Development of Probability Learning Media PjBL-STEM Based Using E-comic to Improve Students' Literacy Numeracy Skills

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Abstract

This research is motivated by the fact that there are still many students who find it difficult to learn the probability material, which affects the students' low literacy numeracy ability. One of the efforts to improve students' literacy and numeracy skills is to innovate interactive learning media and the right approach. Therefore, this study develops interactive learning media in the form of e-comic based on Science Technology Engineering Mathematics (STEM). This research is a type of development research with the ADDIE model which has 5 stages including Analysis, Design, Development, Implementation, and Evaluation. This article will discuss Analysis, Design, and Development due to time constraints. The subjects in this study were two material experts and two media experts. This study used a data collection instrument in the form of a questionnaire. Validation of data from experts will be analyzed using qualitative descriptive analysis and quantitative descriptive analysis. The results of the validation data were calculated using the mean formula. Validation of literacy numeracy ability to get a score of 3.5 with very good qualifications and material validation to get a value of 3.8 with very good qualifications. So that the PjBL-STEM-based interactive e-comic learning media can be declared valid, practical, and effective to improve students' literacy numeracy skills and have very good qualifications. The development of interactive learning media can then be implemented in the classroom to determine the effect of media on students' literacy skills and as a reference for educators to develop interactive learning media with other PjBL-STEM to improve students' literacy skills

Keywords: Learning Media; E-comic, PjBL-STEM; Literacy Numeracy

Abstrak

Penelitian ini dilatarbelakangi oleh masih banyaknya siswa yang merasa kesulitan dalam mempelajari materi probabilitas, hal ini berdampak pada rendahnya kemampuan literasi numerasi siswa. Salah satu upaya untuk meningkatkan kemampuan literasi numerasi siswa adalah dengan melakukan inovasi media pembelajaran interaktif dan pendekatan yang tepat. Oleh karena itu, penelitian ini mengembangkan media pembelajaran interaktif berupa e-comic berbasis Science Technology Engineering Mathematics (STEM). Penelitian ini merupakan jenis penelitian pengembangan dengan model ADDIE yang memiliki 5 tahapan yaitu Analisis, Perancangan, Pengembangan, Implementasi, dan Evaluasi. Artikel ini akan membahas Analisis, Desain, dan Pengembangan karena keterbatasan waktu. Subjek dalam penelitian ini adalah dua orang ahli materi dan dua orang ahli media. Penelitian ini menggunakan instrumen pengumpulan data berupa angket. Validasi data dari ahli akan dianalisis menggunakan analisis deskriptif kualitatif dan analisis deskriptif kuantitatif. Hasil validasi data dihitung dengan menggunakan rumus mean. Validasi kemampuan literasi berhitung mendapatkan nilai 3.5 dengan kualifikasi sangat baik dan validasi materi mendapatkan nilai 3.8 dengan kualifikasi sangat baik. Sehingga media pembelajaran e-comic interaktif berbasis PjBL-STEM dapat dinyatakan valid, praktis, dan efektif untuk meningkatkan kemampuan literasi berhitung siswa dan memiliki kualifikasi sangat baik. Pengembangan media pembelajaran interaktif selanjutnya dapat diimplementasikan di dalam kelas untuk mengetahui pengaruh media terhadap kemampuan literasi numerasi siswa dan sebagai acuan bagi pendidik untuk mengembangkan media pembelajaran interaktif dengan PjBL-STEM lainnya untuk meningkatkan kemampuan literasi numerasi siswa.

INTRODUCTION

Indonesia is a country whose people are still known to have a low level of cultural literacy. It was followed with increasing sophistication tends to result in community technology being reluctant to read and apply a literacy culture. According to Widiantari et al. (2022) the literacy skills of students in Indonesia, especially in the field of literacy numeracy is still low. This is indicated by the results of the PISA and TIMSS tests shown respectively that Indonesia got a math score of 387 out of the average score of 490, while in TIMSS Indonesia got a math score of 395 out of the average score of 500. In line with the importance of literacy culture, numeracy also plays a crucial role in some aspects of life in everyday society. Teaching numeracy or mathematical literacy already should be given to children since he is still at a level of Elementary School gradually.

Mathematics is one of the most important learning materials in the world of education but it is also one of the lessons that are considered difficult by students (Siregar, 2017). Moreover, students have difficulty learning mathematics on probability materials (Anggara, et al., 2018).

Probability in mathematics is centered on two kinds of probabilities: empirical and theoretical.

This can be seen from the achievement of math scores on probability material which is still low, there are still some students who score below 75 there are 16 out of 22 students still find it difficult to work on probability material, this is because students do not take advantage of the time given by the teacher (Putridayani & Chotimah, 2018). In addition, the research by Garfield et al., (2008) shows the basic concept of probability is still very difficult for students because it is deeply learned and often contradicts many of their own beliefs about data and probability. In addition, it is still difficult for students to understand when learning probability because teaching materials are inadequate, such as only using power points and videos viewed from YouTube, so students get bored faster because they are taught with inadequate methods and teaching materials. Therefore, students need an innovative learning approach, teaching materials, and media that can increase their literacy and numeracy skills and help them in the learning process.

