Randwick International of Education and Linguistics Science (RIELS) Journal
Vol. 5, No. 2, June 2024 | Page 595-611 |
https://www.randwickresearch.com/index.php/rielsj

Development of a Web-Based Interactive Multimedia Problem-Based Learning Approach on Algorithms and Programming Material

DOI: *https://doi.org/10.47175/rielsj.v5i2.993*

| Ajeng Zanna Tirahna[1,*] | R. Mursid[2] | Sriadhi[3] |

[1,2,3]Department of Education Technology, Postgraduate, Universitas Negeri Medan, Medan, Sumatera Utara, Indonesia

** ajengzannatirahna@gmail.com*

ABSTRACT

This research and development aims to produce interactive multimedia based on problem-based learning (PBL) using the Web to improve student learning outcomes in algorithms and programming material that is feasible, practical, and effective. This type of development research uses the ADDIE model. This research was carried out at SMK Negeri 6 Mukomuko, the material on algorithms and programming in the informatics class X Phase E. The results of the research show: (1) Expert validation test on product material in the very feasible category, namely 88.14%. (2) The Instructional Design Expert validation test is in the very feasible category, namely 95.56%. (3) The Media Expert validation test is in the very feasible category, namely 91.46%. (4) Individual trials in the very good category, namely 87.55%. (5) The small group trial was in the very feasible category, namely 89.65%. And (6) field trials in the very feasible category, namely 89.15%. The practicality test was very practical, namely 96.67%, while the practicality test results for students were 95.59% in the very practical category. The results of the experiment using PBL-based interactive multimedia in the experimental class gave an average learning outcome of 84, while students who were taught without using PBL-based interactive multimedia got an average score of 60.9. Hypothesis testing uses an independent t-test with significant results. (2-tailed) of 0.00, where the result is <0.05, it is concluded that there is a significant difference between classes taught using PBL-based interactive multimedia and classes taught without using PBL-based interactive multimedia

KEYWORDS

interactive multimedia; Problem Based Learning; web; algorithm and programming

INTRODUCTION

Technological developments in the digital era have transformed many industries, including education. The integration of technology in learning has caused significant changes in the way education is delivered and experienced by both teachers and students. One key aspect of this transformation is the digitalization of learning organizations, which involves the integration of digital technologies into various aspects of educational institutions, such as teaching, learning, and administration (Ifenthaler et al., 2021). This digital transformation has made education more accessible, allowing students to learn from anywhere and at any time, overcoming obstacles such as illness or full-time work (Raja and Nagasubramani 2018).

This transformation certainly has an impact on education in Indonesia, where the quality of education is an essential factor in determining the quality of human resources in a country (Mulyani, 2022). More than that, quality education also plays an important role in the progress of a country. The key to shaping a country's progress is prioritizing education. By developing education, a generation of people can be created who have better mindsets and habits to face problems and challenges.

The content of this informatics subject is very different from the information and communication technology (ICT) that teachers are familiar with. Informatics is defined as a scientific discipline that seeks to understand and explore the world around us, both natural and artificial, which specifically relates not only to the study, development, and implementation of computer systems but also to understanding the basic principles of development based on an understanding of the world. real and artificial worlds (Wisnubhadra et al., 2021). Students are expected to study informatics subjects not only to become computer users but also to realize their role as problem solvers.

Programming algorithm material is a sub-material in informatics subjects. The programming algorithm material is complex and difficult for most students to understand. Students must understand the branching structure and looping structure, which really require activities for coding practice. Along with this, interest in this material may decrease due to the perception that it is unpleasant or irrelevant in everyday life (Smith, 2020; Johnson, 2018).

Through the results of observations of class Most students only rely on textbooks as their main guide to learning. Students experience difficulties understanding algorithms and programming material because the teacher's teaching is monotonous and lacks variety. The KKM in the algorithm material is 75; however, based on observations of student learning outcomes, it is still far below the KKM.

The interactive multimedia developed has an embedded online programming compiler, so students can carry out coding practicums through the interactive multimedia developed. Interactive multimedia is developed according to the syntax in the PBL model. Interactive multimedia can combine all media consisting of text, image, sound, animation, and video elements, as well as interactivity developed on the basis of learning theory and principles. The advantage of interactive multimedia in terms of interactivity is that it is capable of forcing users to interact with the material both physically and mentally, which is influenced by the effectiveness of the instructions on the media, so that it is able to encourage users to be active in the learning presented (Dewantara et al., 2020). Several other advantages are that multimedia is able to change passive learners into active learners, so the teacher is no longer the center of information but becomes a facilitator who guides students in acquiring knowledge (Dewantara et al., 2020).

Several findings state that using interactive multimedia can help students understand the material (Firmansyah et al., 2020). Interactive multimedia has a high level of feasibility and effectiveness when used in algorithms and programming material (Yusuf, 2022; Alisyafiq, 2021; Samodra & Sutrisno, 2021). The use of interactive learning multimedia in the learning process is very effective in attracting students' interest in learning and making learning more interactive, thus improving students' learning outcomes significantly (Arifin et al., 2021).

