the validity and effectiveness of science teaching e-modules through project-based learning, to improve collaboration skills in grade 5 elementary students. The validity of the module has been assessed through expert evaluation, while its effectiveness has been measured by comparing the results of the experimental group with the control group. The e-module includes core competencies, basic competencies, learning objectives and indicators, materials, PjBL stage content, pre-test, post-test, evaluation, and reflection, all of which are expected to improve collaboration skills in grade 5 elementary school students.

Research Methods

The study implemented research and development methods, commonly known as R&D. According to Borg and Gall (1998), this process is used to create and validate educational

products including textbooks, instructional films, computer software, teaching methods, and educational programs like drug education and staff development programs (Sugiyono, 2022:28). Development was carried out using Thiagarajan's (1974) 4-D model, which includes the stages of define, design, develop, and disseminate. The project-based learning e-modules for science learning, aimed at improving student collaboration skills, were developed for grade 5 of SD Insan Bogor. The following is an explanation of the stages of the 4-D model (Thiagarajan, Semmel & Semmel, 1974).

Define means explaining or defining the conditions needed in product development (Harahap, & Zakir, 2022: 1098). Determination of the required conditions is carried out by showing and adjusting learning needs for students. The define stage includes five main steps, namely front end analysis, learner analysis, concept analysis, task analysis and specifying instructional objectives. This stage has the aim of determining and defining learning requirements.

This stage begins after determining the learning objectives. As for the activities in this stage: First, the preparation of a benchmark reference test (constructing criterion-referecnced test), this is the first step in planning the development of e-modules including cover layouts, e-module materials and content, and the characteristics of teaching materials in accordance with learning objectives. Second, media selection is carried out to identify learning media that are relevant to the characteristics of the material and in accordance with the needs of students. Third, format selection (format selection), in development is intended by designing learning content, learning resources, compiling and designing the content of e-module teaching materials, and making e-module designs. Fourth, Initial design, resulting from the analysis that has been carried out. The initial design in question was an interactive multimedia design before the trial.

Develop, activities that must be carried out at this stage include: First, validation/feasibility test of e-modules, serves to determine whether or not media with certain criteria are valid. This is done by testing the feasibility of product design by experts (media experts, linguists and material experts), as well as getting suggestions and criticisms for revision references. The results of this validation are used as improvement material to improve the developed e-module. Second, revision, after validation, the results of the analysis are obtained for revision. The revised product is a development and refinement based on the results of validation by experts (linguists, media experts and material experts) which will then be tested to students. Third, e-module trial, the main purpose of conducting the trial is to determine the implementation and effectiveness of using science learning e-modules. The trial conducted by the researcher used 3 stages, namely individual trials, small group trials and large groups involving respondents from grade 5 students of SD Insan Kamil. The e-modules that have been produced will be disseminated online using a link or limited link for grade 5 SD Insan Kamil.

Results and Discussion

The development of PjBL learning e-modules is carried out using 4-D models (Four-D Models). The flow of 4-D model development, namely the stages of define, design, develop, and disseminate (Thiagarajan, Semmel & Semmel, 1974). The following is an explanation of the stages of developing project-based learning e-modules to improve the collaboration ability of grade 5 elementary school students:

Define

During the definition phase of product development, researchers analyze and identify any problems related to the process. This involves conducting interviews and observations to gain insights. In this case, interviews with the 5th grade homeroom teacher revealed that the current

learning model for science subjects does not often utilize project-based learning. Furthermore, when group work is assigned, not all students are maximizing their collaborative efforts. Observations of grade 5 students showed that they rely heavily on textbooks as their primary learning resource and tend to focus too much on the teacher during the learning process. In addition, they lack the necessary collaborative skills, and traditional learning models, such as lectures, are still commonly used. This limits their ability to work effectively as a team. To address these issues, we have developed an e-module learning program that uses the core competencies and basic competencies outlined in theme 9, "Things Around Us", which is a sub-theme of single and mixed substance with project-based learning (PjBL). The researchers will create e-modules as teaching materials for students, modified with PjBL-based learning.

