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Learning independence: The influence of parental social support and self-regulation

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ABSTRACT

Low parental support and learning attitudes can hinder students' learning processes. This study was conducted to determine the effect of parental social support and self-regulation on the learning independence of fifth-grade students at Fostered Area (Dabin) Elementary School 1, Prambanan District. This study uses a quantitative research type of ex post facto design without providing special treatment to students based on the research instruments created. The population in this study amounted to 122 students, with a research sample of 92 students selected randomly. The research instruments used were in the form of a questionnaire on parental social support, a questionnaire on self-regulation, and a questionnaire on learning independence, which have been proven valid by expert judgment, a validity test, and a reliability test. The tabulated data were subjected to assumption tests in the form of a one-sample Kolmogorov-Smirnov normality test, linearity test, multicollinearity test, and heteroscedasticity test with the help of SPSS 29. Furthermore, the data were analyzed using multiple regression techniques with the help of SPSS version 29 to test the research hypothesis. The results of the study prove that: 1) Parental social support and self-regulation together influence students' learning independence. 2) Parental social support partially influences students' learning independence. 3) Self-regulation partially influences students' learning independence in class V of Fostered Area (Dabin) Elementary School, Prambanan District. So, it can be concluded that parental social support and self-regulation have implications for learning independence. It is hoped that this study can contribute to increasing the role of parents in providing social support to their children. It is recommended that future studies examine interventions or programs designed to enhance self-regulation and learning independence while taking into account the role of social support, particularly from parents.

INTRODUCTION

Learning is an important key in every educational endeavor. Learning is a series of physical and mental activities to obtain a change in behavior as a result of individual experiences in interaction with their environment, involving cognitive, affective, and psychomotor (Pinta et al., 2024). According to Santoso et al., (2023), when learning, independence is needed. Students who are

successful in their studies are certainly balanced with independence (Asih et al., 2023). As conveyed by Widyastuty (2024), one of the learning behaviors that can help students achieve success in their learning is learning independence. In line with this opinion, Rama (2023) stated that there is an influence between learning independence and learning outcomes. Thus, an independent attitude is very necessary to achieve success in learning.

Learning independence is the ability to control or regulate one's thoughts, feelings, and actions freely and to try to overcome feelings of shame and doubt (Rahayu et al., 2023). A learning activity carried out by a person without relying on others as an effort to improve knowledge, skills, or develop achievements is independent learning (Fadilah & Himmawan, 2023; Sorokova, 2020). The freedom of students to explore and analyze learning materials so that students are able to understand learning materials actively and are able to respond to their learning situations is a picture of an independent person (Fatah & Zumrotun, 2023). Learning independence can also help students to plan goals, time, and strategies, manage behavior, motivate themselves, and evaluate self-improvement (Chen et al., 2023; Nurhamidah & Nurachadijat, 2023). Referring to the opinion of Desmita (2015) & Kopzhassarova et al., (2016) that someone independent is someone who meets the following criteria, namely: 1) has a competitive desire to progress for their good; 2) able to make decisions and take the initiative to overcome the problems faced; 3) have self-confidence in carrying out the tasks they have; 4) be responsible for what they do. Independent students know, understand, and immediately carry out tasks that need to be completed by empowering their abilities without having to be reminded or assisted by others. Independent students can carry out tasks and obligations with full self-confidence (Ba'abduh et al., 2024). On the other hand, students who are not independent will harm themselves. They are not able to solve the problems they face because they have weak self-confidence (Maheswari et al., 2024).

Based on the results of observations and interviews in several Dabin 1 Elementary Schools in Prambanan District, several problems related to the learning process were identified. These problems include the lack of student learning independence, the lack of social support from parents for the student learning process, and the lack of self-regulation of students in learning. The lack of student learning independence in the learning process is evidenced by: 1) Some students do not do their homework, 2) students forget to bring their textbooks, 3) students chat when the teacher is delivering the material, 4) students copy their friends' answers, 5) students still depend on teacher guidance and do not have the initiative to find other learning resources from books. The lack of social support from parents in student learning activities is evidenced by: 1) Most parents leave all forms of teaching to the teacher, 2) Few parents ask about the progress of students' learning at school, 3) Parents get angry and blame students when they have difficulty learning, 4) Parents never accompany students when studying at home. The lack of self-regulation in the learning process is proven by: 1) students do not have learning targets, 2) students are resigned to the learning outcomes they get without making any evaluation efforts to improve their learning outcomes, 3) students do not have a strong desire to study seriously without the help of others. The lack of learning independence possessed by students can foster bad learning habits (Desmita, 2015).

On the other hand, if the problem is immediately addressed and the causative factors are found, good learning habits will emerge so that learning activities can be directed towards student-centered learning. Students will also have the initiative, learn of their own accord, and not depend too much on teachers. 2 factors influence learning independence, namely from outside and inside. Factors that come from outside are family, school, and society. Factors that come from within include the physical condition of students, motivation, discipline, interests, talents, intelligence, and self-regulation (Kokan, 2023).

The family has an important role in supporting the formation of learning independence (Irawan et al., 2024). Parents are expected to be able to provide opportunities for children to develop themselves, make decisions they want to make, and learn something. However, there are still many parents of students who are less participatory in the learning program of educational units (Hardianto, 2022). To be independent, a person needs opportunities, support, and encouragement from the family (Brahmana & Yuwono, 2024). Research by Ridhaningtyas et al., (2024) states that parental social support influences students' learning independence. Research by Ardianto et al., (2024) also shows

that the higher the social support given by parents, the higher the learning independence of students. So, it can be said that good parental social support will increase learning independence.

In addition to external factors, there are also internal factors that influence students' learning independence, namely self-regulation (Sagitarini et al., 2023). Self-regulation is substantially formed in the early period through environmental and biological effects (Liman & Tepeli, 2019). Self-regulation is a process in which a person can regulate their achievements and actions, such as setting targets and time for themselves, evaluating and monitoring their success when achieving those targets, determining strategies, and rewarding themselves for achieving those goals (Brenner, 2022; Harahap, 2023; Tzimas & Demetriadis, 2024). Students who have self-regulation can formulate and set their own learning goals because they can be in control of their learning activities (Samini et al., 2023). This ability to self-regulate not only encourages better decision-making but also contributes to overall well-being, as individuals can cope with stress and adversity with greater resilience and control (Ramdass & Zimmerman, 2011). Self-regulation is very important in various aspects of life, including education, work professionalism, and social connection (Ök & Sarıtaş, 2022; Radzitskaya & Islamov, 2024).

Several studies have examined the topic of parental social support, regulation, and learning independence, including learning independence reviewed from parental social support for high school students (Pardosi & Atrizka, 2018), learning success formula reviewed from independence, motivation and social support for college students (Nadiyah et al., 2023), the influence of self-efficacy and emotional intelligence on learning independence of high school students (Saragih & Lubis, 2023), and the influence of self-regulation and discipline on independence in elementary school (Purwaningsih & Herwin, 2020). Although numerous studies have examined the relationships between parental social support, self-regulation, and learning independence, most of these studies have focused on secondary and higher education levels. Moreover, there is a lack of research that simultaneously investigates the role of both parental social support and self-regulation in influencing learning independence among elementary school students. This indicates a research gap that needs to be addressed. The novelty of this study lies in its approach to combining parental social support and self-regulation as predictors of learning independence, specifically within the context of elementary school students. This integrated approach has rarely been explored in previous studies, particularly at the primary education level.

