



THE IMPACT OF PROJECT-BASED LEARNING ON IMPROVING CRITICAL THINKING SKILLS AND TECHNOLOGICAL LITERACY IN LISTENING CLASS

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Article History

Received : 19/06/2025

Revised : 05/09/2025

Accepted : 19/09/2025

Keywords:

Project-based learning,
Electronic modules,
Technological literacy,
Critical thinking,
Experimental research.

Abstract. Vocational high school students need e-modules as innovative media in project-based learning (PBL) to develop critical thinking skills and technological literacy skills. This study aims to analyze the impact of e-modules applied in project-based learning on technological literacy skills and critical thinking skills of vocational high school students in KNX-based Smart Building System Learning, which has not been widely studied. The type of research is an experiment with a quantitative approach. The population of this study was all grade XII students at SMK Negeri 1 Kediri, with 60 respondents. The instruments used were tests and observation sheets to measure critical thinking skills and technological literacy skills. The data collection technique used observation assessments by two expert observers and through tests (pretest and posttest). The data analysis technique used the N-Gain score test and the independent sample t-test using SPSS. The results of the two observers' assessment of the quality of learning were excellent. The results of the independent sample t-test showed that there was a significant difference between student learning outcomes in the pretest and posttest data. The results of the N-Gain score test showed that learning practices were quite effective in improving students' critical thinking skills and literacy skills. This study is helpful in developing the insights of vocational high school teachers in KNX-based Smart Building System learning innovations.

How to Cite: Setyawan, W. H., & Saptaria, L. (2025). THE IMPACT OF PROJECT-BASED LEARNING ON IMPROVING CRITICAL THINKING SKILLS AND TECHNOLOGICAL LITERACY IN LISTENING CLASS. *Prima Magistra: Jurnal Ilmiah Kependidikan*, 6(4), 663-677. <https://doi.org/10.37478/jpm.v6i4.6042>

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Publisher:

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INTRODUCTION

The development of technology in daily life has pushed the integration of technology in the world of Education to prepare participants to educate themselves and face the demands of an increasingly digital world. Development technology has changed the landscape and spatial layout of the economy and employment. Skills 21st century like critical thinking, creativity, collaboration, digital literacy, and literacy technology become more important. The new curriculum tends to include components. This is design learning, which requires the development of relevant teaching media. To help participants educate and develop competence. Utilization of technology is very important in supporting the effectiveness and efficiency of the learning process. This will help students more easily understand the material lesson (Roy, 2019).

School Intermediate State Vocational School 1 Kediri is a school that applies a vocational learning paradigm with an implementation curriculum. Implementation required gradual adaptation so that the achieved objective learning paradigm is new in a comprehensive way. One of the forms of implementation in the application curriculum independently is to prepare relevant learning media for participant Education. Teachers need to prepare relevant and varied learning media to support the Education of learning participants. This includes modules, books, texts, materials, readings, videos, resources, online learning, project modules, and job sheets. Teachers must be capable of identifying and providing sources of integrated learning interests and needs participants to educate, as well as give an outlook on the development of rapidly advancing technology (Setyawan, 2017). Through 4 stages of planning learning, namely: understanding achievements learning (CP), formulating objective learning (TP), compiling channel objective learning (ATP), and designing learning, teachers must create suitable teaching media to educate participants and align with achievements learning in the curriculum.

Currently, the TITL Department needs the development of learning media that can be applied in the department's electricity. Instructional Media This is expected to become a bridge for interaction between the teacher and the participant to educate, so that the activity learning is more effective and efficient. On elements or eye lesson Installation Class XII Electrical Lighting, TITL Department at SMKN 1 Kediri, available content innovative building system implementation, his learning is not yet effective and not maximum. Based on the interview introduction, it is known that learning content often uses monotonous lectures, summarizing based on grids, and learning media that are not integrated with technology. Activity learning tends to be boring; students do not have enough Spirit to study, have less ability in literacy and technology, and are less capable of thinking critically. In line with development learning in the 21st century, the learning process is more interactive, collaborative, and student-centered. Approach This covers using technology in learning, approach-based project or Project-Based Learning (PBL), learning based problems, learning based collaboration (team), as well as emphasis on skills, such as critical thinking, creativity, communication, digital literacy (technology), and adaptability (Sackawati & Nasrudin, 2021a).

