Vol 13(2) (2024): 99-108
DOI: http://dx.doi.org/10.24235/sc.educatia.v13i2.18060

SCIENTIAE EDUCATIA: JURNAL PENDIDIKAN SAINS

https://www.syekhnurjati.ac.id/jurnal/index.php/sceducatia

Development of Motion and Force Learning E-Modules Based on PjBL-STEM-Jigsaw to Improve Student Creativity

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article info

Article history:
Received: 30 June 2024
Received in revised form: 18 September 2024
Accepted: 20 December 2024
Available online: 30 December 2024

Keywords:
Creativity
E-module
PjBL-STEM
Teaching Materials
21st century skills

abstract

This research aims to develop a PjBL-STEM-based learning e-module to improve student creativity in motion and force material. The development of this research is important as a parameter of 21st-century skills that require students to have critical thinking, creativity, collaboration, and communication to face the era of Education 4.0. This research method uses Research and Development (R&D). The selected R&D design is the ADDIE design, which consists of 5 stages (Analysis, Design, Development, Implementation, Evaluation). Class VII students (N=36) were involved as research subjects, using a purposive sampling technique. Data were collected through a creativity test, a student response questionnaire, and an observation sheet. The data processing technique used a paired sample t-test and then the N-Gain test. The analysis results showed that after using the PjBL-STEM-based learning e-module there was an increase in creativity with an N-Gain value of 60% in the medium category. Testing the effectiveness of learning e-modules using SPSS paired sample t-test showed a result of 0.001 which means that PjBL-STEM-based learning e-modules affect student creativity. The descriptive average of creativity increased by 29.83%. In addition, students gave a positive response to the learning e-module which made it easier to understand the material. Based on the data analysis of learning outcomes, interactivity, attractive design, STEM practicum and materials in the e-module can increase understanding and interest in motion and force materials.

1. Introduction

The low overall quality of education in Indonesia, the increasing globalisation that requires an adaptable generation, and the importance of future generations having 21st-century skills are serious problems in Indonesia's education world. These educational problems must be resolved immediately by improving various aspects of education. The education process must be able to accommodate the above issues. The basis of the educational process is classroom learning; therefore, classroom learning must be able to fulfill the expectations of educational goals in Indonesia, one of which is through creative, innovative, and interactive learning, and future-oriented.

The low science achievement of Indonesian students is shown by PISA 2022 data, which shows that Indonesian students still occupy a low level in science literacy, while very few students reach higher levels with indicators of higher thinking skills such as creative thinking (Yusmar & Fadilah, 2023). This fact is reinforced by preliminary research results that student creativity is still in the low category, with an achievement of 44.4%, including aspects of creative thinking skills (Kartini, 2020). Based on observations in the field, one of the things that students need is the availability of teaching modules so that they can learn independently, which can attract students' interest in learning. It was revealed from interviews that students prefer to learn from electronic books to printed books because they are easier to carry and can be read anywhere. E-Modules are very relevant to the development of this technological century (Kaniyah et al., 2022).

E-Modules that are interactive and can build student creativity and reflect interactive learning can be developed based on PjBL-STEM learning (Inayah et al., 2023; Mawaddah, 2023). Research results show that PjBL-STEM is an option that has the potential to develop creativity and communication skills through solving real problems in the lives of students (Roslina et al., 2022; Oktavia, 2022; Megawati et al., 2022). Several studies have shown that project-based learning (PjBL) is one of the learning models that can help students to have creativity, communication skills, the ability to solve problems, and interact and assist in investigations that lead to solving real problems (Taufiqqurrahman & Wijaya, 2022; Wulandani et al., 2022). Some studies report that the PjBL-STEM model can be enhanced to achieve learning objectives with the Jigsaw strategy (Sari et al., 2023). Some literature reports that the Jigsaw strategy can be used to complement PjBL-STEM (Suryono et al., 2023; Septiari, 2021). Jigsaw learning is a learning method based on a multifunctional structure of learning groups that can be used on all subjects and all levels to develop each group's expertise and skills that they have previously learned at expert team meetings (Eni, 2020; Taufina, 2020). The Jigsaw learning model has groups of origin and expert groups (Hidayah, 2023). The group of origin is the parent group of students with diverse abilities, genders, and family backgrounds. The expert group, a group of students consisting of different members of the original group, is assigned to study the topic and then explain it to members of the original group (Solissa, 2023). The expert group is a combination of several experts from the original group. The key to the success of jigsaw is interdependence, i.e., each student depends on his/her team members to provide the necessary information to perform well during the assessment (Uki & Liunokas, 2021; Kharisma, 2020).