Based on several research results,

one learning model that is very relevant to help with problems is Project Based Learning (PjBL). PjBL is a model that uses the project as the core when the learning process is carried out (Meita et al., 2018). In this lesson, students are invited to make projects that focus on product development and solving problems (Anggraini & Ariyanto, 2017). In addition, the effort that can be done is to provide treatment to help students, the treatment in question is to apply STEM integrated Project Based Learning (PjBL-STEM) learning.

STEM education is an important tool for improving understanding and knowledge in a particular field (Siregar et al., 2019). According to Nursyahidah & Mulyaningrum (2022) to acquire and practice 21st-century skills we need an approach through STEM-based education that involves students. The integration of STEM activities can lead to thinking skills that can help students to form the ability to evaluate, analyze, and make arguments and conclusions correctly and logically about the problems to be solved (Ling Chia et al., 2018). STEM integration can make students active, creative, critical, and communicative (Alias et al., 2014). In STEM activities, students will study problems contextually and focus on applying STEM knowledge to solve everyday problems (Berland et al., 2014).

One of the important elements in the learning process is the learning media (Prakasiwi et al., 2021). The rapid development of technology has resulted in more varied learning media (Adnan et al., 2017). One of the learning media that can be used to help them easier to convey learning objectives is comics (Mery et al., 2022). The use of e-comic is very effective as a learning medium which is seen from the psychomotor, cognitive, and affective aspects (Hermawan et al., 2018). E-comic can be made and developed into a very in-teresting medium to realize the effectiveness of students in the implementation of the learning process of science material.

Mathematics e-comic is used by students for learning resources independently or in class, which consists of educational elements that are tailored to the material, environment, and needs of students (Nalurita et al., 2019). E-comic is one of the teaching materials that can be used on online media on the internet, intranet, or other computer network media (Buchori & Setyawati, 2015). The use of attractively packaged comics can be used to shape students' characters by entering character values in comics (Taufiq et al., 2020).

Learning media-based adobe animation is a media that can be used in the probability learning process. Adobe Animate can be implemented in learning activities. Adobe Animate was previously known as Adobe Flash Professional, Macromedia Flash, and FutureSplash Animator (Lardinois, 2020). Adobe Animate is very suitable to be used to create interactive learning media because researchers can create animations easily and freely (Pujiyantini et al., 2021).

Based on the influence of the e-comic learning media on the student learning process as well as the PjBL-STEM learning model above, the purpose of this study is to develop a PjBL-STEM-based e-comic learning media on probability material to improve students' literacy numeracy skills. According to research conducted by (McCaslin, 2015), constructivism and cognitive principles in the integrated learning process in STEM project-based learning.

METHOD

In this study, the type of research used is development. The model used in this study is the ADDIE model which consists of five stages, namely analysis, design,

development, implementation, and evaluation. The researcher uses this type of research and the research model aims to produce and test the effectiveness of the e-comic that is designed systematically. The stage chart of the ADDIE model used in this study is presented in the Figure 1.

Figure 1. The ADDIE Instructional Design Model

At the needs analysis stage, the analysis stage is to identify the material from the syllabus that is following the curriculum. The analysis phase used has 3 ways, namely curriculum analysis, characteristic analysis, and media analysis. Curriculum analysis by identifying Core Competencies, Basic Competencies, and Achievement Indicators at each meeting. Characteristic analysis by analyzing the character of Junior High School one Limpung which is the target of the e-comic research. In addition, there is media analysis analyzing this media such as e-comic when given to students, it can help when teaching and learning and is very feasible to use. Furthermore, at the design stage, the researchers designed the e-comic, including designing the storyline, shaping the characters, designing conversations between characters, making sketches, and coloring the e-comic. At the development stage, the previously designed e-comic was then consulted with the supervisory lecturer. There are four experts,

namely two media experts and two material experts. After the experts have validated, then the e-comic that has been designed is carried out a deficiency analysis which will then be a guide in revising the e-comic to make it better.

This study used a data collection instrument in the form of a questionnaire. The validation data from these experts will be analyzed using qualitative descriptive analysis and quantitative descriptive analysis. The results of the validation data were calculated using the mean formula. The validation of literacy numeracy skills got a score of 4.57 with very good qualifications and material validation got a score of 4.65 with very good qualifications. After validating with the experts, the next step is to determine this validation to see the agreement of the experts in assessing the validity of the developed e-comic. The qualitative descriptive analysis method was obtained from criticism and suggestions from experts and supervisors. While the quantitative descriptive analysis method was obtained by calculating the scores of the experts on the validation sheet which was then searched for the average using the calculation of the expert scores on the validation sheet which was then searched for the average using a four-scale rating guideline. So that the PjBL-STEM-based e-comic learning media can be declared valid, practical, and effective to improve students' literacy numeracy skills and have very good qualifications. The development of interactive learning media can then be implemented in the classroom to determine the effect of media on students' literacy numeracy skills and as a reference for educators to develop interactive learning media with other PjBL-STEM to improve students' literacy numeracy skills.