Design

During the design stage, the goal is to create guidelines and frameworks for the e-module's preparation. The development research consists of three stages, with media selection being the first. In this particular research, the chosen learning media is an e-module, or electronic module, created using Canva. The Canva application was used to design the PjBL-based science learning e-module, which aims to improve the collaboration abilities of 5th-grade elementary school students. Canva is an online design program that offers various graphic designs such as presentations, posters, pamphlets, graphics, banners, invitation cards, photo editing, and Facebook covers (Tanjung &; Faiza, 2019: 80). Canva is currently available in several versions, web, iPhone, and Android so that e-modules can be accessed on any electronic device (Pardede, Natalina & Darmadi, 2022:135). This e-module has been created with A4 size layout settings and uses two titles in Sensei font, with the body text in Medium Poppins type font. The display includes attractive colors, images, and animations, along with learning videos and interactive quizzes. The content covers single and mixed substances, providing a summary to ensure students understand the material correctly. Each chapter includes six stages of PjBL, enabling students to create derivative products from used cooking oil. These stages include determining projects, designing project plans, preparing project schedules, implementing projects, reporting project results, and project evaluation. Additionally, the e-module includes reflection and evaluation questions.

Develop

Before conducting individual, small group, and large group tests, the PjBL-based science learning e-module must be validated by three experts: material experts, linguists, and media experts. The purpose of this validation is to evaluate the effectiveness of the PjBL-based science learning e-modules in enhancing student collaboration. Researchers use specific criteria to determine the validity of learning e-modules.

Table 1
Validity Assessment Criteria

Presentation (%)	Validity Level	Eligibility Criteria
81-100	Highly Valid	No Revision
61-80	Valid	No Revision
41-60	Quite Valid	Needs Revision
21-40	Less Valid	Revision
0-20	Invalid	Total Revision

According to the results of the media expert assessment, the eligibility rate for the PjBL-based science learning e-module is 87%, which is included in the valid category when viewed in Table 1, namely the validity assessment criteria table. The experts also provided some input and suggestions for the development of e-modules, such as changing the font type and size and getting rid of animations that do not match the content.
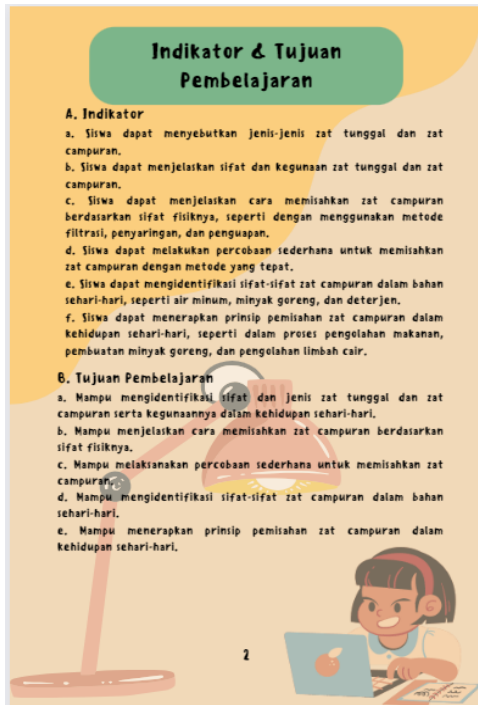

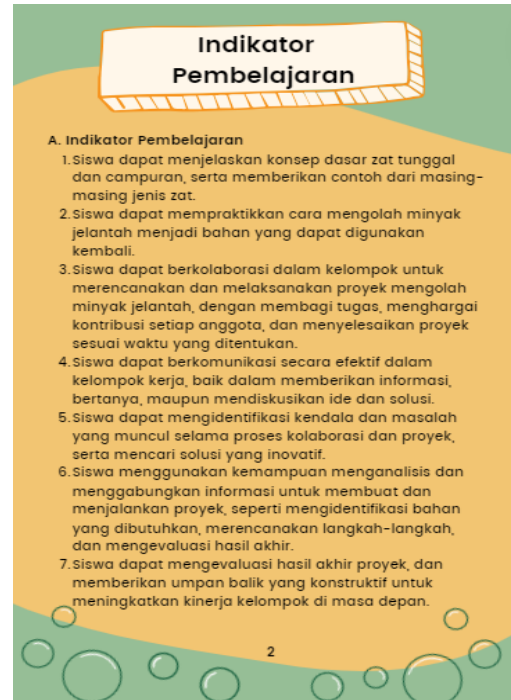**Figure 1 Indicators Before Revision**

Figure 2 Indicators After Revision

The linguists' assessment results showed a validity level of 79% with valid categories. Additionally, the linguists gave feedback to enhance the PjBL-based science learning e-modules by including references and making the bibliography paragraph more prominent.

Figure 3 Bibliography Before Revision

Figure 4 Bibliography Before Revision

The validity level of the assessment results from material experts is 80% with valid categories. Additionally, the material experts have given their input for developing science learning e-modules based on PjBL. This will enrich the resources in the e-modules and provide more examples.