Based on the description above, it is known that parental social support and self-regulation will affect students' learning independence. However, it is not yet clearly known what the level of parental social support and self-regulation of students is, and the influence of both on students' learning independence is not yet clearly known. Therefore, this study aims to determine the effect of parental social support and self-regulation on the learning independence of grade V students at Dabin 1 Elementary School, Prambanan District. It is hoped that this study can contribute to increasing the role of parents in providing social support to their children.

METHOD

The research to be conducted uses a quantitative approach. Specifically, this research is directed at the design of ex post facto research. Ex post facto research is research where researchers are related to instruments that have occurred, and they do not provide special treatment to the instruments being studied (Sugiyono, 2017). The procedures for this research are identification of problems and formulation of hypotheses, determination of variables, selection of research designs, selection of samples and data collection techniques, data analysis, interpretation, and conclusions.

This study was conducted in grade V of elementary schools in the Prambanan District in the 2023/2024 academic year. This study had a population of 122 fifth-grade students from 8 schools in Dabin (Patronage Area) 1, Prambanan District.

Table 1. Population Size

No.	School Name	Number of Students
1	Pandansimping 2 Elementary School	17
2	Sangon 1 Elementary School	5

No.	School Name	Number of Students
3	Prambanan Elementary School	21
4	Pereng Elementary School	15
5	Cucukan 2 Elementary School	19
6	Kebondalem Kidul 1 Elementary School	18
7	Kokosan Elementary School	12
8	Joho 1 Elementary School	15
Amount		**122**

Due to the large population, researchers took several samples from the population that would be used as research subjects. The determination of this research sample refers to the formula developed by Issac and Michael (Sugiyono, 2017). The formula is as follows.

$$s = \frac{a^2.N.P.Q}{d^2(N-1)+a^2.P.Q} \tag{1}$$

Information:
s: many samples
a2: Value a chi square table DK = 1 significance 5% (3.841)
N: large population
P = Q: population size
d: 0.05

$$s = \frac{3,841.122.0,5.0,5}{(0,05)^2.(122-1)+3,841.0,5.0,5} = \frac{117,1505}{0,3275 + 0,96025} = 92,97$$

Sampling in this study was based on the consideration of a fairly large population, namely 122 fifth-grade students from 8 elementary schools in Dabin 1, Prambanan District, in the 2023/2024 academic year. To maintain the efficiency and effectiveness of the study and to ensure that the data collected remains representative, the researcher refers to the formula developed by Isaac and Michael (Sugiyono, 2017) in determining the ideal sample size. The calculation results show that the number of samples needed is 92 students. The random sampling technique was chosen as the sampling method to provide an equal opportunity for each member of the population to become a research subject. This random selection also aims to avoid bias in determining the sample. This process is then consulted with the class teacher to ensure the eligibility of the selected students so that the data obtained later is valid and relevant to the research objectives.

This study uses a questionnaire. The measurement in the questionnaire above uses a modification of the Likert scale. The scale used contains statements consisting of two types of statements, namely, favorable (positive statements) and unfavorable (negative statements). The determination of the score for each answer can be seen in Table 2.

Table 2. Distribution of Modified Likert Scale Scores

No.	Answer	Score	
		Favorable Statement	**Unfavorable Statement**
1	Very Suitable	4	1
2	In accordance	3	2
3	It is not by	2	3
4	Inappropriate	1	4

(Widoyoko, 2022)

The modification is used to compile a questionnaire to obtain data on parental social support, self-regulation, and learning independence. The instrument grid for each variable and the number of questions are as follows.

Table 3. Grid Instrument Support Social Person Old

No.	Variables	Indicator	Sub Indicators	No Item		Amount
				F	**UF**	
1	Social Support of	Emotional	Gaining Empathy	3	2	5

No.	Variables	Indicator	Sub Indicators	No Item		Amount
				F	UF	
	Parents	Support	Getting Attention and Love, Darling	3	2	5
		Support Awards	Get an Award, Positive	3	2	5
			Agreement Idea or Feelings	2	2	4
		Instrumental Support	Immediate Help/Real in the Form of Goods, Time, and Service	3	1	4
		Information Support	Get Advice and Suggestions	2	1	3
			Get Directions from Problem	3	1	4
Number of Items				**19**	**11**	**30**

Table 4. Grid Instrument Regulation Self

No.	Indicator	Sub Indicators	No Item		Amount
			F	UF	
1	Goal Setting	Set a Target Achievement while Studying	1.2	3.4	4
2	Planning	Plan time Study	5.6	7.8	4
		Plan to use the Learning Facilities	9,10	11.12	4
		Reminding myself of the Importance of Studying	13.14	15,16	4
3	Motivation Self	Give yourself a Reward when you Experience Learning Success	17.18	19.20	4
4	Attention Control	Focus Attention	21,22	23.24	4
5	Use of a Strategy Study which Flexible	Own Strategy Study	25,26	27,28	4
6	Self Monitoring	Monitoring Progress Study	29.30	31.32	4
7	Looking for Help Right now	Look for Assistance at the Party Social	33.34	35.36	4
		Look for Assistance from the non Social Party	37.38	39.40	4
8	Evaluation Self	Understand the Advantages and Disadvantages Associated with Something	41.42	43.44	4
Amount Item			**22**	**22**	**44**

Table 5. Grid Instrument Independence Study

No.	Variables	Indicator	Sub Indicator	No Item		Amount
				F	UF	
1	Learning Independence	Believe Self	Brave comes on Stage in a Public Face	1	1	2
			Believe in Ability Self	1	1	2
			Brave Ask	1	1	2
			Brave to put Forward an Opinion	1	1	2
			Brave does the Task Alone	1	1	2
		Able to Work Alone	Do Tasks without being Ordered by Others	1	1	2
			Satisfied with the Results Obtained	1	1	2
		Able to make Decisions	Be Careful in Making Decisions	1	1	2
		Responsible	Brave Confesses Error	1	1	2
			Brave Accepts the Risk for the Actions Taken	1	1	2
			A Responsible Answer to Completing the Task	1	1	2
		Desire to move Forward	Flavor knows which Rall	1	1	2
			Like things New	1	1	2
			Have Creativity, which is Tall	1	1	2

| No. | Variables | Indicator | Sub Indicator | No Item | | Amount |
				F	UF	
		Discipline	Fulfill Regulations in Class and at School	1	1	2
			Prepare Book Lessons yourself without having to be told.	1	1	2
		Active in Learning	Communicating the Results of his Opinion	1	1	2
			Try to find your Knowledge	1	1	2
			Make something to understand the Lesson	1	1	2
Amount				**19**	**19**	**38**

In quantitative research, validity and reliability are two essential components that determine the quality of measurement tools. Validity refers to the extent to which an instrument accurately measures what it is intended to measure, while reliability refers to the consistency of measurement results under similar conditions. Ensuring that an instrument is both valid and reliable is a crucial preliminary step before it is used to collect research data.

