Lectura: Jurnal Pendidikan
Volume 17, Nomor 1, Februari 2026, Halaman 76-87
P-ISSN: 2086-4876
E-ISSN: 2549-063X
DOI: https://doi.org/10.31849/xexxxv37
Link: https://journal.unilak.ac.id/index.php/lectura/article/view/31039

Development of PjBL-Based Science E-Comic to Increase Motivation and Science Learning Outcomes for Class VII Students

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Submitted: 08-12-2025 Accepted: 06-01-2026 Published: 11-02-2026

Abstract
Students' learning outcomes in the field of science that still do not meet the achievement criteria which have become national education standards prove that the quality of education is still not optimal. Learning outcomes can be influenced by internal and external factors. Based on these problems, an innovation in learning is needed that is not only able to increase understanding of science concepts, but can also motivate students to learn independently and actively. Problem-based science e-comics are one of the innovations in science learning to increase students' understanding and independence in learning science. This development research takes the AM3PU3 development model. It is hoped that the development of Project-Based Learning (PjBL)-based science e-comics can be an effective solution to increase student learning motivation and student learning outcomes. The subjects in this study consisted of: content experts, 2 media experts, a design expert, 3 students with low, medium and high abilities for individual trials, 9 students with low, medium and high abilities for small group trials, a science teacher and 30 students for the developed media effectiveness test. Based on the results of the science e-comic feasibility test, it received appropriate categories from the results of the Expert test, individual trial, small group, and teacher response test. The effectiveness of PjBL-based science e-comics is M=78.57 and SD=7.567 which is higher than the Learning Objective Completion Criteria which is 70. Students' learning motivation after learning using e-comic Science has been proven to reach the excellent category.

Keywords: e-comic, learning outcomes, project-based learning, motivation

INTRODUCTION

In the 21st century science and technology are developing rapidly. Technological progress demands that human resources have superior skills. The quality of human resources increases by improving the quality of education. Several factors that influence the quality of education are the learning process, students and teachers (Sudarma et al., 2022). As explained in Law No. 20 of 2003 concerning the National Education System, it states: "Education is a conscious and planned effort to create a learning atmosphere and learning process that is able to develop one's potential in order to have spiritual power, self-control, personality, noble morals, intelligence and skills that will be useful for him and also in the community environment (Hermawan et al., 2024). The National Standard of Education requires teachers and students to utilize developing technology (Dwi et al., 2024). The use of technology in the field of education can not only increase the effectiveness of learning, but also help prepare young people to face future challenges (Octafiona, 2024). Educational technology as theory and practice in the design, development, use, management and evaluation of processes and resources for learning (Amanah et al., 2024).

Educational technology can help students improve their skills. The benefits of educational technology can be used as a facility between teachers and students in communicating so as to increase interaction in the classroom and quality during learning (Sofyan & Kusmana, 2024). Apart from that, educational technology can also be used as a tool to create learning materials that are interesting and easily accessible to students. Interactive learning experiences are also a benefit of using educational technology, as is video, gamification or web-based learning. The use of appropriate technology in education can increase the credibility and quality of education to prepare Indonesia's golden generation (Octafiona, 2024). The development of educational technology in Indonesia in recent years has shown a significant increase. This is a good first step to create a skilled and quality golden generation of the Indonesian nation (Octafiona, 2024). However, it is inevitable that the application of educational technology still leaves some problems in learning such as low motivation to learn from students. Lack of student learning motivation can affect student learning outcomes, so that the criteria for achieving learning outcomes have not been met properly (Adriansyah et al., 2024). Learning motivation is key in an effective learning process (Rusdiana & Febrianto, 2024). Learning motivation can encourage students to optimize learning activities to achieve educational goals.

Based on some of the research includes research by Rusdiana & Febrianto (2024) stated that students' learning motivation is so low because the use of learning media is not optimal and the use of technology in education is still lacking, resulting in monotonous and uninteresting learning. Similar research was conducted by Wulan et al. (2024) found that low learning motivation is due to limited teachers in applying technology to classroom learning. In line with this, Muhdin & Aras (2024) carrying out research at *Sekolah Menengah Pertama* (*SMP*) Negeri 2 Poso, North City, experienced a decline in students' enthusiasm or activity in learning science, making it difficult for students to understand science learning and reducing student learning achievement. This is caused by students not being very focused on learning and still not paying attention to the teacher when explaining the material in class.