Based on the description above, this research is urgently carried out to ensure the availability of e-modules that can build students' creativity. The research problem formulation is: "What are the characteristics of the PjBl-STEM e-module with the Jigsaw strategy that can increase creativity?."

2. Method

The research method used in the development of learning e-modules is Research and Development (R&D) with ADDIE design (Analysis, Design, Development, Implementation, and Evaluation) (Rafles et al., 2023; Ranuhaja et al., 2021). The research subjects were class VII junior high school students, 36 selected by a purposive sampling technique at one school in Bogor Regency. The research instruments used in this study include validation sheets, student response questionnaires, creativity question instruments, and student presentation observation performance assessment sheets. The stages of developing learning e-modules are based on the ADDIE stages (Ranuharja et al., 2021). The research procedure is shown in Figure 1.

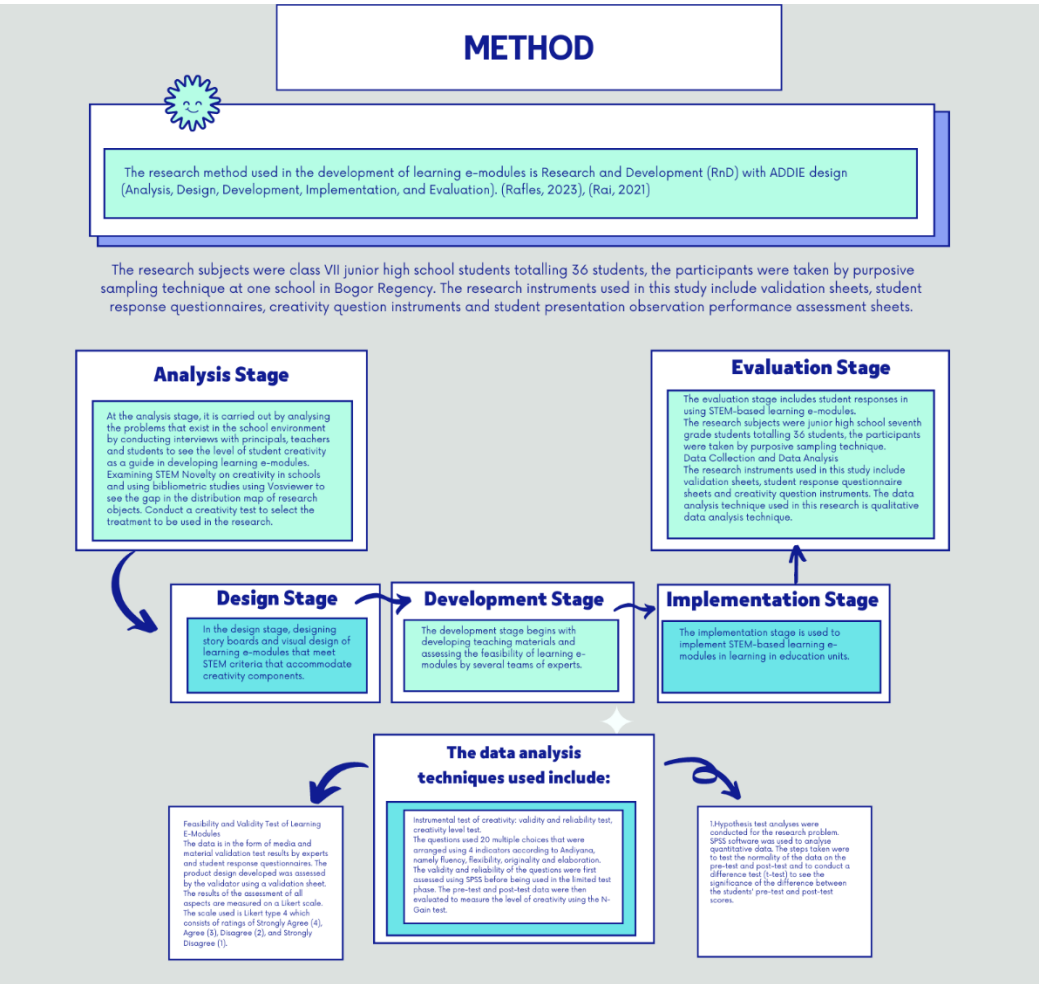

Figure 1. Research procedure

Analysis Stage

At the analysis stage, it is carried out by analysing the problems that exist in the school environment by conducting interviews with principals, teachers and students to see the level of student creativity as a guide in developing learning e-modules and examining STEM Novelty on creativity in schools and using bibliometric studies using Vosviewer to see the gap in the distribution map of research objects. Conduct a creativity test to select the treatment for the research.

Design Stage

In the design stage, designing storyboards and visual design of learning e-modules that meet STEM criteria, and accommodate creativity components.

Development Stage

The development stage begins with developing teaching materials and assessing the feasibility of learning e-modules by several teams of experts.

Implementation Stage

The implementation stage is used to implement STEM-based learning e-modules in learning in education units.

Evaluation Stage

The evaluation stage includes student responses in using STEM-based learning e-modules.