Zega & Lase (2022) state that the use of web-based interactive multimedia is an effective approach to the learning process. Tazkia et al. (2019) stated that web-based interactive multimedia is very valid, practical, and feasible for improving student learning outcomes. Furthermore, the collaborative learning model based on e-learning with the use of interactive multimedia for learning outcomes is conceptually based on an overall

learning approach that can be applied to facilitate, grow, and develop learning awareness so that you are able to think, feel, and use your body in solving life problems. in the real world (Mursid, R. et al., 2023).

Gerlach and Ely (Putri, 2023) argue that, broadly speaking, media are people, materials, or events that create conditions that enable students to acquire knowledge, skills, and attitudes. AECT (Association for Educational Communication and Technology) defines media as all forms and channels used in the process of conveying information. Miarso (2011) stated that media is anything that can stimulate students' thoughts, feelings, attention, and will so that it can encourage the learning process in students.

Learning media is anything that can be used to mediate a message to the recipient so that it can stimulate students' ideas, sympathy, feelings, and interest in being involved in learning activities (Tofanao, 2018).

Multimedia is a combination of various media (file formats) in the form of text, images, graphics, sound, animation, video, interactions, etc. that have been packaged into digital files (computerized) and used to convey messages to the public. Meanwhile, interactive is two-way communication or more than communication components. This can be interpreted as meaning that interactive multimedia is a multimedia display designed by designers so that the display fulfills the function of informing the message and has interactivity for the user. Reddi & Mishra (Abdillah, 2020) state that interactive multimedia is the integration of elements of several media (audio, video, graphics, text, animation, etc.) into a synergistic and symbiotic whole that produces more benefits for the end user than any of the media elements can provide individually.

Interactive multimedia is used together with various media elements such as text, graphics, animation, and video. This is in accordance with the opinion of Vaighon 1998 (Zyahrok et al., 2020), which states that "multimedia is a combination of text, graphics, art, sound, animation, and video, which are interrelated elements." Multimedia can follow the wishes of the user, display multimedia projects, and control the elements presented. From several opinions, it can be concluded that interactive multimedia is a combination of various learning media packaged into one computer system to make it easier for users to use it at the same time and to follow the user's wishes when the multimedia is displayed.

PBL-based interactive multimedia is a learning approach that combines the power of multimedia technology with problem-based learning methods. The essence of this approach is to utilize interactive multimedia, such as text, images, audio, video, animation, and various interactive features, to create a more interesting, effective, and actively involved learning experience.

Interactive multimedia is a learning event or activity that utilizes website media connected to internet access in the learning process (Arief et al., 2018). Interactive multimedia offers several advantages, namely speed and unlimited time and space for accessing information. E-learning provides a very effective learning experience (Rohdiani & Rakhmawati, 2017). Learning activities can be easily carried out by participants because they are connected to the internet network. Websites are able to provide information more efficiently and up-to-date. Websites are more easily accessed by people in various regions just by using the internet (Hasugian, 2018).

The formulation of the problem in this research includes: (1) What is the feasibility of PBL-based interactive multimedia using the web for algorithms and programming material? (2) What is the practicality of PBL-based interactive multimedia using the web for algorithms and programming material? (3) How effective is PBL-based interactive multimedia using the web in algorithms and programming material?

RESEARCH METHODS

The research method applied in this study is the Research and Development (R&D) method. The development carried out in this research utilized the ADDIE development model. ADDIE consists of five stages, which include analysis, design, development, implementation, and evaluation (Hidayat, 2021), to develop PBL-based interactive multimedia using the web in algorithm and programming material for class X Phase E informatics subjects.

This research was carried out at SMK Negeri 6 Mukomuko, which is located at Mekar Mulya Village, Penarik District, Mukomuko Regency, Bengkulu Province. This research begins in the first semester of the 2023–2024 academic year.

The subjects in this research were students. The stages of PBL-based interactive multimedia product design can be seen in Table 1 below:

Table 1. PBL-based interactive multimedia product design stages

No.	Interactive Multimedia	PBL phase
1	Home page, Login, Home	-
2	Learning and usage instructions	**Phase 1:** Orient students to the problem, explain the logistics required, motivate students
3	• Present a problem in text/video form • A form is provided to write/upload answers to problems	
4	Main material in the form of video/animation	**Phase 2:** Organizing students to learn
5	Multiple choice practice activities, matching, fill in the blank	
6	Illustrations or animations and interesting facts	
7	• Problem Solving Tasks (equipped with solving instructions) • Equipped with a form for writing the results of problem solving and equipped with an online C++ compiler (for solving problems related to C++ programs) • Provided a bag for collecting	**Phase 3:** Guide individual or group investigations. **Phase 4**: Develop and present work results. Helping students prepare appropriate results and presenting them in results reports, including helping students share assignments with their friends
8	Reflections	**Phase 5:** analyzing and evaluating the problem solving process, students are asked to provide their responses about the learning that has been passed

The form of learning outcomes text used is multiple choice text, which includes C1 (remembering). C2 (understanding), C3 (application), C4 (analysis), C5 (evaluation), and C6 (creating). Each correct answer is given a score of 1, and an incorrect answer is given a score of 0 (zero). Before this instrument is used, its quality is first examined through trials.