Low motivation to learn was also expressed in the study by Fadilah et al. (2025), which was caused by low student attendance and lack of active student participation in learning, which made learning science boring. Several factors can influence learning

motivation, including the role of students, teachers, content, learning methods and learning environment. Low learning motivation can also influence student learning outcomes, this is proven by research by Rismawati et al., (2024) which was conducted in class VIII of SMP Negeri 2 Pariaman with grades $r=0.052$ and compared to tests *t* with a sig level of 0.05, this means that there is a significant relationship between learning motivation and class VIII students' learning outcomes in learning. Learning outcomes can be influenced by internal and external factors. One of the internal factors that influences it is learning motivation. Learning outcomes are the result of changes in student behavior that include cognitive, affective and psychomotor abilities (Yandi et al., 2023). Basically, students who have quite high learning motivation tend to have good learning outcomes. However, in the case of the field, students' motivation and learning outcomes are not good enough. This was stated in research of Farid & Sudarma (2022) based on his research, the same thing is due to the lack of media and teaching materials used as well as teacher-centered learning resulting in students lacking learning motivation so that their learning outcomes do not meet achievement criteria.

Student learning outcomes that still do not meet the achievement criteria which have become national education standards prove that the quality of education is still not optimal. This is supported by Peni et al. (2024) who stated that the quality of learning in class IX of SMP Negeri 20 Kupang is still relatively low. This can be seen from the student learning results in recent years. The learning media used in delivering the material has not been packaged properly, which is one of the factors in students' low learning outcomes. The development of learning media is an alternative to overcome the problem of low student learning outcomes due to learning media that have not been created interestingly (Dharma et al., 2024). Learning media is something that cannot be separated from teaching and learning activities. Learning media is a tool for teachers to convey things conceptually with good visualization according to existing technological developments. According to Peni et al. (2024) learning media can be used as a trigger for students to learn. Learning media can also be used as a means to make learning more effective and efficient. The use of learning media can improve student learning outcomes.

Learning effective ones require selecting media that suits students' goals, materials, and characteristics. Pagarra et al. (2022) stated that media can be classified into four levels: a) visual, b) audio, c) motion, and d) *manipulative/experiential*. Learning activities for class VII students, especially science learning, require media that is in accordance with the development and characteristics of students. Students of this age find it easier to understand content if it is presented in the form of interesting images and simple stories. Comic media, which falls into the visual category, has great potential in supporting learning, especially for class VII students who are at the concrete-operational to formal-operational stage of cognitive development. Comics are an illustrated story that takes an interesting topic and storyline (Khoiri et al., 2024). Some teachers use comic media to help with classroom learning, comics are felt to be able to develop students' imagination and thinking skills (Khoiri et al., 2024).

Several previous studies have resulted in the opinion that comics can help increase motivation and learning outcomes, such as research conducted by Al-Ghifary et al. (2024) produces media products in the form of interactive comics which have been proven to be able to increase students' conceptual understanding. Interactive comic media is very effective and efficient and can be a solution to students' learning styles that are in line with the era of digitalization. This is supported by similar research such as research by

Peni et al. (2024) states that applying the PBL learning model using comic media can improve the mathematics learning outcomes of class IX students.

The preparation of interactive learning media does not escape a learning model that is suitable for the success of learning media that will be applied in the classroom. *Project Based Learning* (PjBL) is a learning model that is in accordance with achievements in the Merdeka curriculum (Panglipur et al., 2024). The PjBL learning model only focuses learning on the projects that students will implement. The availability of the PjBL learning model combined with learning media in the classroom is still very minimal. However, Putri et al. (2023) revealed that after the existence of STEM-based digital modules *Project Based Learning* can help students to access physics learning materials anywhere. This research is also in line with discussions from Ernawati et al. (2024) students have a positive effect and are more active in seeking information and discussing questions and discussions in class during the implementation of the PjBL learning model.