In this study, content validity was assessed through expert judgment by professionals in relevant academic fields. The validity of the parental social support questionnaire was evaluated by Dr. Budi Astuti, M.Si, a lecturer from the Faculty of Psychology at Yogyakarta State University (UNY). Items were rated based on their relevance using a scale of 1 to 5, and the average score was 3.8. This result indicates that the instrument is suitable for use with minor revisions. The self-regulation questionnaire was assessed by Dr. Nur Cholimah, M.Pd, a lecturer from the Faculty of Education, UNY. The average rating was 3.7, suggesting that the instrument is also appropriate, with some revisions. Meanwhile, the learning independence questionnaire was evaluated by Dr. Muthmainah, S.Pd, M.Pd, a lecturer from the Faculty of Early Childhood Education, UNY. The average score was 3.8, indicating that the instrument is acceptable with minor revisions. Furthermore, to assess the internal consistency of the items in each instrument, a reliability test was conducted using Cronbach's Alpha coefficient. As shown in Table 6, the reliability values for all variables are categorized as very high. Data analysis uses descriptive analysis, prerequisite tests, and hypothesis tests.

Table 6. Reliability Test Results

No.	Variables	Cronbach's Alpha	N of Iems	Criteria
1	Parental Social Support	.895	30	Very High
2	Self Regulation	.936	44	Very High
3	Learning Independence	.907	38	Very High

RESULTS AND DISCUSSION

Results

This study has several stages of data analysis of the research results carried out, including descriptive analysis, assumption testing, and hypothesis testing. The descriptive analysis includes the average (mean), standard deviation, and variance. The assumption tests carried out in this study include residual normality tests with the Kolmogorov-Smirnov test, linearity tests, multicollinearity tests, and heteroscedasticity tests. The next stage is hypothesis testing with simple regression analysis and multiple regression analysis.

Descriptive Analysis

Table 7. Descriptive Analysis Results

No.	Variables	Meaning	Standard Deviation	Variance
1	Support Parents Social	93.32	10.537	111.031
2	Self Regulation	130.07	16.818	282.835
3	Learning Independence	112.85	14.418	207.889

Based on the results, Table 7 shows that the means support social people old, that is own score 93.32, which gives meaning that support social people old participants' education class V Dabin 1 Elementary School, Prambanan District is very high. The mean score of 130.07 from the results of the descriptive analysis of self-regulation means that the regulation of class V students of Dabin 1 Elementary School, Prambanan District, is in the moderate category. The mean score of learning independence of 112.85 means that the learning independence of class V students of Dabin 1 Elementary School, Prambanan District, is in the moderate category.

Normality Test

The normality test aims to determine whether the data obtained from the research sample is normally distributed or not. The normality test uses Kolmogorov-Smirnov. Matter. This is because of sample research, more than 30. Decision making in this normality test is based on Mark Sig. As big as 5% or $\alpha = 0.05$. If mark Asymp sig (2 tailed) > 0.05, then the data is normally distributed, whereas if Asymp sig (2 tailed) < 0.05, then the data is not normally distributed. The normality test in this study was conducted with the help of SPSS version 23. The results are shown in Table 8.

Table 8. Normality Test Results

		Support Social Parent	Regulation Self	Independence and Learning
N		92	92	92
Normal Parameters [a,b]	Mean	93.32	130.07	112.85
	Std. Deviation	10,537	17,562	14,418
Most Extreme	Absolute	.050	.063	.103
Differences	Positive	.050	.045	.055
	Negative	- .044	- .063	- .103
Test Statistics		.050	.063	.103
Asymp. Sig. (2 2-tailed) [c]		.200 [d]	.200 [d]	.108

Based on the results obtained from the SPSS calculation, it can be seen that the significance. The value of the Kolmogorov-Smirnov test on the variable of parental social support is 0.200. This value is greater than α $(0.200 > 0.05)$, so it can be decided that the data sample supports that social parents are normally distributed. The sig. the value of the Kolmogorov-Smirnov test on the variable regulation self is 0.200. Mark the bigger from mark α $(0.200 > 0.05)$, so it can be concluded that the self-regulation sample data is distributed normally. Then mark sig. Kolmogorov-Smirnov on the independence variable Study is 0.108. Mark the bigger α $(0.108 > 0.05)$ so that it can be concluded that the independent learning sample data is normally distributed. Thus, the analysis can be continued to the second prerequisite test.

Linearity Test

The linearity test aims to see the linear relationship between variables. Free with variable bound. In correlation, there should be a connection that is linear connection between the free variable and the variable bound. The linearity value is seen from the value sig. Deviation of linearity. The results of the linearity test calculation are shown in Table 9.

Table 9. Linearity Test Results

No.	Connection	Significance	Information
1	Support Social Persons Old and Independence Study	0.425	Linear
2	Regulation of Self and Independence Study	0.065	Linear

Based on Table 9, it appears that the sig. deviation of linearity value of the parental social support variable as an independent variable and independence Study as variable bound as big as 0.425 or bigger from 0.05, so it can be concluded that the connection between social parents with learning independence is linear. Table 16 also shows that the sig. deviation of linearity value of the self-regulation variable as a variable free and independent Study as variable bound as big as 0.065 or

bigger from 0.05, so that it can be concluded that the relationship between self-regulation and learning independence is linear. Thus, the second prerequisite test is met.

Multicollinearity Test

The purpose of the multicollinearity test is to determine whether or not there is a relationship. Between variable-free. Condition analysis regression is the presence of multicollinearity (Priyatno, 2009). The multicollinearity value is seen from the tolerance value and the VIF value. The results of the multicollinearity test are as follows.

Table 10. Multicollinearity Test Results

Model		Unstandardized d Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	13.624	9.510		1.433	.155		
	Social Support Person Old	.521	.114	.381	4.579	.000	.706	1.416
	Regulation Self	.389	.068	.474	5.697	.000	.706	1.416

Based on Table 10, the known mark tolerance aspect supports social support of parents and self-regulation, respectively, namely 0.706. The tolerance value is more than > 0.10. Then, the VIF value of social support of parents and self-regulation obtained a value of 1.416, which is <10.00, so it can be concluded that the independent variable does not experience multicollinearity with the dependent variable.

Heteroscedasticity Test

Test heteroscedasticity, aiming for test inequality. Variants from one observation to another. The heteroscedasticity test in this study was conducted using the Glejser test, namely by regressing the independent variable against the absolute residual value (AbsRES). The results of the heteroscedasticity test are as follows.

Table 11. Heteroscedasticity Test Results

Model		Unstandardized d Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	13.624	9.510		1.433	.155		
	Social Support Person Old	.521	.114	.381	4.579	.000	.706	1.416
	Regulation Self	.389	.068	.474	5.697	.000	.706	1.416

Referring to Table 11, the Standardized Coefficients section obtained a significance of 0.381 for social support and 0.474 for self-regulation. Based on the results obtained, it exceeded 0.05, so it was stated that there was no heteroscedasticity.

Main Multiple Regression Hypothesis Test

Test The main multiple regression hypothesis aims to make a decision related to the presence or absence of partial influence of parental social support on learning independence, as well as the partial influence of self-regulation on learning independence of class V students at Dabin 1 Elementary School, Prambanan District. The results of the main test in multiple linear regression for the first hypothesis (H1) and the second hypothesis (H2) are summarized in Table 12 below.