Table 2. Question Grid

No	Material	Knowledge Dimensions	Cognitive Process Dimensions						Number of Questions
			C1	C2	C3	C4	C5	C6	
1	Characteristics of algorithms	Factual	1,2				44	43	4
		Conceptual	3,5		22				3

	and programming languages	Procedural	4						1
		Metacognitive		18	25,26				3
2	Algorithms in narrative form, pseudocode, and Factual flowcharts	Factual							
		Conceptual		14				45	2
		Procedural		15,16	24		40	46	5
		Metacognitive		17				47,48	3
3	Procedural programming concepts	Factual			19,20	27,28	36		5
		Conceptual			21	29,30	37		4
		Procedural	6,7		23	31,32	35		6
		Metacognitive	8,9						2
4	Branching logic in procedural programming languages	Factual		12,13			38		3
		Conceptual							
		Procedural							
		Metacognitive				33	42	49	3
5	Loop logic in Factual programming languages	Factual		10,11					2
		Conceptual							
		Procedural					39		1
		Metacognitive				34	41	50	3
Total			9	9	8	8	9	7	**50**

The validity of test items shows the accuracy of a test item to measure what it wants to measure. According to Arikunto (in Saputra, 2022), this can be determined by correlating the score obtained from the item with the total score using point-by-point biserial correlation.

$$\gamma_{pbi} = \frac{Mp - Mt}{St}\sqrt{\frac{p}{q}}$$

Test reliability refers to the consistency of a test when used on the same subject with different administration times. This means that the test gives relatively or close to the same results. According to Arikunto (in Saputra, 2022), test reliability is calculated using the Kuder and Richardson formula, namely as follows:

$$r_{11} = \left(\frac{k}{k-1}\right)\left(\frac{S^2 - \sum pq}{S^2}\right)$$

Table 3. Material Expert Validation Instrument Grid

No	Aspect	Indicators
1	Material information	Clarity of learning outcomes and learning objectives
		Formulation of learning outcomes
2	Material quality	Conformity of objectives with the curriculum
		Suitability of material to purpose (CP)
		Up-to-date material
		Description of a concept or theory
		The order (syntax) of presenting the material
		Conformity of material coverage with objectives (CP)
		Suitability of material depth to objectives (CP)
		Ease of understanding terms and formulations
		Suitability of examples or illustrations to the material
		Providing a summary
		Suitability of time duration with presentation material
4	Evaluation	Practice/exam instructions

		Conformity of question coverage to objectives (CP)
		Distribution of question items based on question domain
		Appropriateness of exam questions to time is provided

(Source: adapted from Sriadhi, 2018)

Table 4. Design Expert Validation Instrument Grid

No.	Aspect	Indicators
1	Learning objectives	Suitability of the formulation of learning objectives
2	Learning activities	Suitability of learning objectives at the learning activity stages (introduction, core and conclusion)
3	Learning methods	Suitability of methods to learning objectives
		Suitability of methods to learning activities (introduction, core and conclusion)
		Suitability of the method to the characteristics of students
		The effectiveness of learning methods in learning activities
4	Learning media	Suitability of media to learning objectives
		Suitability of learning media to learning objectives
		Suitability of media to learning methods
		Suitability of media to student characteristics
5	Times	Accurate time allocation for each stage of activity
		Suitability of time to learning methods
6	Tests	Suitability of tests to learning objectives

(Source: adapted from Bulo, 2020)

Table 5. Media Expert Validation Instrument Grid

No	Aspect	Indicators
1	Aesthetics	Visual quality, text color composition, background
		Accelerate text, visuals, audio and animation
2	Guides and Information	Description of interactive multimedia
		Guide to using interactive multimedia
3	Multimedia Performance	Accuracy in the use of media navigation symbols
		Ease of use of navigation buttons (usability)
		Search accuracy and links (hyperlinks) with interactive multimedia
		Interactive multimedia stimulus response interactivity with users and systems
		Ease of access to educational media
		Interactive multimedia design gives an attractive and positive impression
		Quality of interactive multimedia visual displays
		The letters used are clear and legible
		Color contrast in interactive multimedia design
		Educandy media features can be accessed in their entirety
4	Systematics	Media display (screen) layout
		Menu facilities in media
		Acceleration of letters, numbers and symbols

(Source: adapted from Sriadhi, 2018)

Table 6. Test Instrument Grid for Multimedia User Students

No	Aspect	Indicators
1	Learning Objectives	The description of the multimedia product is very clear
		The multimedia usage guide is easy to understand
2	Material	Suitability of the material to the topic of discussion, learning objectives,

	Quality	concepts or theories and scope of the material
		Presentation of material arranged sequentially (hierarchically)
		Providing examples or illustrations that are easy to understand
3	Evaluation	The media provides instructions for taking exercises/exams
		Practice/exam questions support the achievement of learning objectives
		Exam results are reviewed or fed back in the media
4	Media design and facilities	Learning media is easy to use
		Command buttons have accurate links (hyperlinks).
		Learning media can be run without damage
		Media provides interactive facilities for users
		Letters, numbers and symbols on the media are written clearly
		The visual images (graphics) on the media are very good
		Audio quality is very good
		Video quality is very good
		Animation quality is very good
		The coloring of the media content is very good
5	Pedagogical effects	This media provides what students need
		Students are interested in using this media to learn
		This media makes students more enthusiastic/active in learning
		This media helps to understand learning material
		This media helps improve students' abilities
		This media provides what students need