The subjects who will assess the e-comic validation test are four experts con-

sisting of two media experts and two material experts. The object of this research is e-comic validation regarding probability. This research was conducted using a questionnaire where the types of data are qualitative data and quantitative data. This research data collection uses a rating scale, with guidelines for collecting individual data in the form of numbers which are interpreted in descriptive form. This study uses a research scale sheet in the form of a questionnaire sheet with a scale of 1-4 (1 = not good, 2 = not good, 3 = good, 4 = very good). The stages in validity research are making instrument grids, consulting grids with supervisors, compiling instruments, and conducting validity with media and material experts. The validity sheet of the e-comic instrument that was developed covers seven aspects, namely the writing display, the image display, the comic media function aspect, the feature aspect, the content aspect, the construction aspect, and the linguistic aspect.

The validation instrument sheet has media experts and e-comic material experts. For media experts, there are four aspects in the first aspect, namely the appearance of writing which has indicators such as writing titles on e-comic media, the font size in e-comic media, use of dialogue words, clarity of writing on e-comic media, and ease of understanding the storyline. through the use of language. Furthermore, the image display has several indicators such as the shape of the image, the variation of the image, the suitability of the image with the text, and the color composition. In addition, there is a function of comics media that has indicators such as comics media as learning resources, delivery materials used by comics learning media can be understood by students, comics learning media can attract reading interest, comic learning media encourage students to carry out learning

activities so that learning objectives are achieved. Then for the last one, the characteristic of having also has several indicators such as the presentation of comic illustrations leading to understanding the concept, the proportion of comics as entertainment and knowledge enhancers, and comic media adding to the pleasure when reading them and encouraging readers to read them completely. If the e-comic material expert validation instrument has three aspects, the first aspect, namely the content aspect, the content aspect has several indicators that are validated such as the suitability of the material content with the syllabus, the suitability of the material with core competencies and basic competencies, the suitability of the material with teaching needs, suitability learning materials with indicators that will be achieved by students, the benefits of the material for adding insight into students' knowledge, ease of understanding learning materials, and the truth of the substance in learning materials. The second aspect of the construction has indicators to validate, namely the meaningfulness of the learning material, the suitability of the learning material with the level of student ability, clarity in learning objectives, motivating students, order of presentation in learning materials, systematics of learning materials, and completeness of information in the learning process. material presentation. The last aspect is the language aspect, the language aspect has several indicators such as clarity in providing information, legibility, effective and efficient use of language, use of interesting dialogues or texts that lead to understanding concepts, and use of communicative language.

The third stage is the development stage. At this stage, e-comic media will be developed following the designs that have been made and input from a mentor. The

e-comic learning media that have been developed consists of three parts, namely the opening, the content, and the closing. The next stage is the fourth stage, namely the implementation stage. At this implementation stage, what is done is the application of -based e-comic PjBL-STEM in 9th-grade students of State Junior High School 1 Limpung. The fifth stage is the evaluation stage. This evaluation stage is the last stage of Addie. At this stage, it is done to look at the results of student learning by looking at the results of pre-test and post-test during trials conducted on students of the Limpung State Middle School.

RESULTS AND DISCUSSION

Results

In this development, a product is made in the form of PjBL-STEM-based e-comic learning materials to be used as probability materials for Class VIII SMP in the even semester. This research is the development of PjBL-STEM-based e-comic learning media which is implemented with the ADDIE model. According to Sugiyono (2015), the ADDIE model has 5 stages, namely: (1) analysis stage, (2) design stage, (3) development stage, (4) implementation stage, and (5) evaluation stage. However, the implementation and evaluation stages were not carried out in the study due to time constraints.

Analysis

At this stage, it is carried out in 3 stages, namely analysis of student characteristics, analysis of student characteristics curriculum, and media analysis. The analysis of the characteristics of students finds that junior high school students are at the age of 12-15 years where at this age students enter the stage of concrete-formal cognitive development, and students begin to think abstractly and logically. For this reason, students need learning media that can help to develop students thinking skills. An analysis curriculum is done by analyzing core competencies, and basic competencies, and determining indicators of competency achievement in the material.