PBL, namely an involved learning model, involves students in a direct activity study to do and finish a project, learning specific skills (Wiznia et al., 2012). The benefits of the implementation method learning PBL are that it helps students think critically about problems encountered in life, public (Rineksiane, 2022), stimulates students to construct their knowledge, develop intellectual skills, and encourages them to trust self in creating and producing projects (Maslahah & Rofiah, 2022). PBL method can increase results learning, and students get direct experience in doing the tasks following the prepared project previously (Ardimen et al., 2019). In learning this, students are directed to do exploration, assessment, interpretation, synthesis, and information to produce various forms of results in a Study. The PBL method is an approach consisting of several scientific stages, including observing, asking, collecting information, reasoning, and communicating (Krajcik & Czerniak, 2018). Research results show that learning model-based projects positively enhance the ability to think at a higher-order thinking skills (HOTS) level in fourth-grade elementary school science lessons (Anam et al., 2025). Learning model PBL makes students able to study and always think in a way critical to facing problems (Rineksiane, 2022). Research results review shows that the learning model PBL is effective in increasing the ability of literacy technology students (Nafi'ah et al., 2021).

Literacy technology is enabling skills and knowledge for individuals to effectively use, understand, evaluate, and manage technology (Nafi'ah et al., 2021). Literacy technology is not only a technical ability, but also involves understanding critical thinking and the application of practical technology in various life contexts. In learning innovative building systems, students are capable of installing and configuring a KNX-based innovative building system technology. Their ability to understand methods for working with machines and app technology (Karyono & Gunawan, 2022). Literacy technology covers the ability to discover, evaluate, utilize, share, and create content using digital technology. Framework digital literacy usually includes: 1) Information Literacy, which is the ability to search, evaluate, and use information in an effective way. 2) Media Literacy is the ability to understand, analyze, and produce media in various forms. 3) ICT Literacy, which is the Skills for using technology, information, and communication effectively. Literacy technology is one of the crucial Skills of the 21st century, together with other skills such as critical thinking, collaboration, communication, and creativity. Focus mainly on: 1) Critical Thinking and Problem Solving that uses technology to solve problems and create the right decision. 2) Communication and Collaboration that uses technology to communicate and work in an effective way. 3) Creativity and Innovation that pushes innovation through the use of technology creatively (Purwanti et al., 2022).

Critical thinking skills are the ability to analyze information in an objective way and create decisions based on logical judgment (Taufik et al., 2022). Thinking critically can increase creativity. Creativity is the ability to think of something new based on the processing of information obtained. With the ability to think creatively, someone capable of generating new ideas and thoughts, it is very important to develop the ability to think creatively for participants



to be educated (Turnip & Karyono, 2021). Robert Ennis identifies aspects that he thinks are critical, including: 1) Sensitivity to the problem, which is the ability to recognize problems and determine possible solutions. 2) An analysis argument that is capable of identifying the argument and evaluating its strengths as well as its weaknesses. 3) Evaluation proof that evaluates the relevance and reliability of supporting evidence. 4) Withdrawal of the conclusion is an interesting logical conclusion based on analysis and proof. 5) Assessment of the assumption that identifies and assesses the underlying assumptions of the argument. 6) A retrieval decision that is made based on evaluation arguments and evidence. Learning design needs an appropriate device with the student in control of the material.

Electronic modules (e-Modules) are module learning presented in digital format or electronic (Anggraini & Wulandari, 2021). E-module is a tool or means of content learning materials, methods, limitations, and methods to evaluate those designed by the teacher (Diantari et al., 2018). Teachers' creativity and innovation in designing module electronic must can grow enthusiasm for students to learn and be able to accommodate all learning needs. Learning materials are prepared and delivered via electronic media like computers, laptops, tablets, or other mobile devices. E-Module contains text, images, audio, video, animation, as well as interactivity like exercise questions, quizzes, or simulation (Mahmudin, Ratnawati & Khaharsyah, 2022). Superiority of the e-Module is its flexibility, so that students can learn anywhere and anytime, just following their needs. You can use the e-Module customized with the needs of students, so it can be used for learn material following the level of student understanding (Sari & Listiadi, 2023). E-Module can control the learned content of students because the teacher himself designs it so that it can adapt to the planned curriculum. The existence of an e-Module is expected to make it easier to facilitate students in absorbing lessons, because it can give an atmosphere learn more effective and interesting (Safitri & Dafit, 2025; Saptaria & Setyawan, 2021). Various approaches in designing e-modules. Already, Lots have been done, like the use of the CTL (contextual teaching and learning) approach Oktriani et al. (2023), Sofa & Zahra (2022), live worksheet (Sudarman Satrio Wicaksono, Sudarman, 2022), website Google Sites (Mahmudin, Ratnawati & Khaharsyah, 2022). Research results explain that using a learning based project method in vocational Education has a positive effect on increasing results (Megayanti et al., 2020); Anwar et al. (2021). Based on the background that has been outlined, the research aims to analyze the influence of E-based modules Project-Based Learning (PBL) on Skills literacy technology and capabilities, critical thinking skills of students in Learning Smart Building Systems KNX, based on students' level XII at SMKN 1 Kediri. The expected novelty is that students' critical thinking skills experience a significant increase, indicating that this teaching method is effective in developing analytical, evaluative, and problem-solving skills. Furthermore, the development of students' technology literacy is recorded as very good, underscoring the effectiveness of using e-modules in enhancing students' understanding and mastery of digital technology as a medium for learning and problem-solving.