The research subjects were junior high school seventh-grade students, a total of 36 students; the participants were selected using a purposive sampling technique.

The research instruments used in this study include validation sheets, student response questionnaire sheets, and creativity question instruments. The data analysis technique used in this research is a qualitative data analysis technique. The data is in the form of media and material validation test results by experts and student response questionnaires. The product design developed was assessed by the validator using a validation sheet. The assessment results of all aspects are measured on a Likert scale. The scale used is Likert type 4, which consists of ratings of Strongly Agree (4), Agree (3), Disagree (2), and Strongly Disagree (1).

The questions used 20 choices arranged using four indicators according to Andiyana et al. (2018): fluency, flexibility, originality, and elaboration. The validity and reliability of the questions were first assessed using SPSS before being used in the limited test phase. The pre-test and post-test data were then evaluated to measure the level of creativity using the N-Gain test. SPSS software was used to analyse quantitative data. The steps were to test the normality of the data on the pre-test and post-test, and to conduct a difference test (t-test) to see the significance of the difference between the students' pre-test and post-test scores.

3. Result and Discussion

Based on the findings of the preliminary test, a PjBL-STEM-based learning e-module was designed in the form of a flipbook that is easily accessible, attractive and has various complete features in accordance with the learning outcomes of the material, especially for class VII junior high school. The learning outcomes that have been determined are obtained by exercising creativity through the Let's Practice activity. The most important thing is that this learning e-module is easily accessible either through mobile phones or computers connected to the internet so that students can access it anytime and anywhere. The features in the PjBL-STEM-based learning e-module are made in response to the analysis of student needs at SMPN 1 Klapanunggal. The features of the developed learning e-module can be seen in Figure 2.