Table 12. Main Multiple Regression Hypothesis Test Results

Variables		Pearson Correlation		Unstandardized Coefficients		Standardized Coefficients B	T	Sig.
Bound	Free	r	Sig.	B	Std. Error			
Independence and Learning	Support Social People Old	0.63 8	0.000	.304	.114	.222	2.67 2	.009
	Regulation Self	0.78 5	0.000	.550	.071	.641	7.72 0	<,001

Based on Table 12, it appears that the results of the multiple regression test on the variable of parental social support obtained a t value of 2.672 (> t table) and a sig. value of 0.009 (< 0.05). These results are the basis for making decisions on the first hypothesis, namely, rejecting H0 and accepting H1. So parental social support partially has a significant effect on the learning independence of class V students of Dabin 1 Elementary School, Prambanan District. While on the self-regulation variable, a t value of 7.720 (> t table) and a sig. value of 0.004 (< 0.05) was obtained. Thus, in the second hypothesis, it was decided to reject H0 and accept H1. So, self-regulation partially has a significant effect on the learning independence of class V students of Dabin 1 Elementary School, Prambanan District.

Advanced Multiple Regression Hypothesis Testing

Test the hypothesis, and carry on aiming to make a decision related to the third hypothesis. The provisions used as the basis for decision-making on the hypothesis are the comparison of the F value and the Sig value. If mark test F is bigger than the F $_{table}$ (3,098) and mark sig. <0.05, then H0 is rejected, and H1 is accepted. The calculation was carried out using multiple linear regression analysis through the SPSS version 29 application. The results obtained are as follows.

Table 13. ANOVA Table Summary

No.	Test	R^2	F Test	F table	Sig.
1	Regression Linear Multiple	0.645	80,707	3,098	0.001

Based on Table 13, it looks like the results test F to obtain the value of 80.707 (>3.098) with mark sig. as big as 0.001 (<0.05), so that it can be decided that H0 is rejected and H1 is accepted. So, supporting parental socialization and self-regulation together has a significant influence on the learning independence of class V students at Dabin 1 Elementary School, Prambanan District.

The results regression analysis, which is done to obtain the mark determination coefficient (R^2), are 0.645. This value means that 64% of the independent variables can explain the dependent variables, while 36% of the independence Study students were explained by variables other than not examined in this study. In other words, parental social support and self-regulation together contribute to learning independence by 64%. Thus, parental social support and self-regulation are predictors of students' learning independence.

Effective Contribution and Relative Contribution

Table 14. SE & SR Summary

No.	Variables	Regression Coefficient	Correlation Coefficient	SE	Total SE	SR	Total SR
1	Support Social Person Old	0.222	0.638	14.2%	64.5 %	22%	100%
2	Regulation Self	0.641	0.785	50.3%		78%	

Based on Table 14, it appears that the effective contribution of each independent variable to the dependent variable is different. The effective contribution of the parental social support variable to learning independence is 14.2%, while the effective contribution of the self-regulation variable to learning independence is 50.3%. Based on this, the self-regulation variable provides a greater contribution in explaining independence Study than the variable supporting social parents. Table 14 also shows that the total effective contribution of the two independent variables, namely parental social support and self-regulation, is 64.5%. The relative contribution of each variable is different, where the parental social support variable has a relative contribution of 22%, while self-regulation is 78%. Thus, the total relative contribution of the two free variables is 100%. With comparison variable regulation greater than the variable of parental social support.

This has important implications for the field of education, highlighting the need to strengthen educational programs and learning strategies that focus on developing students' self-regulation skills, such as time management, intrinsic motivation, and effective learning strategies. While parental support remains important, these results emphasize that fostering student learning independence can be more effectively achieved when educational institutions actively promote self-regulation through

learning approaches that encourage autonomy, self-reflection, and personal responsibility in the learning process.

Discussion

Learning carried out by teachers does not only focus on the delivery of the material lesson. However, teachers must provide guidance related to the formation of student character. A teacher can help students to have an awareness of learning, which is important for them to be able to achieve good results. The success of student learning that is achieved is greatly influenced by the awareness of learning that they have. Awareness, students will understand the importance. The study will push students to learn independently, even outside school hours. Student independence in learning will encourage them to carry out and complete tasks given by the teacher (Rifky, 2020; Rustamovna & Obloberdiyevna, 2023).

Characteristics of students who are independent in learning are that they always take the initiative to learn something first, complete the tasks given on business Alone, and become capable of referencing in learning behavior, which is good, competent, as well as quality. Independence Study in students' self can also be seen through the students' thinking process. Students who have learning independence will think creatively and innovatively. When getting information, students with good learning independence will always explore information to get validity of information as well as try as good as Possible to finish problems with careful solutions (Khunafah et al., 2024).

Parental support for students can be in the form of emotional support, information support, instrumental support, appreciation support, and support network (Amna et al., 2023; Wong et al., 2018). Supporting older and very determined persons determines the success of students in completing their education at school. Parents have an important role in determining the success of their children's education. The role and responsibility in guiding the continuation of children's learning at home according to the program that has been studied by children in school (Standsyah et al., 2019). Furthermore, parental support for children can influence behavioral patterns. Child, child which get treatment which good, attention, full of affection from their parents will display good and independent behavior (Yan et al., 2024; Zhang & Wang, 2024).

Referring to the opinion of Grahani et al., (2024), the family influences a person's self-regulation. If the functioning of the family is well-maintained, the child will have good self-regulation. Therefore, children who originate from a family that is supportive and good in matters academic or otherwise will more easily increase the child's willingness, awareness, and responsibility for other things. Strong social support from parents creates a conducive environment for children to develop optimally, both emotionally, socially, and academically (Wang et al., 2024). This family functioning is an important foundation because it supports many aspects, especially the child's psychological development.

Apart from family support, it turns out that social support is also very necessary for students (Wardaniati et al., 2024). When students get enough social support from their surroundings, they will not delay doing their work. If students get social support from the environment, they will be certain of their abilities and be able to do the task well. There is self-regulation in learning and supporting social which will make student capable of achieving their goals. The ability to manage time, set priorities, and monitor learning progress can help students avoid disruptive behavior. Procrastination academic. The existence of support from family, friends, and special people can provide motivation, high self-confidence, and the ability to overcome difficult tasks. Students who have high self-regulation can organize their work, set goals, seek help when needed, use effective work strategies, manage their time for studying, and have self-efficacy (Radović et al., 2024). Therefore, self-regulation in studying and social support can create academic and outside success and help students achieve their goals effectively (Chung & Yuen, 2011; Meo et al., 2024).

From a social cognitive perspective, it is concluded that students' self-regulation position in learning is determined by three mutually supportive factors, namely personal, behavioral, and environmental (Syah & Pertiwi, 2024). A student who has his or her awareness needs to study and will always study because of his/her needs without support from parents or peers. Learning awareness will help students in behavioral changes and awareness of the importance of learning.

Referring to the results of research conducted by Meo et al., (2024), the Pearson correlation value was obtained at 0.230 with a significance of 0.000, thus supporting the results of this study that learning independence does have a significant relationship with parental social support and self-regulation. This shows that self-regulation is good and supports socialization, which is good and has a significant relationship, so that it can reduce academic procrastination in students.

The results of the major hypothesis test in this study indicate that parental social support and self-regulation simultaneously have a significant effect on the learning independence of fifth grade students of Dabin 1 Elementary School, Prambanan District. This proves that parental social support and self-regulation are predictors of learning independence. Direction coefficient regression has proven that support from social person parents and self-regulation have a positive and significant effect on learning independence. This means that the higher the social support of parents and self-regulation, the higher the learning independence of students.