RESEARCH METHODS

This study was a type of experimental study with a quantitative approach. A study experiment is purposeful research to determine whether there is a consequence from the treatment of the subjects under investigation (SirotoVÁ et al., 2021). The research methods of this study used a quasi-experimental design (quasi-experiment) because in this study, there are variables from the outside that researchers cannot control. Before the treatment, good group experiments and group control were given a test, namely a pretest, with the Meaning For known circumstances group before treatment. Then, given treatment, experiments, and group control are given a test, namely a posttest, under known circumstances, to determine the group treatment. Study. This was held at SMK Negeri 1 Kediri City. Study This implemented in the year Teaching 2023/2024 in the even semester, the study was implemented from January to April 2024. Population in research, This is all over student Class XII got it material lesson innovative building systems, KNX based. Samples used in this study totaled two classes, which were class XII TITL 1 and XII TITL 2, with a total of 60 students, consisting of 30 students in



the class experiment and 30 students in the class control. A sample was taken using the simple random sampling technique because the population is homogeneous, where there was a distribution class based on student ability. Data collection techniques use tests and observations. Observation technique is a technique used to obtain activity data. Study teaching classes and activities. Study students, Test methods given before the activity learning conventional (pretest), and tests carried out after the learning process, method project-based learning (posttest). Syntax learning PBL is presented in [Figure 1](#).

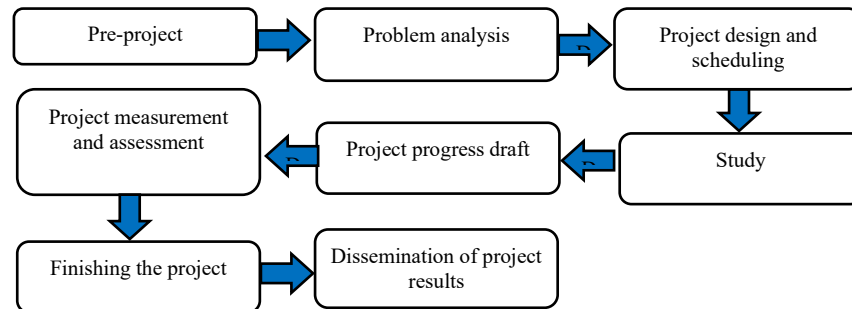


Figure 1. Learning Model Steps Based on Project

In the pre-process project, the teacher gives perception to students about components during installation of the intelligent building system, how to install components, and how to configure components with ETS6 software. At the stage of analyzing problems, students are facilitated in how to analyze problems, such as: components, what will be installed, identifying specification components, and how to install components. Students, in a way, are independent in the group; students read material contained in the e-Module. At the stage of the design and scheduling project, students determine the next component to be installed. The components that will be installed are controlled lights with actuator switches and four gang push buttons. In stage research, students observe specification components for importation into the ETS6 software. Students take notes, results, and document the project's staged draft progress. Stage measurement and assessment filled with try-it-out results, installation of actuator switch components with target results, and light as the installed load will be on. Stage finishing student guided to make a writing report, implement and carry out projects, disseminate or present stages, install components, smart building control, light use actuator switch, and 4 4-gang push buttons.

Data analysis techniques used in the study. This consists of four forms: 1) analysis of the quality of PBL model learning, 2) Analysis of student Activity, 3) Analysis of the effectiveness of results in the Study, and 4) Analysis of student responses to the implementation of learning.

Analysis Quality Learning.

Analysis was done based on the quality PBL model syntax with the use of criteria evaluation. Activity analysis. This was carried out by two observers, namely the material teacher and the smart building system. The score obtained changed to a percentage from every stage implementation syntax method PBL, with the use of the formula presented in the following.

$$\text{Percentage of learning quality} = \frac{\sum \text{Learning step score obtained}}{\sum \text{Maximum learning step score}}$$

Meanwhile, the criteria for quality learning are presented in [Table 1](#).