After completing the assessment on the PjBL-based science learning e-module product, and the expert declares it valid and feasible to use, the next step is to conduct a trial. This trial was conducted to determine student responses to PjBL-based science learning e-module products and was divided into three stages, namely, individual tests, small group tests and large group tests. The assessment results were obtained from the responses of individual test students consisting of 5 respondents of 88% with very valid categories, small group test results consisting of 10 respondents 80% with valid categories, and large group test results consisting of 25 respondents of 83% with very valid categories.
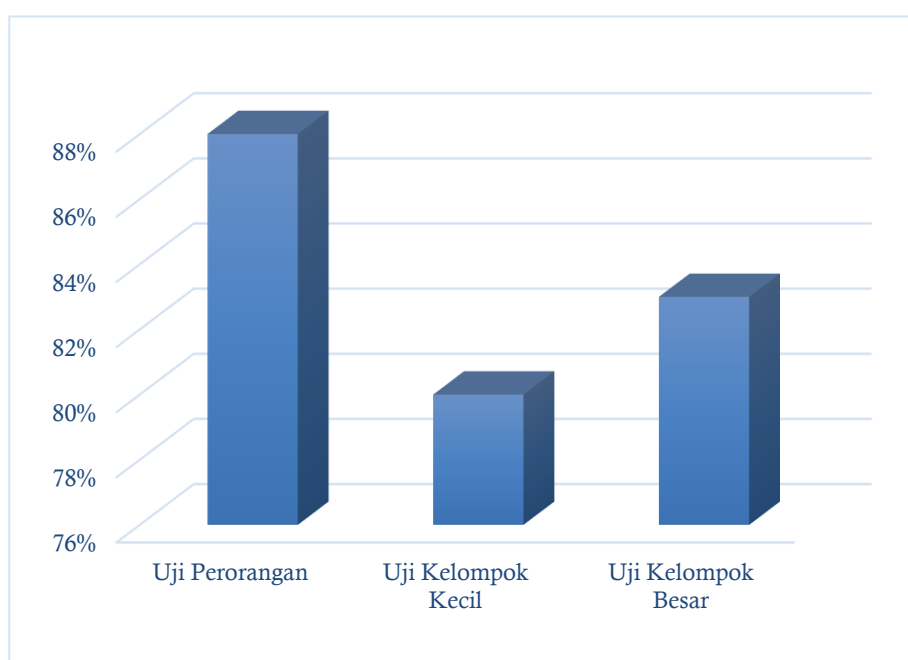

Figure 5 Graph of Trial Results

Researchers conducted individual, small group, and large group trials to evaluate the effectiveness of PjBL-based science learning e-modules. In experimental classes, researchers observed students during the learning process before and after using the e-modules. Five grade 5 elementary school students participated in individual tests, while small group tests involved 10 respondents and large group tests involved 21 respondents. The purpose was to determine whether the e-modules produced positive results.

After making initial observations and final observations on individual tests, improvements were found after and before using the PjBL-based science learning e-module during learning. An increase in the average score of initial and final observations on individual tests of 6.4, an increase in average scores on small group tests of 6.2 and an increase in average scores on large group tests of 4.6. Therefore, from these data, it can be concluded that PjBL-based science learning e-modules are effective for developing collaboration skills for grade 5 elementary school students.
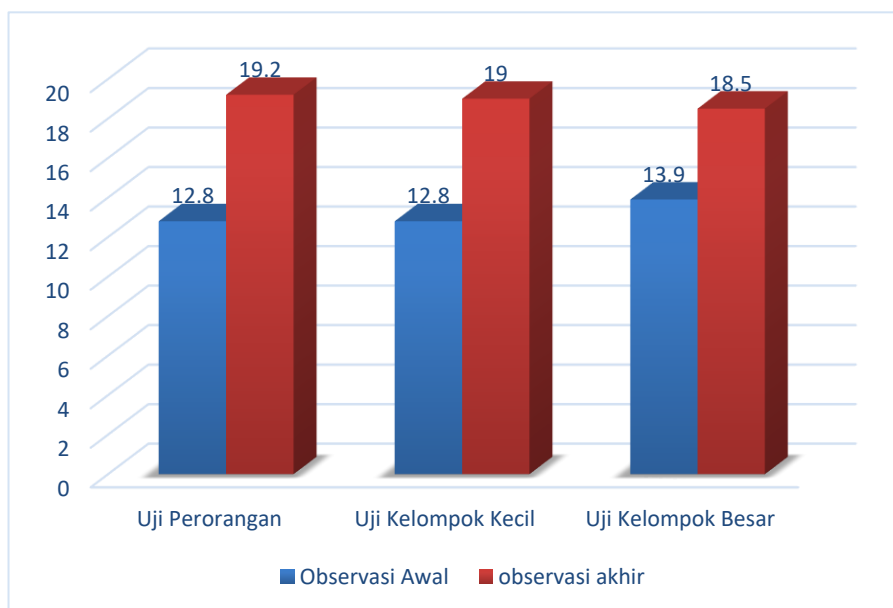
Figure 6 Graph of Individual, Small Group and Large Group Test Score Differences