Based on the results of the study and the findings that have been described, the practical implications that can be applied in the context of education are that teachers, parents, and the social environment must actively collaborate in shaping the character and learning independence of students. Teachers are not only tasked with delivering lesson materials but must also guide students to have a high level of learning awareness through an approach that supports self-regulation. On the other hand, the role of parents is very crucial in providing social support in the form of emotional encouragement, information, and appreciation, and creating a functional and supportive family environment so that children are able to develop psychologically and academically. In addition, social support from the surrounding environment has also been shown to increase students' self-confidence and reduce academic procrastination. Therefore, an integrated educational approach between character building, self-regulation, and social support from both the family and the surrounding environment can effectively encourage the creation of high learning independence in students and support their academic success.

CONCLUSION

Parental social support and regulation partially or simultaneously have a positive and significant effect on learning independence. This study implies that student learning independence will develop if students receive full support from parents as the main element in student life. Parents are required to facilitate both morally and materially while students are in school. Parents do not only work alone, but there is also collaboration from the child to know the importance of learning. Parents have the right to guide their children, and students have the right to choose their path, as long as it is not detrimental. Developing learning independence should first foster a sense of the importance of learning for students. Students must also be capable of controlling themselves so that they can avoid negative things that will hinder their ability of students to be independent in learning. As a suggestion for parents in improving children's learning independence, they should implement every aspect that exists in independence study for students so that they can apply with good at home. It is recommended that future studies examine interventions or programs designed to enhance self-regulation and learning independence while taking into account the role of social support, particularly from parents.

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Development of digital science literacy based on Articulate Storyline based on objects' material for class VIII junior high school

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ARTICLE INFO

ABSTRACT

One solution to overcome the low quality of Indonesian education is to innovate education by developing digital tools for learning. Based on a literature review, digital tools in the form of Articulate Storyline software have many advantages in science learning, especially physics. Therefore, the development of students' digital science literacy based on an Articulate Storyline material on forces on objects for grade VIII junior high school students is important. The purpose of this study was to determine the level of validity and feasibility of Articulate Storyline as a learning medium to develop students' digital science literacy. The method used to develop this media uses 4D (Define, Design, Develop, and Disseminate). Data collection techniques for media validity use media, material, and readability validation instruments, while for students' digital science literacy skills, use practice questions and questionnaires. As supporting data, we also conducted interviews, which were then analyzed descriptively. Respondents in this study were expert validators (Lecturers), Teachers, and Students. The results we obtained showed that (a) the results of the validity of the media, materials, and readability were declared 'very valid' with values of 89.4%, 100%, and 75.8%; and (b) the students' digital science literacy skills was declared 'very good' with a value of 80.0. These results indicate that the development of digital science literacy based on Articulate Storyline is worthy of being developed as an innovative learning medium. We recommend that digital science literacy be developed in other science materials, such as biology and chemistry.

INTRODUCTION

Education is very much needed in various social activities, so education is the most important part and will not be separated from the aspect of human life. According to Hartono (2017), the quality of education in Indonesia is still of concern. The results of data according to the Education For All (EFA) Global Monitoring Report 2011: The Hidden Crisis, Armed Conflict and Education which has been determined by the United Nations Educational, Scientific and Cultural Organization (UNESCO), the education development index score or Education Development Index (EDI), Indonesia according to data in 2008 was at a score of 0.934. EDI is said to be high if it reaches a score of 0.95 to 1, medium if it reaches a score above 0.80, and low if it reaches a score below 0.80

(Hartono, 2017). The data places Indonesia at a medium level in achieving EDI scores and is in 69th position out of a total of 127 countries in the world registered. This is very worrying considering that the quality of education in Indonesia is still not satisfactory.

The low quality of education in Indonesia is caused by various factors, one of which is educational innovation. One form of educational innovation is the use of Information and Communication Technology (ICT) in learning. Teaching and learning activities using ICT can be implemented by using various digital devices as learning media. These digital devices are used by students during learning in class. Therefore, students' ability to use digital devices is important for students to have a smooth learning process in class.

Digital literacy is a skill needed in the 21st century. Digital literacy is the ability to use digital tools to support primary goals in various life situations (Reddy et al., 2020). Digital literacy is also a form of life skill, so it is not only mastering the ability to use technological, information and communication devices, but also mastering the ability to socialize, innovate in learning, and have an attitude, think critically, creatively and inspiringly as digital literacy skills (Febliza & Oktariani, 2020). Digital literacy is not only in the definition aspect, but also in the evaluation aspect of individual digital competence (Zaenudin et al., 2020).

Digital literacy is needed by humans to master digital competencies to carry out tasks and solve various problems in the digital age. Digital literacy competencies consist of four core competencies, namely (1) Internet Searching: a person's ability to operate, use, and carry out activities via the internet, (2) Hypertextual navigation: reading and understanding dynamically on a hypertext, to be able to understand a hypertext in the search window, (3) Content Evaluation: the ability to think critically and evaluate through various things found online also includes the ability to identify the validity and completeness of the information provided, (4) Knowledge Assembly: a person's efforts in carrying out the compilation of knowledge, construction of a collection of information obtained from various sources and collecting and evaluating facts and opinions that are not based on prejudice (Zaenudin et al., 2020). This digital literacy competency is important for students so that they can adapt to advances in technology and information, accompanied by increasingly sophisticated digital devices from the industrial world and institutions.

The development of learning media in the form of digital devices can help students improve creativity, learning motivation, critical thinking, and problem solving (Daryanes et al., 2023; Kurnisar et al., 2023; Nurrahma et al., 2023). One of the digital tools used in previous research is Articulate Storyline. Articulate Storyline is an application software that is useful for creating interactive programs that can be published by users to present information for interactive learning purposes. This application produces a display of material in the form of an attractive presentation so that it motivates students in learning activities (Khusnah et al., 2020). The Articulate Storyline application has a simple appearance like PowerPoint, but the integrated Flash feature in this application can be used to create interactive videos. This application makes it easy for users to publish online or offline, so it can be used in products such as word processing, Compact Disk (CD), personal pages (web), and learning management systems.

Articulate Storyline has four main features that excel as learning media, namely: a) Features for designing interactive learning media (Articulate Storyline engage); b) Features for designing various interactive questions with various variations, such as multiple choice, matching, true-false, and so on (storyline quiz maker); c) Features for combining the results of articulate storyline engage and quiz maker (articulate storyline presenter), d) Features for editing videos and sound recordings (Articulate Storyline video encoder), such as cutting parts of videos or sound recordings that you want to delete, being able to edit the sound level of videos and recordings that have been entered, and being able to make direct sound recordings in this feature (Khusnah et al., 2020).

Previous research related to the development of Articulate Storyline has been widely used by researchers in science learning. For example, the development of interactive multimedia using articulate storylines has been successfully developed in chemistry materials, namely thermochemistry of substances (Herdini et al., 2021) and atomic structures (Lestarani et al., 2023), while in biology materials, namely about cells (Suhailah et al., 2021). Furthermore, an Articulate Storyline research using a contextual approach was also developed in physics material for college

level (Wahyuni et al., 2023). More specific material in physics for secondary school level, Articulate Storyline research has been developed on Newton's laws (Husna & Fajar, 2022) and heat (Fitriyah et al., 2023), while for elementary school level, it has been developed in thematic learning (Alfirzan, et al., 2024). From the literature review above, the development of an Articulate Storyline on physics material about force for high school level has never been done, so we are interested in conducting this research. The novelty of the research we conducted lies in the material and level of education. The benefits of this learning media for students are that it can help in delivering science material, especially physics material, which is abstract and difficult to understand (Suhailah et al., 2021). In physics, force is a form of pull or push that can change the shape, direction, and speed of an object (Zubaidah et al., 2017). There are generally two types of forces, direct (touch) force and indirect (non-touch) force. Direct force is a force that directly touches an object. Indirect force is a non-touch force that acts between two objects (Maduretno, 2017).