Table 1. Criteria Quality Learning

Mark	Criteria
90 – 100	Very good
80 – 89	Good
70 – 79	Enough
60 – 69	Not enough
0 – 59	Very less

Source : [\(Saekawati & Nasrudin, 2021b\)](#)

Analysis Activity Student

Analysis activity observed by students is Skills to think critically and skills in literacy and technology during the application of the learning model PBL. Activity data of students in Skills Think Critical and Literacy Technology was analyzed with the use of a formula, and the percentage of activity of students is presented in the following.

$$\text{Percentage of Student Activity} = \frac{\sum \text{Emerging Student Activity Scores}}{\sum \text{Overall Activity Score}}$$

Meanwhile, the criteria for active students are presented in [Table 2](#).

Table 2. Criteria Quality Learning

Mark	Criteria
90 – 100	Very good
80 – 89	Good
70 – 79	Enough
60 – 69	Not enough
0 – 59	Very less

Source : [Saekawati & Nasrudin \(2021b\)](#)

Two observers used an instrument form sheet observation to evaluate Skills in thinking critically and skills in literacy and technology. Grille Skills think critically and skills literacy technology presented in [Table 3](#).

Table 3. Grid Skills Think Critical and Skills Literacy Technology

Aspect Skills	Indicator	Items
Think Critical		
Identify problem	Identify problem	1. Identify the problem with a clear understanding of the context. 2. Develop and evaluate various solution potentials that will be used.
Categorize	Categorize	3. Choose the most effective solution based on logical analysis. 4. Interpret, meaning the information presented is good in the form of text, graphs, tables, or other data.
Do study	Do Study	5. Identify the consequences of the information or arguments given. 6. Skills in designing, implementing, and reporting results
Communicate results	Communicating Results	7. Articulate the reason behind the decision or conclusions drawn. 8. Develop logical and coherent arguments to support views or decisions.
Make conclusion	Making Conclusions	9. Serve proof in a way that is clear and organized. 10. Make a logical conclusion based on available evidence. 11. Develop possible hypotheses to be tested based on the information provided. 12. Predict possible results from an action or a decision with certainty.
Understanding base technology and society	Basic Understanding of Technology and society	13. Know component-based device hardware and device software. 14. Understand the function base from various device technologies like computers, tablets, and smartphones. 15. Understand and appreciate differences in access to and use of technology in various cultures and communities. 16. Evaluate the role of the public in the development and use of technology 17. Evaluate the importance of innovative technology 18. Show the use of appropriate technology and not right in society 19. Make decisions based on information about the impact of using technology.
Skills in operational technology	Skills in Operational Technology	20. Identification component: main A product, method, Work products, technologies, and methods produce it 21. Operate and maintain product technology and systems 22. Evaluate the strengths and weaknesses of Technology A 23. product



Aspect Skills	Indicator	Items
Think Critical		24. Formulate a solution to a problem with a technology product 25. Optimizing the use of technology to increase efficiency and effectiveness in various tasks.
Technology design	Technology Design	26. Analyze principles, concepts, and application of energy 27. Understand issues in technology like automation, artificial intelligence, and its impact on the world of work and daily life.

Source: Data Processed, 2024

Analysis of the Effectiveness of Learning Outcomes for Students

Analysis results: Study students in the application of learning models, PBL is measured with test instruments—the results of the study from pretest and posttest scores for the experiments and the class control. Data normality test was measured using the Shapiro-Wilk Test. To measure the effectiveness of the method PBL with the e-module in the study, this study used the technique of analysis Normalized Gain (N-Gain). The Gain score is the difference between posttest and pretest scores. Data processing uses SPSS application version 26. The formula calculation of N-Gain scores was presented in the following.

$$N - Gain = \frac{Skor\ Posttest - Skor\ Pretest}{Skor\ Maksimum - Skor\ Pretest}$$

Meanwhile, N-Gain criteria are presented in Table 4.

Table 4. Normalized Gain Criteria

Percentage	Classification
N-gain > 7.0	Tall
3.0 ≤ N-gain ≤ 7.0	Currently
N-gain < 3.0	Low

Source: Latifah (2020).

Table 5. Categories Interpretation Effectiveness With N-Gain Score

Percentage	Interpretation
< 40	Ineffective
40-55	Less effective
56-75	Enough Effective
>76	Effective

Source: Latifah (2020).

Table 5 presents the category of effectiveness interpretation based on the N-Gain (Normalized Gain) score used to evaluate the success rate of a learning method. This table provides a systematic guide in interpreting the results of the N-Gain calculation which is the difference between the normalized posttest and pretest scores.