(Source: adapted from Sriadhi, 2018)

Table 7. Practicality Test Instrument Grid

Aspect	Indicator	Description
Accessibility	Ease of use of PBL Based Interactive Multimedia	PBL-based Interactive Multimedia is easy to access
		PBL-based Interactive Multimedia provides flexibility in use
		PBL-based Interactive Multimedia provides easy navigation
Usefulness	Efficiency	PBL-based Interactive Multimedia helps save time in learning preparation
		Complete learning materials are available
	Ease of helping to increase the achievement of learning objectives	Learning materials in video form attract students' interest in learning
		PBL-based Interactive Multimedia provides an interesting learning experience
		The available practice questions help students hone their problem solving skills
		Interactive Multimedia makes programming practice easier
Presentation	Interactive Multimedia Display makes it easier for students to understand new knowledge	Multimedia provides interactive facilities for users
		The language used in PBL-based Interactive Multimedia is easy to understand
		Selection of font type and size is easy to read

(Source: adapted from Mutmainnah, 2022)

Feasibility Test Data Analysis Techniques

The input obtained from the expert validation results is then analyzed using the following formula (Sriadhi, 2018): (1) Tabulate the answer scores for each instrument item in each

aspect; and (2) Find the average answer score for each aspect using the formula:

$$x = \frac{\sum X}{n}$$

Information:
x : Average score
∑X : Total score of statement items
n : Number of data (number of statement items)

Table 8. Interpretation of Expert Assessment and Acceptance of Multimedia Users

No	Interval Mean Score	Interpretation
1	4,17-5,00	Very Eligible
2	3,33-4,16	Eligible
3	2,50-3,32	Not Appropriate
4	1,00-2,49	Not Eligible

(Source: Sriadhi, 2018)

Practicality Test Data Analysis Techniques

Practicality analysis uses a Likert scale with the following steps: (1) Give a score for each item with answers of strongly agree (4), agree (3), disagree (2), and strongly disagree (1); (2) Adding up the total scores for all indicators; and (3) Practicality analysis using the equation:

$$P = \frac{F}{N} X\ 100\%$$

With description:
P = Percentage of practical value
F = Score obtained
N = Ideal score
Determine product practicality criteria. After the percentage of practicality value was obtained, grouping was carried out according to the criteria according to Sugiyono (2018) as shown in Table 9.

Table 9. Distribution of Practicality Analysis Results

Score	Criteria
85% - 100%	Very Practical
70% - 84%	Practical
55% - 69%	Quite Practical
40% - 54%	Less Practical
0% - 39%	Impractical

(Source: Sugiyono, 2018)

Effectiveness Test Data Analysis Techniques

Data collection techniques using posttests in control and experimental classes were carried out to determine the effectiveness of PBL-based interactive multimedia using the web with test results on algorithm and programming material for students. Next, the data generated from the test will be tested for effectiveness.

Before carrying out an effectiveness test with the t-test, there are requirements that must be met, namely carrying out a normality test and a homogeneity test. After both are fulfilled, the independent sample t-test can then be carried out on the research data.

Hypothesis test

The research hypothesis needs to be tested for truth, in this research the statistical technique used to test the hypothesis is the t-test (independent test).

Ho : $\mu_1 = \mu_2$
Ha : $\mu_1 \neq \mu_2$

Information:

μ_1 : Average student learning outcomes using the developed interactive multimedia
μ_2 : Average student learning outcomes without using the interactive multimedia developed
Ha : There is a significant difference in learning outcomes between classes that study using interactive multimedia and classes that do not use interactive multimedia.
H0 : There is no significant difference in learning outcomes between classes that study using interactive multimedia and classes that do not use interactive multimedia.

To test the hypothesis, the two-party test formula is used:

$$t_{count} = \frac{\bar{x}_1 - \bar{x}_2}{S\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

Where S is the root of the combined variance calculated by the formula:

$$S^2 = \frac{(n_1-1){S_1}^2 + (n_2-1){S_2}^2}{n_1 + n_2 - 2} \text{ where } S = \sqrt{s^2}$$

Information:

$\bar{x}_1$: average experimental class score
$\bar{x}_2$: average control class score
n_1 : number of experimental class samples
n_2 : number of control class samples
${S_1}^2$: variance in the experimental class
${S_2}^2$: variance in the control class
S : combined variance
t : calculation price

with db = n1 + n2 – 2, the correlation criteria obtained are said to be significant (the hypothesis is accepted) if the t_count > t_table for a significance level of 5%.