The use of Articulate Storyline as a learning medium is expected to improve students' digital science literacy skills in the field of force. The application of an articulate storyline is also able to provide new insights for teachers to innovate learning in the classroom. This aims to produce better learning quality. The purpose of this study was to determine the level of validity of the development of digital science literacy based on an articulate storyline on the material of force in physics for the Junior High School (SMP) level. In addition, this study also aims to determine the level of feasibility of the products we develop. In the future, this study is also expected to be able to increase students' interest in learning so that teachers can develop an Articulate Storyline media on other science materials.

METHOD

Our research is a development research oriented towards product development in the form of an Articulate Storyline. This research was conducted in one of the schools, namely Junior High School 1 Kandat, Kediri Regency, East Java. The subjects of the research were students of class VIII H in the odd semester. Data collection techniques were conducted by conducting interviews with science teachers and giving questionnaires to junior high school students. The research method used was the 4D research method, which was implemented in class VIII H of Junior High School 1 Kandat. The research method in product development used the 4D method by Thiagarajan (Thiagarajan et al., 1974). The stages of the 4D method are Define, Design, Develop, and Disseminate (Yahya, 2020). Details of the stages are explained as follows.

Define

This stage analyzes learning devices and student analysis. Then investigates the problems that arise during the learning process. Researchers also analyze learning devices and learning objectives in order to find several solutions that will be applied during learning activities. In addition, researchers conduct observations at schools to be studied to analyze student needs and determine learning media that are appropriate for students.

Design

In this stage, we conduct the plan of the material, learning strategies, learning media, and learning models. Then, we design the teaching materials, assignments, and quizzes as final evaluations. These designs were compiled in articulate storyline applications that support various devices (laptops, computers, or smartphones) for students in classroom teaching.

Develop

The development of an Articulate Storyline as a digital science literacy learning media is carried out at this stage. After the Articulate Storyline media has been successfully developed, a validation process is carried out to determine whether this learning media is feasible to be applied or not in learning activities. The validation process carried out consists of media, material, and readability validation. Media and readability validation uses a Likert scale using 4 classifications (very good, good, not good, and very bad), while material validation uses a Gutmann scale with 2

classifications (true and false). The media and material validators in this study are expert validators (lecturers), while the readability validators are teachers and students. After obtaining the validation results, the scores obtained are calculated as quantitative data to determine the rating scale expressed in percentages. The calculation of the results used the following Formula 1 (Yahya, 2020):

$$P = \frac{\sum R}{N} \times 100\% \tag{1}$$

P = Percentage of the score
$\sum R$ = Score of answers given by the validator
N = Maximum score

After obtaining the percentage of the score, the next step is to convert P (in Table 1) to find out whether the learning device is good/or valid.

Table 1. Category of the Percentage of Score

No.	Percentage	Description	Category
1	75.01% - 100%	Very Good	Very Valid, can be used without Revision
2	50.01% - 75.00%	Good	Quite Valid, usable, and needs a little Revision
3	25.01% - 50.00%	Less Good	Less Valid, Recommended not to use, and needs Revision
4	0.00% - 25.00%	Not Good	Invalid, should not be used

Disseminate

After the product is declared valid, learning is then carried out using Articulate Storyline media using the blended learning model. Blended learning is one of the learning models in its implementation that combines traditional learning models with technology-based learning (Yahya, 2020). The combination of blended learning model is a form of face-to-face learning model with mobile phone media (smartphones), as well as a combination of offline learning experiences with online learning experiences (Hrastinski, 2019). The principle of blended learning is learning that combines oral communication and written communication directly on electronic media online, so that a unique learning experience is created according to the desired educational context and objectives (Fathullah, 2020). In addition, interviews were also conducted with science teachers at the school as additional supporting data in this study. Data on students' science abilities in studying the material on the force of objects was obtained using the practice question instrument contained in the media, while data on students' digital literacy with articulate storyline media was obtained using an instrument in the form of a questionnaire in the form of Google Form questionnaire.

RESULTS AND DISCUSSION

Results

Articulate Storyline is software that is useful for creating interactive programs that can be published by developers to present information for interactive learning purposes (Khusnah et al., 2020). The result of our product development, in Figures 1 & 2, is an Articulate Storyline as interactive learning media that can be accessed online by students. This articulate storyline media discusses the material on forces on objects consisting of phenomena, definitions, types of forces, formulas, laws that apply to forces, and applications. In addition, it is also equipped with learning videos, basic competencies (KD), instructions for use, and practice questions to improve students' learning abilities. This interactive media can be accessed on computers or smartphones to improve students' digital science literacy skills. For more complete references, you can access the interactive media available here https://bit.um.ac.id/digscilit_as. This interactive media feature begins with a brief introduction, then a command to log in. However, users can skip the login feature via the menu (red box) provided.

Figure 1. Differences in Interactive Media Display on Computers (Left) and Smartphones (Right)

Figure 2. Display Features on Interactive Media Divided into Various Options

After successfully logging in, users are presented with various features that can be freely accessed by users. The features are divided into basic competencies (KD), learning materials, learning videos, practice questions, product references, developer profiles, and usage instructions, as seen in Figure 3. This interactive media is divided into three main features that will be the object of research. The main features are learning materials, learning videos, and practice questions. Materials and videos are used to increase students' insight and understanding of the force on objects, while practice questions are used to train students' abilities in understanding science.

Figure 3. Material Menu Display (Left), Learning Video Menu (Center), Practice Questions (Right)

After successfully developing the articulate storyline media with the material of force on objects, we conducted product validation. The product validation that we conducted consisted of media validation, material validation, and readability validation. The results of media, material, and readability validation are shown in Tables 2, 3, and 4, respectively.

Table 2. Articulate Storyline Media Validation Results

No.	Rated aspect	Percentage (%)	Category
1	Media View	87.5	Very Valid
2	Presentation of Material	88.9	Very Valid
3	Benefits of Interactive Media	91.7	Very Valid
Average Score		**89.4**	**Very Valid**

Table 3. Material Validation Results in Articulate Storyline Media

No.	Rated aspect	Percentage (%)	Category
1	The Phenomenon of Force on Objects	100	Very Valid
2	The Definition of Force	100	Very Valid
3	Newton's Law	100	Very Valid
4	The Application of Force	100	Very Valid
5	The Videos of Force on Objects	100	Very Valid
6	Practice Question	100	Very Valid
Average Score		**100**	**Very Valid**

Table 4. Articulate Storyline Media Readability Validation Results

No.	Rated Aspect	Percentage (%)	Category
1	Ease of Reading Force Definitions in the Media	80.0	Very Valid
2	Ease of Reading Newton's Formulas and Laws in the Media	71.3	Quite Valid
3	Ease of Reading the Application of Force in the Media	80,0	Very Valid
4	Ease of Reading Text Integrated into Learning Videos	66.4	Quite Valid
5	Ease of Reading Practice Questions in the Media	85.0	Very Valid
Average Score		**75.8**	**Very Valid**

The average score percentage that we obtained was the media validation result of 89.4%, with a very valid category, the material validation result of 100%, with a very valid category, and the readability validation of 75.8% with a valid category. The percentage of material validation got a perfect score using the Gutmann scale after revision. This aims to ensure that all concepts in the physics material about the force on objects are correct. Unlike material validation, we use a Likert scale for media and readability validation. The lowest percentage (66.4%) that we obtained was in the aspect of ease of reading the text integrated into the learning video in readability validation. This low percentage is due to the appearance of the text in the video, which is quite small to read when the video is played in portrait mode on a smartphone. Therefore, we suggest that the video should be played in landscape mode. All of the validation data results can be concluded that the Articulate Storyline media that we have developed is valid and suitable for use as a learning medium.