Based on the table, the interpretation of effectiveness is divided into four categories: Ineffective: When the N-Gain score is less than 40%, the implemented learning method is considered ineffective in improving student learning outcomes. In this category, learning interventions fail to have a significant impact on improving student understanding or competence. Less Effective: In the N-Gain score range of 40-55%, the learning method shows limited effectiveness. Although there is an increase in learning outcomes, the resulting impact has not met expectations and needs to be re-evaluated or improved in implementation. Effective Enough: An N-Gain score between 56-75% indicates that learning methods have been proven to be quite effective in improving student learning outcomes. At this level, learning interventions have made a meaningful contribution to improving student competence. Effective: When the N-Gain score is above 76%, the learning method is categorized as very effective. This shows that learning interventions have a significant and substantial impact on improving student learning outcomes.

In the context of research that implements the PBL (Problem-Based Learning) model with e-modules, this table is an important reference to determine the extent of the effectiveness of the learning methods applied. The results of this interpretation will provide empirical



evidence regarding the success of the implementation of PBL with e-modules in improving student learning outcomes (Latifah Nurul, Ashari, 2020).

Analysis Response Student

Response data students obtained from the survey questionnaire responses of students to the implementation of the learning method PBL. Questionnaire: This is given via Google Forms after the learning process. Analysis of student responses using the grid presented in Table 6. The criteria for evaluating student learning are presented in Table 7.

Table 6. Grid Response Students in Applying Learning Methods PBL

Aspect Evaluation
1. Atmosphere learning fun
2. Meaningful and contextual learning
3. Push students to think critically
4. Increase enthusiasm in Study
5. Push attitude: active, creative, and innovative
6. Push the ability of the cooperation team
7. Practice Skills Communicate
8. Learning nature is flexible and attractive
9. Push the ability literacy technology
10. Push the ability to solve a problem
11. Push students to produce products that are useful

Source: Data processed, 2024

Table 7. Criteria Response Students in Applying Learning Methods PBL

Mark	Criteria
5	Very good
4	Good
3	Pretty good
2	Not good
1	Very Not Good

Source: Saekawati & Nasrudin (2021b)

5-Point Likert Scale: This table of 6 uses a Likert scale with a value range of 1–5, which is a common standard for measuring attitudes, perceptions, or levels of satisfaction. Each number represents the qualification level of the student's response to aspects of PBL learning (as listed in Table 6). Category Criteria Table 7: there are 5 (Very Good): Shows a very positive response. Students find the PBL method to be very effective and provide a great learning experience. 4 (Good): Positive response. Students rated the PBL method as good and beneficial, although there was room for minor improvement. 3 (Pretty Good): The response is quite adequate. Students consider the PBL method to be decent, but it is not special or needs significant improvement. 2 (Not Good): Negative response. Students feel that the PBL method is less effective or does not meet expectations. 1 (Very Not Good): Very negative response. Students rated the PBL method as a complete failure in providing a meaningful learning experience (Saekawati & Nasrudin, 2021b).

RESULTS AND DISCUSSION

This study aims to analyze the influence of the implementation of the E-module using the Project Learning (PBL) steps to measure the level of Skills, literacy, technology, and critical skills of students of SMK Negeri 1 Kediri. Project Learning is an involved learning model for students that directly involves them in learning through several activities, such as studying, to teach students that they can finish a project learning specific skills. Literacy technology enables individuals to use, understand, evaluate, and manage technology effectively. Critical thinking skills are the ability to analyze information objectively in a logical way and make decisions based on logical judgment. Analysis results in a quality application PBL model learning material for smart building systems. The KNX method is presented in Table 8.



Table 8. Observation Results Quality Learning with the Project-Based Learning Method

Aspect Evaluation	Observer 1	Observer 2	Average (%)
1. Pre-Project	86	90	88
2. Analysis Problem	88	87	87.5
3. Design and scheduling project	92	94	93
4. Study	89	92	90.5
5. Draft the progress project	92	94	93
6. Measurement and assessment project	90	95	92.5
7. Finishing the project	90	90	90
8. Dissemination of project results	92	95	93.5

Source: Data processed, 2024

Based on [Table 8](#), in the pre-process project, assessment of the second observer of teacher activities in giving apperception to a student about components during installation of innovative building systems, KNX-based, way of installation components, and methods for configuring components with ETS6 software, gets a mark average of 88%, meaning quality learning fulfills good criteria. At the stage of analyzing problems, the assessment of the second observer of teacher activities involves the description component. What will be installed, identify specification components, and how to install components in the e-module, get a mark average of 87.5%, meaning quality learning fulfills good criteria. At the stage of designing and scheduling a project, an assessment of the second observer to teacher activities in direct student interaction. To determine the next component to be installed, form-controlled lights with a switch actuator and a push button four gangs get a mark average of 93%, meaning quality learning fulfills excellent criteria—stage research, assessment, and second observer to teacher activities in direct student observation.