Furthermore, an independent sample t-test was carried out using SPSS 26 for Windows to determine the improvement of student collaboration skills after using the PjBL-based science learning e-module. To perform an independent sample t test, the data requirements used must be normally distributed and homogeneous, then normality and homogeneity tests are carried out.

This normality and homogeneity test is to find out whether the data used is normally distributed or not with a level of α 0.05. When testing normality and homogeneity assisted with SPSS 26 for Windows, normality tests are performed using the formula One Kolmogrov Smirnov.

H0= Normal distributed sample

Ha= Sample is not normally distributed

This conclusion is based on the significant level obtained greater than 0.05 then H0 is accepted and if the significant level is less than 0.05 then Ha is accepted and H0 is rejected. The results of this normality test are obtained from the results of the experimental class and the control class.

Table 2
One Sample Kolmogrov-Smirnov Test Normality Test Results

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Kelas	Statistic	df	Sig.	Statistic	df	Sig.
keterampilan kolaborasi	pre eksperimen	.148	21	.200[*]	.960	21	.518
	post eksperimen	.182	21	.067	.908	21	.051
	pre kontrol	.163	21	.151	.932	21	.151
	post kontrol	.154	21	.200[*]	.963	21	.572

Based on the results of Table 2 regarding the normality test at the initial observation of the experimental class obtained sig 0.200, the final observation of the experimental class

obtained sig 0.067, the initial observation of the control class obtained sig 0.151 and the final observation of the control class obtained sig 0.200, the result is greater than 0.05 then H0 is accepted and Ha is rejected. It can be said that the result data is distributed normally.

Table 3
Homogeneity Test Results

Test of Homogeneity of Variance		Levene Statistic	df1	df2	Sig.
keterampilan kolaborasi	Based on Mean	3.653	1	40	.063
	Based on Median	3.184	1	40	.082
	Based on Median and with adjusted df	3.184	1	37.010	.083
	Based on trimmed mean	3.686	1	40	.062

Based on the results of the homogeneity test in Table 3, a sig result of 0.063 was obtained. This indicates that the sig is greater than 0.05 and it can be concluded that the data is homogeneous.

Table 4
Hasil Uji Independent Sample T-Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Keterampilan Kolaborasi	Equal variances assumed	3.653	.063	4.985	40	.000	2.381	.478	1.416	3.346
	Equal variances not assumed			4.985	33.724	.000	2.381	.478	1.410	3.352

Based on the findings presented in Table 4, it was observed that the experimental class exhibited an average difference of 2.381 in comparison to the control class. The data was collected from participants in both groups, and the sig (2-tailed) p-value was calculated to be 0.000. Consequently, Ha was confirmed, and a significant difference was detected between the control and experimental classes, indicating a boost in collaboration skills. The method of evaluating effectiveness involved comparing the experimental and control classes, with the former receiving treatment while the latter did not. Taking all these factors into account, it can be concluded that utilizing PjBL-based science learning e-modules can have a positive impact on student collaboration skills.

Conclusion

The results of research and development show that PjBL-based science learning e-modules are the right and effective method to improve collaboration of grade 5 elementary school students. Validation by experts in the e-module assessment also showed valid results, with the material aspect reaching 80% in the valid category, the media aspect reaching 87% in the very valid category, and the language aspect reaching 79% in the valid category. The effectiveness of PjBL-based science learning e-modules in improving student collaboration can be observed through initial observation and final observation of student collaboration achievements. The results showed significant changes, with individual test scores increasing from an average of 12.8 at the initial observation to 19.2 at the final observation. Small group test scores also increased from an average of 12.8 to 19 at the final observation. In the experimental class large group test, the score increased from an average of 13.9 at the initial observation to 18.5 at the final observation. This shows that the average final observation results are higher than the initial observations in achieving student collaboration skills. In addition, PjBL-based science learning e-modules are also able to improve students' collaboration skills when compared to control classes. There was a mean difference between the control class and the experimental class of 2.381 with a significance (2-tailed) of 0.000. Therefore, it can be concluded that PjBL-based science learning e-modules are effective and appropriate to be used to develop student collaboration skills in grade 5 elementary school.

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