RESULTS AND DISCUSSION

Results

Stages of analysis and storyboard design, then an initial PBL-based interactive multimedia product is built. PBL-based Interactive Multimedia was developed using the Moodle 4.1 platform. The following displays the UI/UX of an interactive multimedia product that has been developed by applying the phases of the PBL learning model:

Figure 1. Home page

Figure 2. Login page

Figure 3. Main material presented in video or ebook form

This testing is carried out at the end of software development to find out whether the software can function properly. The following is a table for interactive multimedia blackbox testing

Table 10. Results of interactive multimedia blackbox testing

No	Testing	Test Cases	Expected results	Test result	Conclusion
1	When Clicking the Login Menu	Click the login menu	The Dashboard Page appears	According to expectations	Valid
2	When you click on the My Courses menu	Click the My Courses Menu	A list of sub-chapter names for programming algorithm material appears	According to expectations	Valid
3	When you click on the sub-chapter menu, algorithm and programming material	Click Menu 1. Characteristics of algorithms and programming	Material components appear in the form of user instructions, problem solving, ebooks, video materials, let's practice, let's discuss and reflect	According to expectations	Valid
4	When Clicking the Troubleshoot Menu	Click the Troubleshoot Menu	Problems arise for students to solve problems	According to expectations	Valid
5	When Clicking on the E-book Menu	Click the E-Book Menu	A screen appears to view or download the E-Book	According to expectations	Valid
6	When you click on the learning video menu	Click the Material 1 menu – Algorithm Concepts	A display appears to view the learning video	According to expectations	Valid
7	When Click Menu Let's Practice	Click the Let's Practice Menu	Questions appear for practice	According to expectations	Valid
8	When you click on the Programming Practical Menu	Click the Programming Practical Menu	Practical questions and online C++ compilers appeared	According to expectations	Valid

No	Testing	Test Cases	Expected results	Test result	Conclusion
9	When you click on the menu, let's discuss	Click the Let's Discuss Menu	Questions appear for group discussion	According to expectations	Valid
10	When Clicking the Reflection Menu	Click the Reflection Menu	The Reflection Input Page appears	According to expectations	Valid

Table 11. Summary of the average percentage of feasibility research results for PBL-based Interactive Multimedia

No.	Respondents	Average	Percentage Average	Criteria
1	Material Expert	4,41	88,14%	Very Eligible
2	Learning Design Expert	4,78	95,56%	Very Eligible
3	Media Expert	4,57	91,46%	Very Eligible
4	Individual Trials	4,37	87,44%	Very Eligible
5	Small Group Trials	4,48	89,65%	Very Eligible
6	Field Trials	4,46	89,15%	Very Eligible
	Average	4,51	90,23%	Very Eligible

PBL-based Interactive Multimedia Practicality Test Results by teachers.

Table 12. Average percentage of PBL-based Interactive Multimedia media practicality test results for teachers

No.	Assessment Aspects	Average	Percentage Average	Criteria
1	Accessibility	4,67	93.33%	Very Practical
2	Usefulness	4,83	96,67%	Very Practical
3	Presentation	5	100%	Very Practical
	Average	4,83	96,67%	Very Practical

Practicality Test Results of the products developed which have been given to students.

Table 13. Average percentage of PBL-based interactive multimedia practicality test results for students

No.	Assessment Aspects	Average	Percentage Average	Criteria
1	Accessibility	4,73	94,67%	Very Practical
2	Usefulness	4,78	95,67%	Very Practical
3	Presentation	4,82	96,44%	Very Practical
	Average	4,78	95,59%	Very Practical

The results of the research in the experimental class showed that the lowest score for students was 64 and the highest score was 100. Meanwhile, the mean score was 84. The following is descriptive data for the class that was taught using PBL-based Interactive Multimedia or called the Experimental class.

The results of the research in the control class showed that the lowest score for students was 40 and the highest score was 80. Meanwhile, the mean score was 60.93. The following is descriptive data for the class taught using textbooks, which is called the Control class.

Table 14. Normality Test

Tests of Normality							
		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	GROUP	Statistic	Df	Sig.	Statistic	df	Sig.

Learning Results	Experimental Class	0,146	30	0,101	0.947	30	**0,141**
	Control Class	0,144	30	0,114	0.956	30	**0,242**
a. Lilliefors Significance Correction							

From the results of the normality test carried out on the research data, the significance value for the experimental class was 0.141 and the control class was 0.242. Based on the criteria used, if the significance value is greater than 0.05, then the data can be said to be normally distributed.

Table 15. Homogeneity Test

Test of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Learning Results	Based on Mean	0,090	1	58	**0,765**
	Based on Median	0,151	1	58	0,699
	Based on Median and with adjusted df	0,151	1	54,374	0,699
	Based on trimmed mean	0,93	1	58	0,762

Based on the homogeneity test results table above, a significance value of 0.765 was obtained. Based on the criteria used, if the significance value is greater than 0.05, then the data is said to be homogeneous.

Table 16. Hypothesis testing using t-test

Independent Samples Test								
		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Learning Results	Equal variances assumed	8,286	58	**0.000**	23,067	2,784	17,494	28,639
	Equal variances not assumed	8,286	57,971	**0.000**	23,067	2,784	17,494	28,639

From Table 16, it can be seen that the significance value (2-tailed) is 0.000, which means the value is less than 0.05. Based on these results, it can be concluded that there is a significant difference in learning outcomes between classes that study using PBL-based interactive multimedia and classes that do not use PBL-based interactive multimedia.

Discussion

The development of interactive multimedia products in this research was carried out by taking into account the results of needs analysis, curriculum, and student characteristics. Therefore, the use of the PBL model is able to facilitate these needs. The PBL-based interactive multimedia that has been developed contains algorithms and programming material, and in this material there are many programming practicums. For this reason, the development of interactive multimedia has embedded a C++ online compiler to support programming practicum students. This is in line with the research results of Amri et al. (2020), who found that interactive multimedia can improve student learning outcomes.