On analysis media, the e-comic media created must meet the criteria of several of the following aspects: (1) The visual aspect, in this aspect the e-comic must meet the appropriateness of the image from the storyline, the suitability of the background, the layout of the preparation images, and the suitability of coloring; (2) Typographical aspects, in this aspect of e-comic, must meet the selection of text types appropriate, text readability, and text size; (3) The aspect of characterization, in this aspect of e-comic, must meet conformity characters; (4) The material aspect, in this aspect the e-comic must meet the suitability of the material specified learning, clarity in conveying messages, and ease of understanding; (5) Linguistic aspect, this aspect e-comic must meet language suitability which is used with the correct language rules, the use of sentences that are easy to understand and effective, and efficient, and the use of punctuation and clear symbol.

Design

At this stage, it is done by designing PjBL-STEM-based e-comic learning media, determining the characters, designing storylines, making conversation scripts, and coloring characters. In making the design of the e-comic learning media, it was designed with the help of Adobe Animate software. The e-comic design is presented in Figure 2 and Figure 3.
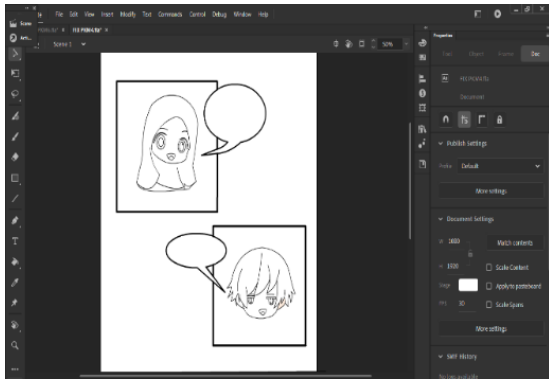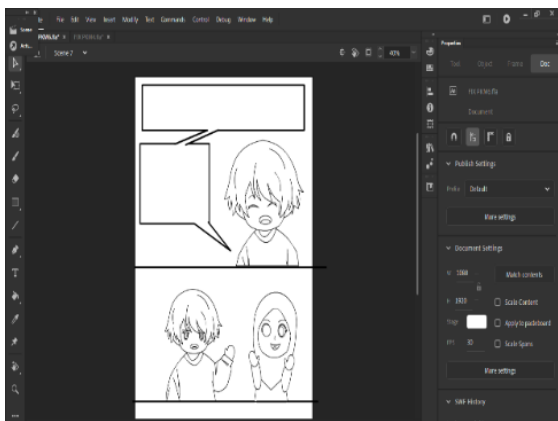
Figure 2. The design of the e-comic

Figure 3. The design of the e-comic

In this study, in addition to STEM-based e-comic, there are several instruments including test instruments (pre-test and post-test questions). The pre-test was used to determine the student's initial abilities before using STEM-based e-comic. While the post-test was used to determine the students' abilities after using STEM-based e-comic.

Development

At this stage, the e-comic media will be developed according to the designs that have been made and input from the accompanying lecturers. The e-comic learning media that has been developed consists of three parts, namely the opening part, the content part, and the closing part. The opening section consists of a cover and a character introduction. The content section consists of a character dialogue about a project that will be made

and an overview of the material. The closing section consists of instructions for working on student activity sheets and conclusions. The STEM-based e-comic media is divided into six series, the first series is about making STEM-based projects, the second series is about e-comic statistical material, the first is related to analyzing data and determining the median mean and mode, the third series contains the next material is the distribution of data consisting of ranges and quartiles, the fourth series contains e-comic material probability, which are related to empirical probability and theoretical probability, the fifth series contains e-comic material probability, which are related to the relationship between empirical probability and theoretical probability. The following is presented in figure 4, figure 5, figure 6, and figure 7 which are the e-comic opening, content, and closing sections.

Figure 4. The opening part of the PjBL-STEM-based e-comic learning media

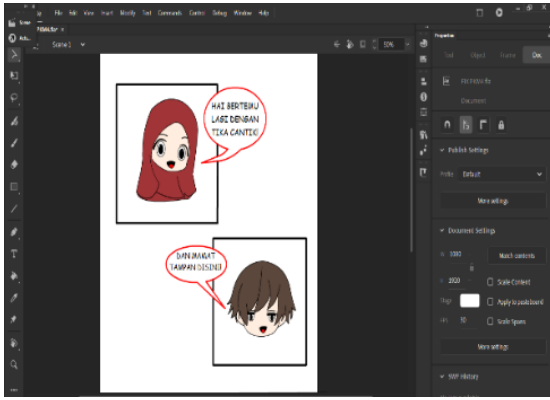*Figure 5. The opening part of the PjBL-STEM-based e-comic learning media*

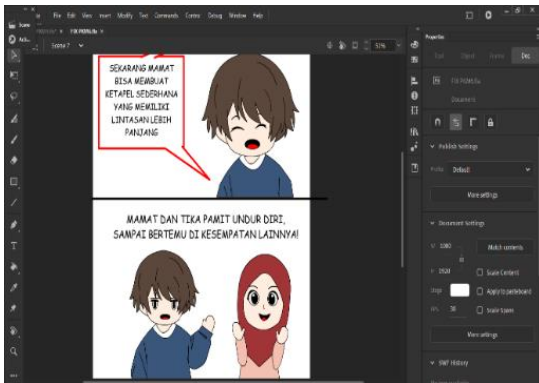*Figure 6. Contents of STEM-based e-comic learning media*

Figure 7. The closing part of the STEM-based e-comic learning media

Then after developing a STEM-based e-comic, the next step is to do a validation test by experts. The validation test was carried out by material experts and media experts for STEM-based e-comic. The names of validators and their roles are shown in Table 1.