Table 9. Observation Results on Skills: Think Critical and Skills Literacy Technology

Aspect Skills Think Critical	Observer 1	Observer 2	Average (%)
1. Identify the problem	88	89	88.5
2. Categorize	91	90	90.5
3. Do study	87	88	87.5
4. Communicate results	89	90	89.5
5. Make a conclusion	88	86	87
Average			88.6
Aspect Skills Literacy Technology			
1. Understanding base technology	90	92	91
2. Technology and society	92	94	93
3. Skills in operational technology	92	85	88.5
4. Technology design	90	90	90
Average			90.6

Source: Data processed, 2024

The observation specification component, imported into the ETS6 software, gets a mark average of 90.5%, meaning quality learning fulfills excellent criteria. At the stage of the draft progress project, assessment of the second observer to teacher activities in direct student interaction, taking notes on results, and documenting the project with a mark average of 93%, meaning quality learning fulfills excellent criteria. At stage measurement and assessment, the assessment second observer to teacher activities in direct student For do trials results installation actuator switch components with target results light as installed load will get a mark average of 92.5%, meaning quality learning fulfills excellent criteria. At the stage of finishing, assessment of the second observer of teacher activities in direct student involvement. To make writing reports on implemented and carried out projects, dissemination or present stages, install a smart building control light use switch actuator and push button four gang, get a mark average of 93.5%, meaning quality learning fulfills excellent criteria. Based on the analysis, the conclusion



is that serving the ion to improve learning with a method of project-based learning produces excellent results. Observation results of activity students showing critical thinking skills and literacy technology skills during the application of the learning model PBL are presented in Table 9.

Based on Table 9, assessment second observer to activity student in identify problem, categorize, do research, communicate result, make conclusion get mark average of 88.6% meaning learning that has been done held can increase Skills think critical with OK, learning PBL with the developed e-module push student For capable identify problem with clear and understanding context, develop and evaluate various potential solutions that will be use, have the most effective solution based on logical analysis, interpreting meaning information presented in form text, graphs, tables or other data, identifying consequence from information or given arguments, skills in design, implement and report results, articulate the reason behind decision or conclusions drawn, composing logical arguments based on available evidence, develop possible hypothesis tested based on given information, predict possible results from action or decision specific. Based on evaluation second observer to activity student in understanding base technology, technology and society, skills operational technology, and design technology get mark average of 90.6% meaning learning that has been done held can increase Skills literacy technology very well, learning PBL with the developed e - module push student For capable know component base device hardware and devices soft, understanding function base from various device technology like computers, tablets, and smartphones, understand and appreciate difference in access and use technology in various culture and community , assess role public in development and use technology, rate importance innovation technology , shows use appropriate technology and not right in Society, making decision based on information about impact use technology, identification component main A product, method Work products, technologies and methods manufacture, operate and maintain product technology and systems, assess strengths and weaknesses technology A product, formulate solution problem with a technology product, optimize use technology For increase efficiency and effectiveness in various task, analyze principles, concepts, and application energy, understanding issues technology like automation, intelligence man-made, and its impact to the world of work and life daily. Results data test Study student in application of learning models PBL using e-module has met the prerequisite tests, normality is presented in Table 10.

Table 10. Kolmogorov-Smirnov Normality Test

Table Tests of Normality							
Kolmogorov - Smirnov^a				Shapiro - Wilk			
	Kelompok	Statistic	df	Sig.	Statistic	df	Sig.
Result	Experiment	.151	30	.078	.923	30	.031
	Control	.137	30	.158	.936	30	.072

a. Lillifors Significance Correction

Based on Table 10, the prerequisite test results, first, in the form of the Kolmogorov-Smirnov Normality test, show a marked significance of $0.078 > 0.05$ and a posttest of $0.158 > 0.05$, so it can be concluded that the data is usually distributed. Prerequisite test results are presented in the form of a homogeneity test, which is presented in Table 11.

Table 11. Homogeneity Test
Test of Homogeneity of Variances

		Levene Statistic	df1	df2	df3
Result	Based on Mean	2.488	1	58	.120
	Based on Median	2.229	1	58	.141
	Based on Median and with adjusted df	2.229	1	50.556	.142
	Based on trimmed mean	2.603	1	58	.112

Based on Table 11, the homogeneity test results show marked significance $0.120 > 0.05$, so it can be concluded that the data fulfill the condition of homogeneity. Furthermore, an independent sample t-test was carried out. The results are presented in Table 12.