There are five main materials in the developed PBL-based interactive multimedia, including: (1) Characteristics of Algorithms and Programming, (2) Narrative Algorithms, Pseudocode, and Flowchar; (3) Programming (Data Types, Variables, and Operators); (4) Branching Logic; and (5) Looping Logic. In this interactive multimedia presentation,

problem-solving exercises related to problems that occur in the five main topics are presented. The development of interactive multimedia was developed so that students do not find it difficult in the algorithm and programming learning process; it is more varied, systematic, and fun. So this interactive multimedia is expected to be able to support the achievement of learning objectives and improve student learning outcomes in algorithms and programming material.

The findings of this study are in line with several other studies that demonstrate the feasibility of interactive multimedia. Research by Fakhriah et al. (2022) found that the interactive media developed had very good eligibility criteria based on several aspects, such as presentation techniques, media, visuals, material content, language, material explanations, quizzes, and evaluation. Research by Anggraeni et al. (2021) developed interactive multimedia, which received very good eligibility criteria based on several aspects such as media aspects, technical quality, material coverage, material accuracy, up-to-dateness, and media presentation. Tabrani et al. (2021) found that the interactive multimedia developed had very good eligibility criteria based on several aspects, such as material presentation, content suitability, media suitability, and language presentation.

Theories related to the practicality of interactive multimedia support these findings. According to Arikunto (2010), practicality is related to the ease of use of evaluation tools, both in preparation, use, interpretation/conclusion of results, and storage. Milala (2022) also states that practicality refers to the ease of use of learning media by teachers and students, which makes the learning process meaningful, interesting, fun, and useful, as well as increasing creativity in the learning process.

The findings of this research are also in line with previous research, which shows the practicality of interactive multimedia. Research by Arifin et al. (2021) found that the interactive multimedia developed made it easier and more helpful to understand the learning material. Yusuf et al. (2022) show that the interactive multimedia developed is very valid, very suitable, and very practical and can support the learning process for teachers and learning resources for students.

Based on the results of the research and data processing carried out, there are significant differences in the learning outcomes of algorithms and programming material between students who learn using PBL-based interactive multimedia and students who are taught using textbooks. Students who study using PBL-based interactive multimedia get a higher average score compared to students who study using textbooks. This is in line with the opinion of Nuriansyah (2020) that learning media that involve active interaction and have new or unique elements can increase students' enthusiasm for learning, and this increase in motivation will help improve learning outcomes. Mursid, R. et al. (2022) stated that improving learning outcomes is very helpful in achieving quality science and knowledge in the field, problem solving, developing interests and talents, as well as the application of technology in the 21st century in the ability to think creatively through the application of holistic and effective learning strategies.

This finding is in accordance with existing theory that the use of effective learning media is used to increase the achievement of learning objectives (Nurhayati, 2019). Apart from that, interesting multimedia learning media can help increase students' interest and motivation to learn. Interesting media can also make it easier for students to understand and remember the material presented.

This is in line with the research results of Amri et al. (2020), who found that interactive multimedia can improve student learning outcomes. Sekarwangi et al. (2021) show that the results of using PBL-based interactive multimedia play an important role in the effectiveness of learning activities. Mashami and Khaeruman (2020) showed similar

results for PBL-based interactive multimedia. PBL can improve the generic learning outcomes of students, and Mursid, R. et al. (2023) stated that the collaborative development model based on e-learning can provide appropriate benefits so that it can increase students' understanding through the use of various ICT-based learning resources, and its application is directly based on e-learning.

CONCLUSION

Based on the formulation, objectives, results, and discussion of the development of PBL-based interactive multimedia, it can be concluded as follows:

1. The PBL-based interactive multimedia developed is very suitable for use in the class X algorithm and programming material at SMKN 6 Mukomuko.
2. The PBL-based interactive multimedia developed is very practical to use in class X algorithms and programming material at SMKN 6 Mukomuko.
3. The PBL-based interactive multimedia developed is very effective for use in the class X algorithm and programming material at SMKN 6 Mukomuko.

REFERENCES

Abdillah, T. R. (2022). Pengembangan Media Pembelajaran Interaktif Menggunakan Metode Ivers & Barron. *Jurnal Tika*, *7*(2), 179–188. https://doi.org/10.51179/tika.v7i2.132

Alisyafiq, Shidqie. (2021). Aplikasi Pembelajaran Multimedia Interaktif Algoritma Dan Pemrograman Dasar Untuk Mahapeserta didik Berkebutuhan Khusus Berbasis Android. Other *thesis*, Univeristas Komputer Indonesia

Amri, M. F., Saragih, A. H., & Yulia, E. (2020). The development of Interactive Learning Media based on Problem Based Learning (PBL) using Macromedia Flash 8. *Proceedings of the 5th Annual International Seminar on Transformative Education and Educational Leadership (AISTEEL 2020)*. https://doi.org/10.2991/assehr.k.201124.039

Anggraeni, S. W., Alpian, Y., Prihamdani, D., & Winarsih, E. (2021). Pengembangan multimedia Pembelajaran Interaktif Berbasis video untuk Meningkatkan Minat Belajar Siswa Sekolah Dasar. *Jurnal Basicedu*, *5*(6), 5313-5327. https://doi.org/10.31004/basicedu.v5i6.1636