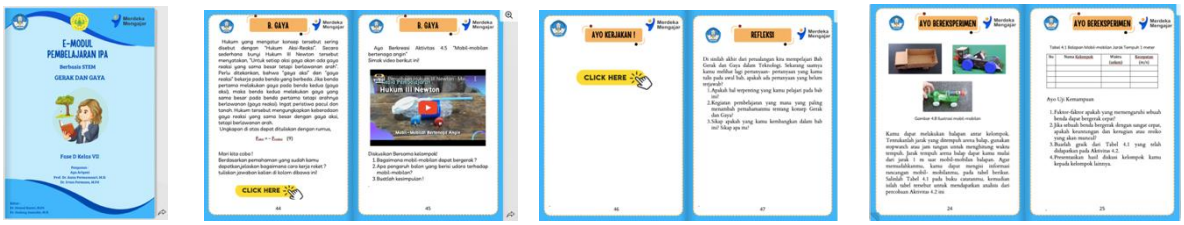

Figure 2. Features of e-module development

At the development stage, there were inputs and suggestions from media experts and material experts as follows in Table 1, after validation from the two experts. The recapitulation of the feasibility of the developed learning materials and e-modules shows an average feasibility percentage of 90% with very feasible criteria. This is in line with Candra (2020), which shows a feasibility percentage of 85.6%, which is very feasible. This also aligns with research (Fitriani, 2019), which shows a recapitulation result of 84.7% with very feasible product criteria. Therefore, the product developed by researchers can be operated as a support for the learning process, while the minimum CVR value that meets the valid criteria according to Lawshe (1975) for the number of respondents 15 is 0.49. Table 4.3 shows the average CVR of 0.90, and CVI of 0.91 with valid criteria. Both results are obtained from the feasibility value in each question given to the teacher and show that the criteria of the learning e-module can be used for learning.

Table 1. Results of learning e-module improvement based on expert assessment

No	Component	Before Revision	After Revision
1	Cover (Image illustration and title revised)		
2	Format improvement Table of contents		
3	Improvement of link appearance format	 	 

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After validation of the training materials, a limited trial of the product was conducted to assess its effectiveness. Examining students' written test results, including pre-test and post-test scores, was used to determine learning efficiency using PjBL-STEM-based learning e-modules on students' creativity. The limited test was given to 36 junior high school students in grade VII. In general, the N-Gain of student creativity results obtained a score of 0.60 (medium category), averaging 51.25 to 80.83. The complete data is shown in Table 2.

Table 2. Student's creativity test result

Description	Pre-test	Post-test
Number of students	36	36
Lowest score	30	65
Highest score	80	95
Mean score	51.25	80.83
Lowest score	12.894	8.238
Mean N-Gain	0.60 (medium category)	

Based on Table 2, the increase in post-test scores compared to the pre-test shows an increase in student creativity after using the PjBL-STEM-based learning e-module, as seen from the N-Gain value of 0.60 in the moderate category. In other words, the PjBL-STEM-based learning e-module effectively increases student creativity. The increase in creativity is due to the "Let's Practice" practice in the learning e-module, which can stimulate student creativity. STEM practice itself is carried out in addition to training creativity can also solve student problems in the concept of motion and force material.

Furthermore, an inferential test was conducted to determine the significance level of the pre-test and post-test. Pre-test and post-test creativity data were analysed using SPSS, as shown in Table 3.

Table 3. Learning e-module validation results normality test

Value	Number of students	Normality test		Homogeneity test		Hypothesis test	
		Value	Description	Value	Description	Value	Description
Pre-test	36	0.109	Normal	< 0.001	Inhomogeneous	0.003	Significant
Postest	36	0.079	Normal				

The initial step in proving the significance of using PjBL-STEM-based learning e-modules on student creativity is to conduct a prerequisite test, namely, a normality test as a descriptive statistical test. The normality test used is the Shapiro-Wilk test, which is used to test the normality of the data because the sample is less than 100. Based on the normality test output on the SPSS version 29 data in Table 3, the test statistic Sig value is 0.109 for the pre-test and 0.079 for the post-test. Both data points are greater than 0.05, meaning the data is normally distributed. The next stage is the homogeneity test.