A combination of project-based learning (PjBL) and *e-comic* is an innovative solution. PjBL allows students to learn through real-world projects, and electronic comics present material in an engaging and easy-to-understand way. This combination not only significantly increases student motivation, but also improves learning outcomes. Therefore, the development of PjBL-based scientific e-comics is a learning medium that is very suitable for class VII students. In the opinion of (Kartika et al., 2024) the use of digital comics using the PjBL learning model in the mathematics learning process can improve students' mathematical creative thinking abilities, this can be seen from the statistical results that have been obtained. Similar research was conducted by Panglipur et al. (2024) with research involving learning models *PjBL* help from comic media can help students' initial understanding of the Pythagorean theorem applied in everyday life.

Various previous studies have shown that the application of innovative learning models and the use of digital learning media can increase the motivation and learning outcomes of science for junior high school students. Several studies report that the PjBL model is effective in encouraging active student involvement, improving critical thinking skills, and improving understanding of science concepts. Other research also reveals that the use of visual and digital media, such as learning comics, can increase students' interest, attention and learning motivation because of the presentation of more contextual and interesting material. Nevertheless, most of these studies still separate the use of learning models and learning media, so that their impact on motivation and learning outcomes has not been tested in an integrated way. In addition, research on media development *e-comic* science at junior high school level generally still focuses on aspects of feasibility and practicality, and is limited to improving cognitive learning outcomes, without examining in depth the influence on student learning motivation. On the other hand, application *e-comic* those specifically designed to be PjBL-based and adapted to the characteristics of class VII students are still very limited.

Based on the results of an initial interview with a teacher teaching science class VII subjects at SMP Negeri 6 Denpasar, information was obtained that students' learning motivation in science learning is still relatively low. This is reflected in the lack of student enthusiasm when participating in learning, low activity in asking and expressing opinions, and student involvement which is not optimal in practicum activities and group discussions. The teacher also said that this condition has an impact on students' learning outcomes, where most students have not reached the established Learning Objective Achievement Criteria (*Kriteria Ketercapaian Tujuan Pembelajaran/KKTP*), especially

on material that demands understanding of concepts and application in the context of everyday life. It is suspected that the low motivation and learning outcomes are caused by the learning process which is still dominated by lecture methods, limited use of interactive learning media, and not yet optimal application of student-centered learning models.

Based on the problems that have been described, an innovation is needed in learning media that is not only able to increase understanding of science concepts, but can also motivate students to learn independently and actively. It is hoped that the development of PjBL-based e-comics can be an effective solution, considering that this approach has been proven to be able to increase student involvement in project-based learning and present material in an interesting and interactive manner. Thus, this research aims to develop and test effectiveness *e-comic* PjBL-based science in increasing motivation and learning outcomes for class VII students. The results of this research are expected to contribute to the development of innovative learning media that suit student needs and support the achievement of learning goals in the Merdeka Curriculum.

METHOD

This research intended to develop learning modules in the form of e-comic based PjBL to increase motivation and learning outcomes for class VII students in science subjects. This research used design *Research and Development* (R&D) with a development model according to Santyasa (2023), namely the model AM3PU3 has the following stages: a) needs analysis, b) reviewing theory, c) reviewing empirical data, d) finding problems, e) draft development, f) expert testing, g) user testing, and h) field testing. The subjects in this research consisted of: (a) content experts, (b) 2 media experts, (c) a design expert who mastered Educational Technology, (d) 3 students who had low, medium and high abilities for individual trials, (e) 9 students with low, medium and high abilities for small group trials, (f) a science teacher and (f) 30 students to test the effectiveness of the media developed. The data collected is divided into 3 parts, namely (1) the results of questionnaires from material experts, media experts and design experts, (2) the results of individual trial response questionnaires, (3) the results of small group trial response questionnaires, and (4) the results of science teacher response questionnaires and (5) the results of field trials involving 30 class VII students. The types of data used are qualitative and quantitative data.