Table 1. List of validators

Validator	Description
Dina Prasetyowati, S.Pd., M.Pd.	Material expert validation Media expert validation
Dr. Muhammad Prayito, S.Pd., M.Pd.	Material expert validation Media expert validation

The validation of the PjBL-STEM-based e-comic learning media test validation with the topic of probablity is carried out offline by giving validation test sheets to two material experts and two media experts. Based on comments and suggestions from media experts, it shows that in the validation assessment of PjBL-STEM-based e-comic media oriented to literacy

numeracy skills, the criteria are very good, with a score of 4 (very good) and 3 (good). From the results of the distribution of the score, the result is 3.5 with very good qualifications. The results of the validation test by material experts on the suitability of the curriculum and the suitability of the learning material were spread at a score of 4 (very good) and 3 (good). From the results of the distribution

The score was obtained at 3.8 with very good qualifications. Based on the results of the study, shows that the PjBL-STEM-based e-comic learning media for probability for junior high school materials developed in this study shows valid or feasible results. The following table shows the results of the average validation scores by media experts in table 2.

Table 2. Media expert validation results

Aspect	Score	
	Validator 1	Validator 2
Writing	19	15
Pictures	20	16
E-Comic Media Function	15	14
Characteristics	11	10
Total	65	55
Average	3,5	
Qualification	Very good	

Furthermore, the results of material expert validation can be seen in table 3.

Table 3. Results of material expert validation

Aspek	Score	
	Validator 1	Validator 2
Content	27	28
Construct	27	25
Language	20	29
Total	74	72
Average	3,8	

The following are the revisions from material experts and media experts along with the results after the revision.
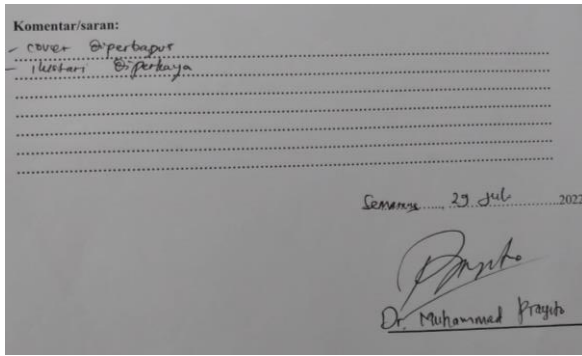
Figure 8. Comments/suggestions

Figure 9. Before revision
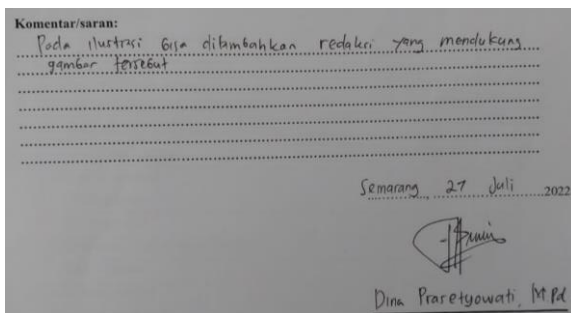

Figure 10. After revision

Figure 11. Comments/suggestions

Figure 12. After revision

Implementation

At this implementation stage, what is done is the application of STEM-based e-comic to 9th-grade students of State Junior High School 1 Limpung. At this stage, three classes were carried out, namely the small class, the experimental class (e-comic STEM), and the control class (conventional). In a small class, 6 students were taken to be given a pre-test, then continued with the provision of e-comic and student activity sheets, and closed with a post-test. In the Experiment class, 31 students were taken to be given a pre-test, then continued with the provision of STEM-based e-comic and student activity sheets, and closed with a post-test. The control class (conventional) was given a pre-test and then given conventional learning without using e-comic media, then closed with a post-test. The implementation of e-comic in some of these classes can be seen in Figure 13, Figure 14, and Figure 15.

Figure 13. Implementation of e-comic

Figure 14. Implementation of e-comic

Figure 15. Implementation of e-comic

Evaluation

This evaluation stage is the last stage of ADDIE. At this stage, what is done is to see the results of student learning by looking at the results of the pre-test and post-test during the trials conducted on students of the State Junior High School 1 Limpung. After learning in the experimental class (e comic PjBL-STEM) and control class (conventional) is completed, students will be given post-test questions for final data

analysis. This final data analysis was conducted to determine whether there were differences in learning outcomes in the form of students' literacy numeracy skills between the experimental class (e-comic PjBL-STEM) and the control class (conventional). The following steps are carried out in the final data analysis.