Levene's test was used to test the homogeneity of the data. The significance value (Sig) based on the Mean is < 0.001, so it can be concluded that the pretest and post-test data variance is not the same or Homogeneous. Thus, one of the conditions (not absolute) of the independent sample t-test is not met.

Based on the results of the fulfilled prerequisite test (normal conditions), a paired t-test was conducted, which was used to compare the averages of 'pre-test creativity' and 'post-test creativity'. The t-count was -11.601, and the sig value was 0.003. The significance value is smaller than the commonly used significance level of 0.05. This shows that the null hypothesis (H0) is rejected, meaning that there is a difference between the pre-test and post-test values, so that the PjBL-STEM-based learning e-module can be used to increase student creativity, especially in motion and force materials.

These findings suggest that PjBL-STEM-based learning e-modules are an effective tool for enhancing student creativity. Learning e-modules provide an interactive and engaging learning environment that promotes critical thinking and problem-solving skills, key components of creativity. In addition, creativity is fostered from the "Let's Practise" activities. The results of the N-Gain acquisition of each creativity indicator illustrate that the application of PjBL-STEM-based learning e-modules has a significant impact on increasing student creativity. The N-Gain value of each creativity indicator can be seen in Table 4.

Table 4. N-Gain results for each creativity indicator

No	Creativity Indicator	No Problem	Pretest average	Postest average	N-Gain
1	Fluency	1 10 11 12 16 20	52.78	80.09	0.57835663
2	Flexibility	2 4 6 9 19	47.22	83.33	0.68416067
3	Originality	3 5 7 8 14 17	62.04	82.87	0.5473551
4	Elaboration	13 15 18	42.59	73.15	0.53231144

Table 4 shows that the increase in student creativity after learning using PjBL-STEM-based learning e-modules on all four indicators is in the medium category. Elaboration ability has the lowest N-Gain value of 0.532. Flexibility has the highest N-Gain value of 0.684. High detail indicates that the presentation of material in the learning e-module is presented in full, so that students can make answers and ask questions from different points of view regarding motion and force material. This is in line with Fatma (2021), which states that flexibility is the ability of students to produce varied ideas, answers, or questions, and the results of the study show that

students have been able to provide answers or questions that vary, even though the objectives are the same. Meanwhile, the low elaboration ability shows that students are not yet adept at developing or issuing ideas or adding details to ideas in answering questions that are presented in a varied manner. The PjBL-STEM-based learning e-module presents complete material, but the short learning time makes the understanding of the material incomplete. This is in line with (Ayuningsih et al., 2022), which states that elaboration is the ability of students to respond to all questions using enthusiasm, actively, and innovatively in solving problems. The research output shows that students have not been able to develop or refine ideas or add details to them.

The fluency and originality indicators have N-Gain values that are quite effective. Both indicators can be trained at each stage of PjBL-STEM in the "Let's Try" activity and the final product produced. The practical results show that students are fluent and flexible in producing the expected product (Siswanto, 2018; Widana et al., 2021; Zahirah et al., 2023)..

4. Conclusion

Developing PjBL-STEM-based learning e-modules to improve student creativity is an innovation applied in science learning, especially on motion and force materials. PjBL-STEM-based learning e-modules contain qualities that fulfill the elements or requirements of teaching materials, such as presentation feasibility, content feasibility, language feasibility, design and appearance, and pedagogical factors. The resulting learning e-module is based on curricular demands and student characteristics, and can help students increase their creativity. In addition, STEM activities and practice questions can help students improve their creativity. The PjBL-STEM-based learning e-module substantially improves students' creativity with a simple N-Gain score of 0.60. Based on the data analysis of learning outcomes, interactivity, attractive design, STEM practicum, and materials in the e-module can increase understanding and interest in motion and force materials.

Acknowledgments

The Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia funded this research. Therefore, this report is part of the reporting made during the research. The researcher would like to thank all parties who have contributed to this research. This research is expected to provide benefits for developing education in Indonesia to achieve sustainable education.

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