After the media was declared valid, we implemented learning using the blended learning model using this Articulate Storyline media. At the end of the learning, we used the practice question instrument contained in the media to obtain data on students' science abilities in studying the material on forces on objects. In addition, we also used an instrument in the form of a questionnaire to obtain data on students' digital literacy with the Articulate Storyline media. In general, the results of these two datasets are presented in Table 5.

The results of students' digital science literacy skills in Table 5 obtained an average percentage of 80.0%. This means that grade VIII students at Junior High School 1 Kandat have very good digital science literacy skills. They not only have science skills, but also have good digital literacy skills after learning is carried out with blended learning. The articulate storyline media helps students understand science better, and they are skilled at using the software. Regardless of the learning method used by the previous teacher, the results of this study show positive things about the digital science literacy skills of students at Junior High School 1 Kandat.

Table 5. Results of Students' Digital Science Literacy Skills

No.	Rated aspect	Percentage (%)	Category
1	Students' Science Performance Related to the Material on Forces on Objects	79.9	Very Good
2	Students' Digital Literacy Skills using Articulate Storyline Media	80.2	Very Good
	Average Score	**80.0**	**Very Good**

Discussion

The use of technology in learning in schools shows the existence of learning innovation by a teacher and has a positive impact on students in the classroom. Improving students' digital literacy skills can be done by getting students used to searching, processing, analyzing, and interpreting information and data during the learning process, both offline and online (Getenet et al., 2024). In addition to offline and online learning, students' digital literacy skills can also be improved through game-based learning, along with their learning motivation and involvement in learning (Zheng et al., 2024). The dimensions achieved when students have good digital literacy skills include their technical, cognitive, and socio-emotional skills (Ng, 2012). This further contributes significantly to students' self-efficacy (Prior et al., 2016). Further studies have found that digital literacy skills are an important element in fostering a passion and social entrepreneurial behavior that can benefit students in the future (Ip, 2024). Because previous studies have shown a gap between students' digital literacy in learning and their social lives (Smith & Storrs, 2023). The results of other studies also suggest improving students' digital literacy skills, because these skills are the basis for avoiding cyberloafing behavior and using the internet more for educational purposes (Arslantas et al., 2024). To facilitate students' digital literacy skills, support for conducive Information and Communication Technology (ICT) resources in schools is also needed (Chen & Xiao, 2024).

An Articulate Storyline has various features that are useful in carrying out more interactive learning activities to improve students' digital literacy. The advantages of this application have four main features (Khusnah et al., 2020): a) Features for designing interactive learning media (articulate storyline, engage), b) Features for designing various interactive questions with various variations. Among them are multiple choice, matching, true-false, and so on (storyline quiz maker), c) Features for combining the results of articulate storyline engage and quiz maker (articulate storyline presenter), d) Features for editing videos and voice recordings (Articulate Storyline video encoder). This feature can help teachers provide interactive learning activities to students in the future. From the results of the research that we found, the use of an Articulate Storyline has a positive effect on the digital science literacy skills of students at Junior High School 1 Kandat. However, the use of Articulate Storyline also has several disadvantages. The display of the results of the Articulate Storyline product when used via a smartphone is sometimes not full screen. Although it still works well, there is a margin of around 1 pixel to 3 pixels when turned on via a smartphone.

The results of this study are supported by the results of interviews with students, who felt very happy and very enthusiastic to learn science when using articulate storyline learning media. According to them, learning science using this media greatly facilitates the learning process. The teaching and learning process is essentially a communication process, namely the delivery of messages from the sender to the recipient. In order for communication to take place effectively, media is needed as a tool to convey the message. Therefore, learning media can be used by teachers to deliver material in science learning. Several research studies show the positive impact of developing Articulate Storyline in learning (Alfirzan et al., 2024; Daryanes et al., 2023; Fitriyah et al., 2023; Hadza et al., 2020; Lestarani et al., 2023; Wahyuni et al., 2023).

In addition to media and material aspects, readability aspects also greatly influence the success of learning. Valid readability aspects reflect the use of good language and are appropriate for the age of students, making it easier for them to understand science material. Therefore, learning success is also influenced by the use of appropriate language. Students will easily understand what the teacher is conveying if the teacher uses language that is appropriate to the level of understanding of the students. The advantages of articulate storylines as interactive learning media in science material, the

force on objects, show students' excellent science skills and digital literacy skills. This can foster students' motivation to continue learning and be more active in managing learning independently. The growth of this motivation is due to the attractive appearance of the media and its practical function. Thus, this media is important to be developed by junior high school teachers the future in various science materials.

CONCLUSION

The use of technology in education will produce good quality learning. Students become critical thinkers, have conceptual thinking, and can easily access various learning resources. The articulate storyline application is an interactive multimedia software that can be used by teachers or students. Learning using multimedia is based on the premise that interactions between students in the classroom will be more diverse. Multimedia contains several important elements, including text, graphics, photos, animations, and sound. With the combination of these important elements in teaching and learning activities, an articulate storyline can be used as an application for technology-based learning media.

The purpose of this study was to determine the validity and feasibility of Articulate Storyline as a learning medium to develop students' digital science literacy. The method used to develop this media uses 4D, which consists of Define, Design, Develop, and Disseminate. To get the data, we used several instruments, like media validity, material validity, and readability validity, while for students' digital science literacy skills, we used practice questions and questionnaires. Our results showed that (a) the media, material, and readability validity were declared 'very valid', and (b) the students' digital science literacy skill was declared 'very good'. These results indicate that developing digital science literacy based on Articulate Storyline is feasible as an innovative learning medium.

Our research results also showed positive things about the digital science literacy skills of students. An Articulate Storyline can improve students' digital literacy skills and science learning outcomes. This is in line with previous research that Articulate Storyline was able to improve students' understanding and train students' critical thinking skills. Therefore, this media can be the best learning innovation in the future. Thus, we recommend that the development of digital science literacy based on Articulate Storyline can be developed for various science learning activities, such as physics, biology, chemistry, and earth and space science. By looking at the needs of students and the time allocation required, teachers can adapt science materials in this application optimally and efficiently. Articulate Storyline is a new, innovative learning media that can be utilized by teachers in learning in the 4.0 era. Teachers should continue to develop students' digital science literacy at every level of education. In addition, support for the availability of information technology devices in schools is very much needed by the principal and the local government. Then, for students, it is hoped that they will be wiser in using their digital literacy skills and need assistance in using them.