Normality test

The normality test aims to determine whether the sample taken is from a population that is normally distributed or not.

Table 4. Results of the Final Data Normality Test

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
Pre Test Eksperimen (E-comic)	.102	31	.200[*]	.959	31	.271
Post Test Eksperimen (E-comic)	.087	31	.200[*]	.978	31	.753
Pre Test Konvensional	.120	31	.200[*]	.946	31	.118
Post Test Konvensional	.101	31	.200[*]	.965	31	.393

a. Lilliefors Significance Correction

*. This is a lower bound of the true significance

Based on table 4, it can be seen that the significance value (Sig.) for all data, both in the Kolmogorov-Smirnov test and the Shapiro-Wilk test, shows a value > 0.05. So it can be concluded that the data for this study is normally distributed.

Test of Homogeneity of Variance

Once it is known that the research data is normally distributed, the homogeneity test will then be carried out on the research data. This homogeneity test was conducted to determine whether the experimental class and control class had homogeneous (same) or heterogeneous (unequal) variances.

Table 6. Results of 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
Students learning outcomes	Equal variances assumed	.088	.768	3.789	60	.000	7.806	2.060	3.686	11.927
	Equal variances not assumed			3.789	59.481	.000	7.806	2.060	3.685	11.928

Table 5. Results of Homogeneity Test Analysis

Students learning outcomes

Levene Statistic	df1	df2	Sig.
.088	1	60	.768

Based on Table 5, it can be seen that the significance value (Sig.) Based on the Mean is 0.768 > 0.05, it can be concluded that the variance of post-test data in the experimental class and post-test data in the control class is the same or homogeneous.

Independent Test Sample t Test

The independent sample t-test aims to determine whether there is an average learning outcome in the form of literacy numeracy skills in the experimental class that is better than the control class. This test is also to find out one indicator of the effectiveness of learning media products.

Based on Table 6, the significance value (Sig.) is 0.000 < 0.05. So it can be concluded that there is a difference in the average learning outcomes in the form of students' literacy numeracy skills between the experimental class and the control class.

Table 7. Student Learning Outcomes

Class	N	Mean	Std. Deviation	Std. Error Mean
Post-test Experiment	31	83.45	8.481	1.523
Post-test control	31	75.65	7.722	1.387

Based on Table 7, it can be proven that the average class that uses e-comic PjBL-STEM is 83.45 while the average class that does not use e-comic PjBL-STEM is 75.65. From this analysis, it can be concluded that there is an increase in the average score in the experimental class compared to the control class. So that the PjBL-STEM e-comic learning media can be declared effective.

The next step was to test the practicality of the e-comic PjBL-STEM. At the end of the lesson, students were given a student response questionnaire to the PjBL-STEM e-comic learning media.

Table 8. Average student response questionnaire

		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
N	Valid	31	31	31	31	31	31	31	31	31	31
	Missing	0	0	0	0	0	0	0	0	0	0
	Mean	3.97	4.55	4.35	4.32	4.45	4.55	4.55	4.52	4.58	4.48

Based on the data in Table 8, it can be seen that the response of students to the PjBL-STEM e-comic media with an overall average result of 4.8. So it can be said that e-comic is practical. In addition, based on student responses in the learning process that has been carried out, it can be concluded that most students anthusistic the learning media because e-comic learning media can help students understand probability and can also increase students' enthusiasm for learning.

This is in line with research by Dwidevi (2014), that one of the learning models that are considered to be effectively able to integrate STEM is the Project

based learning model. In addition, the research conducted by Wicaksana and Ridlo (2017) also supports the results in this study that using the PjBL (project-based learning) learning model can improve the character of students' epistemic curiosity and have an influence on mathematical literacy skills.

Discussion

Based on the results of the development, it was found that the PjBL-STEM-based e-comic learning media developed using the ADDIE model were declared valid, effective, and practical. With the validation results showing an average score by media experts showing a score of 3.5 with very good qualifications and by material experts showing a score of 3.8 with very good qualifications, it can be said that e-comic is valid. The practicality test of e-comic learning media is carried out by giving a student response questionnaire to e-comic learning media by obtaining an average score of 4.8, so it can be said that e-comic is practical. The average in the experimental class showed an increase compared to the control class so the e-comic was declared effective to improve students' literacy numeracy skills. The results of this study are in line with research conducted by Octaria, et al., that learning media is said to be good if it meets the aspects of validity, practicality, and effectiveness (Octaria et al., 2022).