Based on the data collection method in this study, a viable and effective instrument was used to develop *e-comic* PjBL-based science is observation sheets, validation questionnaires, and description tests. Determine the eligibility scores of content experts, media experts, design experts, teacher practitioner experts, individual students, small group students and student learning motivation responses using the following formula (Santyasa, 2023).

$$Appropriateness\ (K) = \frac{Total\ score\ of\ approriateness}{Maximum\ of\ total\ score} \times 100\%$$

According Santyasa (2023) the criteria for success can also refer to classical completion. The study completion of all students who were sampled in this research was used in data analysis with the following formulation.

$$Individual\ Completeness = \frac{raw\ score}{maximum\ score} \times 100\%$$

Students are declared to have completed their studies if the student's completion score reaches ≥ 65%. Individual completeness is used as a benchmark for determining classical completeness, with the following generality.

$$Classical\ Completeness = \frac{the\ number\ of\ students\ achieved\ learning\ completeness}{Total\ of\ students} \times 100\%$$

A class is said to have completed classical studies if an average of 85% of students have completed it individually. Know the effectiveness of use *E-Comic* Science based *Project Based Learning* (PjBL) developed is the aim of the product effectiveness test. This test uses the criteria for Achievement of Learning Goals and classical completion which are matched with the score *post-test* as a standard value criterion of product effectiveness. Determining the effectiveness of a learning motivation questionnaire can be analyzed descriptively quantitatively by looking for an average value (*mean*) and percentage of success. Average formula (*mean)* is as.

$$\bar{X} = \frac{\sum X}{N}$$

Description:
$\bar{X}$ = average value (*mean*)
$\sum X$ = total score (student grades)
N = many students

FINDINGS AND DISCUSSION

Findings

Expert Test Results Learning Content

The aim of carrying out an expert study content test is to determine the feasibility of the product being developed in the form of *e-comic* PjBL based science. The learning content expert test specializes in the content section which includes the learning material or content contained in *e-comic* science. The learning content expert test is expected to be able to provide input so that it can be perfected *e-comic* developed PjBL based science. Expert test of learning content on products *e-comic* this science is carried out by a lecturer with a doctorate from the Master of Science Education study program at Ganesha University of Education. The Expert test was carried out on Friday, September 5 2025 online. Input submitted to the expert test of the content of the product learning *e-comic* this science is the addition of inquiry activities or process skills by utilizing simulation and/or animation. An example is on the topic of the solar system, students are asked to provide hypotheses about the influence of the planet's location from the sun on its orbital speed. For example, in the classification of living things, students can be asked to classify living things based on their similar characteristics. Some input certainly provides improvements to the products developed in the form of *e-comic* science.

Based on expert assessment, the learning content in the developed product received a final score of 26 with a maximum score of 26. This gives a 100% percentage result on the product learning content expert test *e-comic* science. The results of the material content expert test percentages, if interpreted, are included in the Very Worthy qualification, the following is the calculation.

$$Appropriatness\ (A) = \frac{\text{Total Appropriateness Score}}{\text{Maximum Score}} \times 100\%$$

$$Appropriatness\ (A) = \frac{26}{26} \times 100\%$$

$$Appropriatness\ (A) = 100\ \%$$

Learning Media Expert Test Results

The learning media expert test on the developed product is: *e-comic* science was held on Friday, September 5, 2025. The lecturers involved in the expert learning media test involve lecturers with doctoral qualifications from the Ganesha University of

Education Science Master's study program. The Learning Media Expert Test specializes in determining the suitability of existing media in material and content *e-comic* developed science. The expert input of the learning media provided is to provide additional information in addition to figures, graphs, tables, etc. on *e-comic* science and equipping products with inquiry activities such as stimulation or animation.

The learning media expert test assessment received a score of 7 from a maximum score of 10. This shows that the percentage in the expert test on learning media is 70%. If interpreted the results of the percentage of learning content media in *e-comic* the science developed includes the Very Decent qualification. The following is a calculation of the learning media expert test *e-comic* PjBL based science.

$$Appropriatness\ (A) = \frac{\text{Total Appropriateness Score}}{\text{Maximum Score}} \times 100\%$$
$$Appropriatness\ (A) = \frac{7}{10} \times 100\%$$
$$Appropriatness\ (A) = 70\ \%$$

Computer Media Expert Test Results

The implementation of the expert computer media test aims to determine the feasibility of learning media developed in technical and design aspects, such as appearance, ease of use and interactive multimedia rules. This test was carried out by a lecturer with doctoral qualifications from the Master of Educational Technology study program at Ganesha University of Education, the test was carried out on Thursday, July 31 2025 online.