Table 12. Statistics Descriptive
Independent Sample Test

		Levene's Test for Equality of Variances					t-test for Equality of Means		95% Confidence interval of Difference	
		F	Sig.	t	df	Sig.(2-tailed)	Mean difference	Std. Error difference	Lower	Upper
Result	Equal variances assumed	2.488	.120	9.582	58	.000	4.500	.470	3.560	5.440
	Equal variances not assumed			9.582	53.817	.000	4.500	.470	3.558	5.442

Based on [Table 12](#), it is known that the mark significance (2-tailed) in the independent samples test is $0.000 < 0.05$, then it can be concluded that there is a fundamental difference between the results of the Study students on pretest and posttest data. Statistical test results are presented in a descriptive format that shows the class mean value of experiments and the class control presented in [Table 13](#).

Table 13. Statistics Descriptive

Kelas				Statistic	Std. Error
Ngain_per	Experiment	Mean		68.6062	1.88963
		95% Confidence interval for Mean	Lower Bound	64.7415	
			Upper Bound	72.4710	
		5% Trimmed Mean		68.8992	
		Median		67.6073	
		Variance		107.121	
		Std. Deviation		10.34993	
		Minimum		42.86	
		Maximum		87.50	
		Range		44.64	
		Interquartile Range		14.48	
		Skewness		-.433	.427
		Kurtosis		-.044	.833
	Control	Mean		38.6439	2.56901
		95% Confidence Interval for Mean	Lower Bound	33.3897	
			Upper Bound	43.8982	
		5% Trimmed Mean		38.7559	
		Median		40.0000	
		Variance		197.994	
		Std. Deviation		14.07103	
		Minimum		9.09	
		Maximum		69.44	
		Range		60.35	
		Interquartile range		18.94	
		Skewness		-.202	
		Kurtosis		-.059	

The results of the N-Gain score test calculation are presented in [Table 14](#). Based on [Table 14](#), the known results calculation of the N-Gain score test between learning in a class experiment and a class control. The average value for class implementing experiments learning method PBL with module gets a mark amounting to 68.6, including N-Gain category 56-75, which means practice learning is effective in increasing critical thinking skills and literacy skills of students.

Table 14. N-Gain Score Test Calculation Results

N-Gain Score (%) Class Experiment	N-Gain Score (%) Class Control
77.78	54.35
72.73	48.84
75.00	25.00
76.09	14.29
60.00	30.30
75.00	22.86
72.22	29.41
66.67	12.50
87.50	9.09
78.13	37.50
67.65	48.78
63.89	41.86
66.67	46.67
52.17	56.25
79.25	69.44
74.36	39.39
67.57	33.33
62.50	42.86
64.29	25.00
65.91	37.50
57.89	30.00
81.82	54.55
80.49	42.31
65.63	31.43
Mean	38.6

Source: Data processed, 2024

The average value for the class implementing the control learning method is 38.6, including category N-Gain<40, which means that practice learning conventional is not effective in increasing critical thinking and literacy skills of students. The distribution frequency response of students' application learning is presented in [Table 15](#).

Table 15. Response Results in Students Applying Learning Methods PBL

Aspect Evaluation	Frequency evaluation		
	Very good	Good	Pretty good
1. Atmosphere learning fun	20	10	0
2. Meaningful and contextual learning	20	9	1
3. Push students to think critically	18	10	2
4. Increase enthusiasm in Study	10	15	5
5. Push attitude: active, creative, and innovative	12	12	6
6. Push the ability of the cooperation team	14	10	6
7. Practice Skills: Communicate	14	12	4
8. Learning nature is flexible and attractive	12	10	8
9. Push the literacy technology	17	12	1
10. Push the ability of students to solve a problem	16	8	6
11. Push students to produce valuable products	20	6	4
Average			

Source: Data processed, 2024

Based on [Table 15](#), known results show that students in the application method learning PBL assisted by a module get an evaluation with three categories: outstanding, reasonable, and sufficient. Students state that during the learning process, the atmosphere of learning felt like having fun, students feel meaningfulness in learning, and it is contextual. Learning with a system, this assessed nature is flexible and engaging, can push students to think critically, improve enthusiasm, encourage an active attitude, creativity, and innovation. Learning method PBL can push the ability of the cooperation team, coach Skills, communicate, encourage

literacy technology, push the ability of students to solve problems, and push students to produce products really useful.