The PjBL-STEM-based e-comic learning media for probability materials developed received a positive response from students. This is supported by Siregar et al., (2019) that e-comic media in learning mathematics is more effective than using the lecture method in learning. the use of e-comic media makes it easier for students to understand and allows students to master learning objectives better. Students do more learning activities because they don't just listen to the teacher's explanation, e-comics can increase student motivation and learning achievement (Budi, 2016; N. Siregar et al., 2019). Research result of Cahyani et al., (2020) stated that the STEM-integrated Project Based Learning e-module increases creativity and student learning outcomes, although not significantly, it is still in the moderate category. The PjBL learning model with the STEM approach also has advantages in the implementation of learning. The advantage of this PjBL is that it can increase student learning motivation by making students more active and successful in solving complex problems, improve problem-solving skills, enhance collaboration, encourage students to develop and practice communication skills, and can improve student skills in managing various sources (Raitu & Kurniawan, 2016). Learning using the STEM approach has the potential to create meaningful learning because students are trained to solve mathematical problems through projects that are integrated with one or another field of knowledge. Apart from that, STEM also provides students with the experience that mathematics has real benefits for everyday life (Indriani, 2020). Based on this description, this study packaged PjBL-STEM-based probability learning media using e-comic. The new thing in this research is an e-comic based PjBL-STEM learning media on probability material that is able to improve students' literacy numeracy skills and increase students' interest and motivation to learn. The new thing in this research is a e-comic based PjBL-STEM learning media on probability material that is able to increase students' interest and motivation to learn.

Implication of Research

Based on the results of this study obtained theoretical and practical implications. The theoretical implication is, by using PjBL-STEM can affect students' learning motivation, thereby affecting student achievement. The practical implication is that this research can be used as input for teachers and prospective teachers to pay attention to learning media, learning methods, and appropriate approaches.

Limitation

Based on the researcher's direct experience in this research process, some limitations can be considered for further research. Some of the limitations of these studies include: (1) The material studied only focuses on probability material for class VIII; (2) In the data collection process, the information provided by the respondents sometimes did not reflect the true opinions of the respondents. This happened because of different thoughts, assumptions, and different understandings for each respondent as well as other factors such as honesty in filling out the packet.

CONCLUSION

Based on the research and development that has been carried out, it can be concluded that the product developed is in the form of e-comic PjBL-STEM for probability material declared: (1) valid based on the media expert test with a score of 3.5 with very good qualifications and the material expert test with a score of 3.8 with very good qualifications good, (2) practical based on student response questionnaires with an average score of 4.8, (3) effective based on an increase in the average score where the class that uses e-comic PjBL-STEM is 83.45 and the class that does not use e-comic PjBL -STEM is 75.65. From the description of the results above it is known that the development of PjBL-STEM e-comic is feasible to be applied to students and suitable to be used as a companion for learning mathematics.

REFERENCES

Adnan, F., Prasetyo, B., & Nuriman, N. (2017). Usability testing analysis on the Bana game as education game design references on junior high school. *Jurnal Pendidikan IPA Indonesia*, *6*(1), 88–94. https://doi.org/10.15294/jpii.v6i1.9597

Alias, N., DeWitt, D., & Siraj, S. (2014). An evaluation of gas law webquest based on active learning style in a secondary school in Malaysia. *Eurasia Journal of Mathematics, Science and Technology Education*, *10*(3), 175–184. https://doi.org/10.12973/eurasia.2014.1074a

Anggara, B., Priatna, N., & Juandi, D. (2018). Learning difficulties of senior high school students based on probability understanding levels. *Journal of Physics: Conference Series*, *1013*(1). https://doi.org/10.1088/1742-6596/1013/1/012116

Anggraini, G. R., & Ariyanto, A. (2017). Analisis Kesulitan Pemahaman Konsep Pada Materi Pythagoras di Kelas VIII SMP Negeri 3 Kartasura. *Seminar Nasional Pendidikan Matematika*, 1–9.

Berland, L., Steingut, R., & Ko, P. (2014). High School Student Perceptions of the Utility of the Engineering Design Process: Creating Opportunities to Engage in Engineering Practices and Apply Math and Science Content. *Journal of Science Education and Technology*, *23*(6), 705–720. https://doi.org/10.1007/s10956-014-9498-4

Buchori, A., & Setyawati, R. D. (2015). Development Learning Model Of Character Education Through e-Comic In Elementary School. *International Journal of Education and Research*, *3*(9), 369–386.

Budi, D. (2016). Pengembangan Perangkat Pembelajaran melalui E-Comic Berbasis Scientifik Approach pada Mata Pelajaran Matematika Materi Limit Fungsi. *Kontinu: Jurnal Penelitian Didaktik Matematika*, *4*(1), 71–83.