Based on an assessment from computer media experts on *e-comic* the PjBL-based science developed as for the score obtained was 59 out of a maximum score of 60. So the percentage result in the computer media expert test is 98.33 %. The results of the computer media expert test percentage if interpreted include the Very Worthy qualification. The following is the calculation.

$$Appropriatness\ (A) = \frac{\text{Total Appropriateness Score}}{\text{Maximum Score}} \times 100\%$$
$$Appropriatness\ (A) = \frac{59}{60} \times 100\%$$
$$Appropriatness\ (A) = 98.33\ \%$$

Learning Design Expert Test Results

The learning design expert test aims to determine the feasibility of the product being developed in terms of learning design before being tested on students. test the learning design expert on the product *e-comic* pjbl-based science was held on Thursday, July 24 2025. This test was carried out by a lecturer with a doctoral qualification who has expertise in the field of learning design from the Master of Educational Technology study program at Ganesha University of Education.

Based on the results of testing the feasibility of learning designs on products *e-comic* science obtained a score of 39 from a maximum score of 40. This results in a percentage of eligibility in its learning design area of 97.50 %. The following is the calculation.

$$Appropriatness\ (A) = \frac{Total\ Skor\ Kelayakan}{Total\ Skor\ Maksimal} \times 100\%$$
$$Appropriatness\ (A) = \frac{39}{40} \times 100\%$$
$$Appropriatness\ (A) = 97.5\ \%$$

The results of the learning design expert test percentage if interpreted include the Very Decent qualification. Some general inputs are summarised in Table 1.

Table 1 General Input of Learning Design Experts

No	General Input
1	There is one article *background* the chocolate is too strong/too brown so the writing is less interesting
2	It would be desirable to provide a glossary for terms that may be too scientific
3	The back cover should include a summary of the content of the material in the e-comic you created

Test effectiveness was carried out by 32 class VII students at SMP Negeri 6 Denpasar on Monday, September 22 2025. This test aims to determine the effectiveness of the product being developed. This test uses KKTP and classical completeness which are matched with post-test scores as a reference for determining the effectiveness of the product being developed. Based on the results of the individual post-test, there were 6 students who did not complete individually and 29 other students were declared complete. This decision was taken by looking at the individual completion of the class VII science KKTP at SMP Negeri 6 Denpasar, the score of which was 70. The results of individual completion calculations are continued with classical completion calculations so that you get a figure of 82.86 % in the "Very Good" category in terms of learning outcomes. Product use *e-comic* pjbl-based science developed based on the results of effectiveness tests is stated to be very good for application in learning as an additional medium. With an average score of 78.57 and a standard deviation of 7.567, it can be concluded that the students' learning outcomes have exceeded the criteria for achievement of learning objectives. Apart from that, the mean score of – 1 elementary school of 71.00 which is still above KKTP shows that students' learning outcomes are relatively consistent.

Based on the learning motivation questionnaire that was filled in by class VII students at SMP Negeri 6 Denpasar on Monday, September 22 2025, a percentage result of 92 % was obtained in the category "Very high". This states that the product *e-comic* the science developed can improve students' learning motivation very well.

Discussion

The feasibility of PjBL-based science e-comics was analyzed based on learning content experts, learning media experts, computer media experts and learning design experts. This validation aims to ensure that the science e-comic developed meets feasibility standards before being used in the classroom learning process. The results of the expert validation of the learning content obtained a final score of 26 with a maximum score of 26 making the percentage 100% with the category very feasible. The results of these results show that the material presented is in accordance with the Learning Achievements of the Independent Curriculum, the correctness of science concepts, and the integration of the material with the PjBL syntax. The presentation of material in the form of stories, dialogue between characters, and the context of everyday life is considered capable of helping students understand concepts more concretely and meaningfully.

The results of validation by learning media experts obtained a score of 7 out of 10 maximum scores so that it was presented at 70% with very decent qualifications. The aspects of visual appearance, illustration, text readability, color composition and topography are considered to be in accordance with the characteristics of class VII

students. Meanwhile, the validation results of computer media experts stated that the science e-comic developed was very feasible with a score of 59 out of a maximum score of 60 so that the percentage results in the computer media expert test were 98.33 %. The results of the validation test of the learning design expert obtained a result of 97.50 % with very feasible qualifications. Based on the validation results, it can be concluded that the PjBL-based science e-comic meets the criteria for the feasibility of learning content, media and implementation, so it is suitable for use as a science learning medium in class VII.