Arief, R., Wazirudin, M. I., Rachman, A., & Hapsari, D. P. (2018). *Pengembangan Aplikasi Pembelajaran Tik Berbasis Web Menggunakan Model ADDIE Untuk Peserta didik SMK*. Institut Teknologi Adhi Tama Surabaya, 509–514. http://ejurnal.itats.ac.id/sntekpan/article/view/333

Arifin, Z., Tegeh, I., & Yuda Sukmana, A. (2021). Independent Learning through interactive multimedia based on problem based learning. *Jurnal Edutech Undiksha*, *9*(2), 244. https://doi.org/10.23887/jeu.v9i2.41292

Arikunto, S. 2010. Prosedur Penelitian Suatu Pendekatan Praktik. Jakarta: Rineka Cipta

Bulo, Mariliana Berlian. (2020). Pengembangan Strategi Pembelajaran Menyenangkan Permainan Bisik Berantai Pada Pembelajaran Bahasa Inggris Kelas II di SD Mardi Yuana. *Tesis*. Jakarta: Universitas Negeri Jakarta

Dewantara, Rinu Bhakti, et al., (2020). Analisis Kebutuhan Pengembangan Multimedia Interaktif Berbasis Problem Based Learning pada Materi Biologi SMA. *Jurnal Pendidikan, 5* (6), 749-753. https://www.neliti.com/publications/487785/analisis-kebutuhan-pengembangan-multimedia-interaktif-berbasis-problem-based-lea

Fakhriah, L., Pramadi, R. A., & Listiawati, M. (2022). Pengembangan media Interaktif Berbasis Google slide Berbantu Aplikasi pear deck pada Materi Sistem Pertahanan

Tubuh. *Jurnal Educatio FKIP UNMA, 8*(1), 15-21. https://doi.org/10.31949/educatio.v8i1.1473

Firmansyah, F. H., Fajriyah Aldriani, S. N., & Dewi, E. R. (2020). Pengembangan Multimedia Pembelajaran Interaktif untuk Mata Pelajaran Matematika untuk Kelas 5 Sekolah Dasar. Edsence: *Jurnal Pendidikan Multimedia, 2*(2), 101–110. https://doi.org/10.17509/edsence.v2i2.29783.

Hasugian, P. S. (2018). Perancangan Website Sebagai Media Promosi. *Journal Of Informatic Pelita Nusantara, 03*(01), 82–86. https://ojs.unikom.ac.id/index.php/visualita/article/view/6230

Hidayat, F., &. (2021). Model ADDIE (*Analysis, Design, Development, Implementation and Evaluation*) Dalam Pembelajaran Pendidikan Agama Islam. *Journal Inovasi Pendidikan Agama Islam (JIPAI),* 28-28. https://journal.uinsgd.ac.id/index.php/jipai/article/view/11042

Ifenthaler, D., Hofhues, S., Egloffstein, M., & Helbig, C. (2021). *Digital transformation of learning organizations.* Springer Nature.

Johnson, M. R. (2018). Making Programming Engaging: Strategies for Educators. *In Proceedings of the International Conference on Computer Science Education* (pp. 123-135). https://www.researchgate.net/publication/350465131_Strategies_on_Teaching_Introducing_to_Programming_in_Higher_Education

Mashami, Ratna Azizah and Khaeruman. (2020). Pengembangan Multimedia Interaktif Kimia Berbasis PBL (Problem Based Learning) untuk Meningkatkan Keterampilan Generik Sains Siswa. Hydrogen: *Jurnal Kependidikan Kimia, 8* (2), 85-96. https://e-journal.undikma.ac.id/index.php/hydrogen/article/view/3138

Miarso, Y. (2011). *Menyemai Benih Teknologi Pendidikan.* Jakarta: Kencana Prenada Media Group.

Milala, H. Farta, et al. (2022). Keefektifan Dan Kepraktisan Media Pembelajaran Menggunakan Adobe Flash Player. *Jurnal Pendidikan Teknik Elektro, 11*(2), 195-202. https://ejournal.unesa.ac.id/index.php/jurnal-pendidikan-teknik-elektro/article/view/43450

Mulyani, A. Y. (2022). Pengembangan Critical Thinking dalam Peningkatan Mutu Pendidikan di Indonesia. *DIAJAR: Jurnal Pendidikan dan Pembelajaran*, 100-105. https://journal.yp3a.org/index.php/diajar/article/view/226

Mursid, R., Saragih, A. H., & Hartono, R. (2022). The Effect of the Blended Project based Learning Model and Creative Thinking Ability on Engineering Students' Learning Outcomes. International Journal of Education in Mathematics, Science and Technology, 10(1), 218–235. https://doi.org/10.46328/ijemst.2244

Mursid, R., Sriadhi, & Sitompul, H. (2019). The Effect of ICT-Based Learning Media and Innovation Attitude to Learning Result Teaching With HOTS. In: *Proceedings of The 2nd International Conference On Advance And Scientific Innovation, ICASI*, Banda Aceh, Indonesia. https://www.researchgate.net/publication/337694469_The_Effect_of_ICT-Based_Learning_Media_and_Innovation_Attitude_to_Learning_Result_Teaching_With_Hots

Mursid, R., Muslim., & Farihah. (2023). Collaboration-based development model e-learning on course learning achievements working skills. International Journal of Instruction, 16(2), 307-328. https://doi.org/10.29333/iji.2023.16218a

Mutmainnah, F. N. (2022). Pengembangan E-LKPD Informatika Berbasis Problem Based Learning Untuk Meningkatkan Kemampuan Berpikir Komputasional Siswa Kelas X Sman 1 Silaut. *Tesis*, Pascasarjana Teknologi Pendidikan, Universitas Negeri Medan.