Cahyani, A. E. M., Mayasari, T., & Sasono, M. (2020). Efektivitas E-Modul Project Based Learning Berintegrasi STEM Terhadap Kreativitas Siswa SMK. *Jurnal Ilmiah Pendidikan Fisika*, *4*(1), 15-22. https://doi.org/10.20527/jipf.v4i1.1774

Garfield, J. B., Ben-Zvi, D., Chance, B., Medina, E., Roseth, C., & Zieffler, A. (2008). Developing students' statistical reasoning: Connecting research and teaching practice. *Developing Students' Statistical Reasoning: Connecting Research and Teaching Practice*, January, 1–408. https://doi.org/10.1007/978-1-4020-8383-9

Indriani, K. W. ade. (2020). Peningkatan Kemampuan Berpikir Matematis Siswa Pada Materi Bangun Datar Melalui Model Pembelajaran Proyek Terintegrasi Stem. *Media Pendidikan Matematika*, *8*(1), 51-62. https://doi.org/10.33394/mpm.v8i1.2462

Ling Chia, P., Mistima Maat, S., Pendidikan, F., & Kebangsaan Malaysia, U. (2018). An Exploratory Study of Teachers' Attitudes towards Integration of STEM in Malaysia 45. *International Journal of Electrical Engineering and Applied Sciences*, *1*(1), 2600–7495.

Meita, L., Furi, I., Handayani, S., & Maharani, S. (2018). Eksperimen Model Pembelajaran Project Based Learning Dan Project Based Learning Terintegrasi Stem Untuk Meningkatkan Hasil Belajar Dan Kreativitas Siswa Pada Kompetensi Dasar Teknologi Pengolahan Susu. *Jurnal Penelitian Pendidikan*, *35*(1), 49–60. https://doi.org/10.15294/jpp.v35i1.13886

Mery, M. W., Ganda, R., Panjaitan, P., & Wahyuni, E. S. (2022). *Uji Kelayakan E-Comic Pada Materi Sistem. 20*, 43–57.

Nalurita, B. R., WALID, W., & ... (2019). Problem Solving Skill Seen from Adversity Quotient through Problem Based Learning Assisted by E-Comic Math. *Unnes Journal of Mathematics Education Research*, *10*(2), 147–154.

Nursyahidah, F., & Mulyaningrum, E. R. (2022). The Impacts of STEM on Mathematics And Science Through Lesson Study : A Systematic Literature Review. *Kalamatika: Jurnal Pendidikan Matematika, 7*(2), 125-142.

Octaria, D., Kesumawati, N., & Retta, A. M. (2022). Selecta Capita of Mathematics E-Book for SHS on Contextual Teaching and Learning (CTL) Approach. *Kreano, Jurnal Matematika Kreatif-Inovatif*, *13*(1), 136–150. https://doi.org/10.15294/kreano.v13i1.31654

Prakasiwi, L. R., Warsono, Gusemanto, T. G., & Herawati. (2021). Development of Adobe Animate Assisted Physics Learning Media as Online Learning Aid. *Proceedings of the 6th International Seminar on Science Education (ISSE 2020)*, *541* (Isse 2020), 574–581. https://doi.org/10.2991/assehr.k.210326.083

Pujiyantini, T., Romadhon, S., Ayu, R. T., Fairuzia, K. N., & Murtianto, Y. H. (2021). Jatibarang local wisdom berbasis adobe animate sebagai terobosan matematika digital. *Aksioma: Jurnal Matematika Dan Pendidikan Matematika*, *12*(3), 360–369.

Putridayani, I. B., & Chotimah, S. (2018). Analisis Kesulitan Belajar Siswa Dalam Menyelesaikan Soal. *MAJU: Jurnal Ilmiah Pendidikan Matematika*, *7*(1), 57–62.

Raitu, H., & Kurniawan, A. (2016). Pengaruh Mode Project Based Learning dengan Tugas Creative Mind Map Terhadap Kemampuan Koneksi Matematika dan Hasil Belajar. *Jurnal Media Pendidikan Matematika: J-MPM*, *4*(2), 57–63.

Siregar, N. R. (2017). Persepsi siswa pada pelajaran matematika: studi pendahuluan pada siswa yang menyenangi game. *Prosiding Temu Ilmiah X Ikatan Psikologi Perkembangan Indonesia*, 224–232.

Siregar, N., Suherman, S., Masykur, R., & Ningtias, R. S. (2019). Pengembangan Media Pembelajaran E-Comic Dalam Pembelajaran Matematika. *Journal of Mathematics Education and Science*, *2*(1), 11–19. https://doi.org/10.32665/james.v2i1.47

Taufiq, M., Wijayanti, A., & Fajriah, E. (2020). The implementation of e-comic earth layer to enhance students' self-directed learning. *Journal of Physics: Conference Series*, *1567*(2). https://doi.org/10.1088/1742-6596/1567/2/022070

Widiantari, N. K. K., Suparta, I. N., & Sariyasa, S. (2022). Meningkatkan Literasi Numerasi dan Pendidikan Karakter dengan E-Modul Bermuatan Etnomatematika di Era Pandemi COVID-19. *JIPM (Jurnal Ilmiah Pendidikan Matematika)*, *10*(2), 331-343. https://doi.org/10.25273/jipm.v10i2.10218