Based on the results of data analysis carried out in the e-module implementation process learning method, Project-Based Learning (PBL) material Smart Building Systems KNX, quality learning produces excellent value. This matter is supported by the results assessment by two observers providing evaluation of all teacher activities in learning, which include: pre-project, analysis problems, design and scheduling project, research, draft progress projects, measurement and assessment project, project finishing, and dissemination of results. Learning process project. This is a project group where the data group consists of 3 students. As for the theme project, install a light with KNX actuator switches. The teacher gives a question key that directs students to understand the material, and gives an assignment to students to do an activity in a group study. Task the student to analyze the building, import push button devices, switch actuators, and configure virtual KNX and ETS software. For operating the task here, students need to study the installation process of a light using a switch actuator. After doing observations, students must understand concepts and practices of the process of building design and configuring installation lights with virtual KNX-based actuator switches. At this stage, this student does analysis problems, designs a project, composes a timetable for completing the project, and studies. The teacher becomes a facilitator and evaluator of the activity process, studying the student. The teacher monitors and facilitates students in the research process. To simplify the monitoring process, a rubric was created that can record the whole important activity. Teachers play a role as mentors in the completion process of the project task. The teacher assigns students to gather draft progress projects and do measurement and assessment projects. Expected learning outcomes are lit up with control using a 4-gang push button. The teacher prepares a rubric evaluation to help teachers measure achievement in the standard solution project. Student proceeds to the project finishing and dissemination stages, results of the project with the present method of procedure for installing the switch actuator alone. Research result, this supports the results of a previous study that concluded that the use of e-modules in the learning process will foster creativity, develop productive thinking habits, create an active, practical, innovative, and fun learning environment, and develop literacy abilities in students (Hastuti & Setyawan, 2021; Karyono & Gunawan, 2022; Setyawan & Nawangsari, 2021).

Application of learning models based on a project with media in the form of e-modules can increase critical thinking skills in students and improve their literacy and technology skills. Think critically, a student can learn something about problems in a systematic way, face various complex problems, formulate problems, think innovatively, and design solutions to problems in an appropriate way (Fitriyah & Ramadani, 2021). A critical-thinking attitude is shown by the ability to identify problems, categorize, conduct research, communicate results, and draw conclusions. An understanding of basic technology, technology and society, operational technology skills, and design technology shows literacy and technology skills. Application learning PBL relevant with criteria Skills 21st century includes: capabilities think critically, solving problems, creativity and innovation, collaboration, communication, literacy information, media literacy, literacy technology, flexibility capabilities adapt, lead and take responsibility, initiative, productivity, accountability, as well as interaction social and cross culture (Fitriyah & Ramadani, 2021). N-Gain score test results in the class experiment show that practicing learning effectively increases critical thinking skills and literacy skills in students; meanwhile, the class control group shows no improvement.

Response results in the application method learning PBL assisted by an e-module, which gets evaluated with three categories, namely outstanding, reasonable, and sufficient. Good. Students state that during the learning process, the atmosphere of learning felt fun, and students felt meaningfulness in learning and context. Learning with a system. This assessed nature is flexible and engaging, can push students to think critically, improving enthusiasm in learning, encouraging an active attitude, creativity, and innovation. Learning method PBL can push the



ability of the cooperation team, coach Skills, communicate, encourage literacy technology, push the ability of students to solve problems, and push students to produce valuable products.

CONCLUSIONS AND SUGGESTIONS

The implementation of project-based learning models supported by e-modules significantly improved students' critical thinking skills and technological literacy. Students' critical thinking skills improved well, indicating that this learning approach successfully encouraged analytical, evaluative, and problem-solving skills. Furthermore, the improvement in students' technological literacy skills was recorded as very good, confirming the effectiveness of using e-modules in developing students' understanding and mastery of digital technology as a learning and problem-solving tool. These results indicate that the combination of project-based learning and e-module media is an effective strategy for developing 21st-century competencies, especially critical thinking skills and technological literacy. Weakness in practice learning the use of the PBL method. This method is for difficult students to understand material, who tend to feel difficulty. Working in a group requires content discussion, the need for foresight, students to review material, do literacy, and think critically about skills in the solution projects being worked on. The solution is that a teacher must be sensitive and capable of facilitating current students who are weak in learn the manufacturing process project, for example, by providing peer tutoring or direct guidance. Implications of study, these include: pushing students to develop critical thinking skills through problem-solving. Student Study For analyzing information, creating decisions, and evaluating solutions, sincerely. Besides that, students also learn to increase their Skills in collaboration through Work. The same applies in teams, sharing ideas, and sharing tasks, which helps practice Skills in collaboration required in daily work and life. Suggestions for the researcher are that the next design is expected to use a more comprehensive and controlled design. For example, using a study experiment or quasi-experimental design with group control to compare the effectiveness of PBL-based E-Modules with other learning methods more thoroughly. Also, besides Skills, think critically and literacy technology, research can consider next to measure the impact of PBL on other skills such as creativity, collaboration, or interpersonal skills. This matter gives a more complete Figure of the effect of PBL learning.

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