Putri, A. S & Sadewa, D. (2023). Rujukan Animasi 2D Sebagai Media Pembelajaran Bahasa ArabTerhadap Materi Bagian Luar Tubuh Manusia Dengan Metode SAV. *Jurnal Teknik Informatika dan Terapan, 1*(2), 01-05. https://journals.indexcopernicus.com/publication/3883763

Raja, R., & Nagasubramani, P. C. (2018). Impact of modern technology in education. *Journal of Applied and Advanced Research, 3*(1), 33–35. https://www.researchgate.net/publication/325086709_Impact_of_modern_technology_in_education

Rohdiani, F., & Rakhmawati, L. (2017). Pengembangan Media Pembelajaran Berbasis Web Pada Mata Pelajaran Dasar Elektronika di SMK Negeri 3 Jombang. *Jurnal Pendidikan Teknik Elektro, 06*(01), 105–110. https://ejournal.unesa.ac.id/index.php/jurnal-pendidikan-teknik-elektro/article/view/18212

Samodra, J., & Sutisno, A. (2021). *Pengembangan Media Pembelajaran Algoritma Pemograman Berbasis Web. The 4 Conference on Innovation and Applicatioan of Science and Technology*, Universitas Widyagama Malang.

Saputra, H. D., et al. (2022). Hasil belajar mahasiswa: analisis butir soal tes. Edukasi: *Jurnal Pendidikan, Volume 20* (1), 15-27. https://doi.org/10.31571/edukasi.v20i1.3432

Sekarwangi, T., Sartono, K. E., Mustadi, A., & Abdulah, A. (2021). The effectiveness of problem based learning-based interactive multimedia for elementary school students. *International Journal of Elementary Education, 5*(2), 308. https://doi.org/10.23887/ijee.v5i2.31603

Smith, J. A. (2020). The Challenge of Teaching Programming and Algorithms: Student Perceptions. *Journal of Computer Science Education, 28*(3), 259-274. https://www.researchgate.net/publication/314925658_CHALLENGES_IN_TEACHING_PROGRAMMING_AND_ALGORITHMS

Sriadhi. (2018). *Penilaian Kelayakan Multimedia Pembelajaran*. Medan: Universitas Negeri Medan

Sugiyono. (2018). Metode Penelitian Kuantitatif, Kualitatif dan R&D. Bandung : CV. Alvabeta.

Tabrani, M., Puspitorini, P., & Junedi, B. (2021). Pengembangan multimedia interaktif berbasis Android pada materi kualitas instrumen evaluasi pembelajaran matematika. *Jurnal Inovasi Teknologi Pendidikan, 8*(2), 163-172. https://doi.org/10.21831/jitp.v8i2.42943

Tazkia, Zahra, Sahyar & Juliani, Rita. (2019). Kelayakan Multimedia Interaktif Berbasis Web di Tingkat SMA. *Jurnal Pendidikan fisika, 8* (1). https://jurnal.unimed.ac.id/2012/index.php/jpf/article/download/12651/pdf

Tofanao, T. (2018). Peranan Media Pembelajaran Dalam Meningkatkan Minat Belajar Peserta didik. *Jurnal Komunikasi Pendidikan, 2*(2), 102-113. https://journal.univetbantara.ac.id/index.php/komdik/article/view/113

Wisnubhadra, I., Wijanto, M. C., Natali, V., Mulyati, S., Pratiwi, H., Saputra, B., & Astiani, K. (2021). Buku Panduan Guru Informatika untuk SMP Kelas VII. Jakarta: Pusat Kurikulum dan Perbukuan. Retrieved from https://buku.kemdikbud.go.id/katalog/buku-panduan-guru-informatika-untuk-smp-kelas-vii

Yusuf, A. (2022). Pengembangan Multimedia Interaktif Sub Materi Algoritma Dan Pemrograman Mata Pelajaran Informatika Pada Kurikulum Sekolah Penggerak Untuk Peserta didik Kelas X SMA. *Thesis*, Universitas Negeri Padang

Zega, I. D., Ziliwu, D., & Lase, N. K. (2022). Pengembangan Media pembelajaran multimedia interaktif berbasis web Pada Materi Keanekaragaman Hayati. *Educativo: Jurnal Pendidikan*, *1*(2), 430–439. https://doi.org/10.56248/educativo.v1i2.60

Zyahrok, et al. (2020). *Pengembangan Multimedia Interaktif Berdalam (Sumber Daya Alam) Pada Pembelajaran Ilmu Pengetahuan Alam Pada Siswa Kelas IV Sekolah Dasar*. *Undergraduate thesis*, Universitas Nusantara PGRI Kediri