The effectiveness of science e-comics on student learning outcomes was analyzed based on test results after the application of learning using PjBL-based science e-comics. This analysis aims to determine the extent to which the use of the media developed is able to improve the achievement of students' learning outcomes. Results of descriptive statistical analysis show that the average score (mean) of student learning outcomes is 78.57 with a standard deviation of 7.57. These average scores show that in general students obtain good learning results. Relatively low standard deviations indicate that student learning outcomes tend to be homogeneous, so there are no too striking differences in abilities between students. When compared with a KKTP of 70, the average score for student learning outcomes has exceeded the specified completion limit. This shows that classically students have achieved learning completion. Thus, PjBL-based science e-comics are stated to be effective in improving student learning outcomes.

This effectiveness cannot be separated from the characteristics of science e-comics which present material in visual and narrative form. The presentation of material through stories and illustrations helps students understand abstract science concepts to be more concrete. In addition, the implementation of PjBL encourages students to actively engage in learning through project activities, group discussions, and real problem solving. The results of this study reinforce constructivist learning theory, which emphasizes that students must actively engage in project-based activities to acquire knowledge. As outlined in Mayer's multimedia learning theory, the integration of e-comics with the PjBL model shows that the use of digital visual media can increase learning attention, retention and transfer (Mayer, 2024). Apart from that, Mayer's theory about the use of multimedia can influence students' cognition by utilizing two things, namely images and sounds (Rahayu & Budiharto, 2025). This is in line with the use of PjBL-based e-comics which collaborate between the two so that students can better understand the material, especially science.

Good learning media can help better understand concepts, this is in line with the development of science e-comics which were developed to make it easier for students to understand each concept. Dharma et al. (2024) stated that developing media in comic form is able to provide a good understanding of the learning process. Research by Rismawati et al. (2024) fully supports this so that it can increase student learning motivation and learning outcomes. Research by Latul et al., (2024) supports the development of digital comics that are able to improve student learning outcomes with a significant level of results of $0.000 < \alpha\ 0.05$.

Based on the results of the learning motivation questionnaire analysis, most students showed high learning motivation after participating in learning using PjBL-based science e-comics. The 92 % percentage of motivation to learn lies in the very high category of motivation. These findings indicate that the use of science e-comics can increase student interest and involvement in the learning process. These results show that science e-comics provide an interesting and enjoyable learning experience. The

presentation of material in visual form, storylines, as well as student involvement in project activities encourages the emergence of students' intrinsic motivation to learn.

This result is in line with the theory of learning motivation which states that the use of interesting and contextual learning media can increase students' learning motivation. In addition, project-based learning provides students with opportunities to actively participate and work together, which positively impacts students' learning motivation. The research results obtained are supported by research from Santyasa et al. (2020) showing that PjBL has a positive influence on student learning motivation. This study shows that PjBL provides opportunity for students to freely carry out experimental activities, review literature in libraries, surf the internet, and collaborate with teachers. Therefore, learning resources become more open and diverse, including exploring the environment. Student learning motivation is very high because the use of science e-comic media is also supported by research conducted by Suciani et al. (2022) that student learning motivation can have a good influence on student learning outcomes. Thus, it can be concluded that PjBL-based science e-comics are effective in increasing student learning motivation, in terms of very high percentage qualifications.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that the PjBL-based science e-comic developed in this study is both feasible and effective for use in learning. The feasibility analysis conducted by learning content experts showed a score of 100% with a "Very Worthy" qualification, while media content experts provided a score of 70% with the same qualification. Computer media experts rated the product at 98.33%, and learning design experts at 97.5%, both categorized as "Very Worthy." Moreover, further development of PjBL-based science e-comics is recommended by enriching each chapter with more essential subtopics and incorporating up-to-date examples of science applications that align with the PjBL learning model. Future research is also encouraged to include more varied interactive quizzes and learning activities to enhance student engagement. In addition, the application of a more focused and explicit PjBL syntax within the e-comic is suggested to help students better understand the learning process and content. Lastly, expanding learning resources and quiz materials is recommended to provide more varied learning experiences and reduce student boredom during the learning process.

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