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Enhancing creative thinking skills on biotechnology materials: Development of an e-module using Google Sites

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ABSTRACT

Updates are not yet available for media learning based on electronic learning, which incorporates creative learning into biotechnology material and has a positive impact on otherwise boring lessons. The lack of such innovative digital teaching resources makes it difficult for students to engage actively and think creatively during biotechnology lessons. Therefore, this study aims to: 1) determine the validity of e-modules on biotechnology material to improve students' creative thinking skills; 2) determine the effectiveness of these e-modules; and 3) assess their practicality in real classroom settings. This research utilized the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation) and involved 95 third-semester students from the Biology Education Study Program. Data collection instruments included questionnaires and tests, with analyses conducted descriptively and statistically. The results show that: 1) the Google Sites-based e-module is highly valid, with validation scores of 86.36% from media experts, 93.75% from material experts, and 81.94% from small group trials; 2) the module is effective in improving students' creative thinking, supported by a Wilcoxon test significance value of 0.000 (<0.05); and 3) the module is practical to use, with a practicality score of 88.18% based on student responses in large-scale trials. In conclusion, the e-module developed using Google Sites is valid, effective, and practical, making it suitable for wider application. These findings support the integration of technology in education and encourage teachers to develop similar digital resources. Further research is recommended to explore the development of Google Sites-based e-modules using neurobiology content and critical thinking as variables.

INTRODUCTION

21st-century skills have been running for approximately two decades and are known as the knowledge age, namely, efforts made to achieve skill proficiency based on habits and life needs based on knowledge (Angga et al., 2022). This knowledge is supported by the application of technology, so that 21st-century skills require humans to be more sensitive to information technology, one of which is in learning (Sukatiman et al., 2024; Tok et al., 2022). Learning in the 21st century requires skills that must be mastered by students, so efforts are needed to master 21st-

century skills. One of the skills that students must have is creative thinking skills (Mariana & Kristanto, 2023; Ardiansah & Zulfiani, 2023; Suwistika et al., 2024).

It is important for students to have creative thinking skills because creative thinking skills are one of the skills that should be possessed in facing the 21st century. Creative thinking skills are also very important in supporting competence in the global or modern era due to the increasing level of complexity of problems, in addition, universities must prepare their graduates to have competent skills, if only knowledge is not enough to prepare students to survive in the world of work (Karunarathne & Calma, 2024; Santia, 2018). This is by what was stated by Susanti et al., (2022), that students' creative thinking skills are very much needed in facing 21st century learning, because if students have creative thinking skills, it is certain that students can create thoughts that are original, authentic, creative or innovative, imaginary and scientific (Smyrnaiou et al., 2020). The ability to analyze, relate, and synthesize various concepts to solve a problem is also included in creative thinking skills (Liline et al., 2024; Sugandi et al., 2021).

Creative thinking skills have four indicators in their application. First, fluency: This first indicator focuses on the correctness or fluency of students in answering questions and the ability of students to provide ideas for solving problems. Second, diversity: This indicator refers to the diversity in applying new ways or ideas to solve a problem or the ability of students to think flexibly. Third, new ways (originality), this indicator refers to new ways that emerge from one's own unique or unusual thoughts in solving a problem. Fourth, elaboration: this indicator refers to enriching an idea or product (Ernawati et al., 2023; Torrance, 1974; Zakiah et al., 2020). In essence, all humans have creative talents, but to foster creative thinking skills, stimulation or supporting power is needed to support these creative thinking skills. This is according to research by Gunawan et al., (2018), which states that improving creative thinking skills is a major challenge for every educational institution because educators must be able to stimulate students' creativity.

The reality in the field is that students' creative thinking skills are still lacking. Based on research conducted by Wijayanti et al., (2023), prospective teacher students in the PGSD (Elementary School Teacher Education) study program are still categorized as low in creative thinking skills, especially in the originality indicator, namely the lack of students in generating new ideas or concepts. This was also shown in a survey conducted by PISA (Program for International Student Assessment) in 2015, which proved that Indonesia was in the 63rd position out of 72 countries in the fields of science and mathematics (Mu'minah & Aripin, 2019). Then, equivalent to the results of a survey conducted by The Global Creativity Index in 2015 showed that Indonesia was in 115th position out of 139 countries (Dewi et al., 2017). Furthermore, in the same year, namely 2015, the results of the TIMSS (Trends in International Mathematics and Science Study) research, Indonesia was ranked 69th out of 76 countries (Khoiriyah et al., 2018).

Based on the results of research conducted by Zega (2022), namely the results of the CPMK (course learning achievement) completion test on biotechnology course material with biotechnology course achievement indicators including (1) outline, overview and learning content; (2) conventional biotechnology; (3) selective breeding; (4) antibiotic production; (5) fermentation; (6) bioprocess; (7) bioproduct; (8) modern biotechnology concepts; (9) cloning; (10) gene therapy techniques; (11) genetic engineering; (12) bioethics, so that the results obtained are that students still have difficulty understanding the material so that the learning objectives of the biotechnology course have not met the expected achievement standards. This is due to many factors, one of which is the absence or inappropriate use of learning media in the learning process. So, it requires the development of learning media that are specifically designed to improve 21st-century skills.

Web-based modules, or what are known as e-modules, can be an option to support learning activities. The content of e-modules can be designed to be more varied, not only in the form of writing but can including graphics, images, or videos, and independent practice tests (Moore, 2019). This will certainly make the learning process more interesting, fun, and practical. Based on the results of research conducted by Wahyuliani et al., (2022), the e-module products that have been developed can improve creative thinking skills. According to Pada et al., (2021), the use of e-module media must vary and must be adjusted to the material to be delivered, so educators and e-module developers must be very careful in designing instruction (Yang et al., 2023).

The material that will be used in the development of this e-module is biotechnology material. According to Dawson (Handoko et al., 2016), there are factors that limit the teaching of biotechnology, namely: lack of educator content in the field of biotechnology, lack of experience and suitability of the learning process, lack of learning resources, and lack of learning time. Based on the results of interviews with lecturers in charge of biotechnology courses in the Biology Education Study Program at Sebelas Maret University, most of the learning has been done using technology systems such as online attendance, online assessments, and e-learning. However, the use of e-learning has not been running as a whole due to the lack of materials in e-learning, so educators only use previous materials that have been used without updating and adjusting to the characteristics of students. One of them is the biotechnology course.

Then in the biotechnology material, there has been no update of electronic-based learning media that contains creative learning that can improve students' thinking skills, besides that biotechnology material seems boring because the material is complex and the study is quite broad starting from discussing microorganisms, cells and tissues that produce various products needed by humans. This is what was stated by Iza & Fitriani (2022), stating that learning related to biotechnology is quite complex because the discussion is about the division of biotechnology, both in terms of conventional and modern biotechnology in life. Therefore, an e-module based on Google Sites was developed to help convey the material and make it simpler and easier to understand.

Several relevant studies have been conducted on the development of Google Sites-based e-modules. Tompe et al., (2017) research on the development of local potential-based biotechnology modules for junior high school students has proven to be effective and practical in improving learning outcomes. The effectiveness of Google Sites-based e-modules has also been studied by Lativa et al., (2024), who studied their impact on creative thinking skills in biology subjects on the topic of plant diversity and obtained the expected results, namely improving creative thinking skills. In addition, several studies on Google Sites-assisted e-modules were also tested to influence motivation, interest, learning outcomes, reasoning abilities, and digital literacy abilities, and the results were proven to improve (Efendi & Insani, 2024; Ernest & Putra, 2023; Ghozali et al., 2024; Nugroho et al., 2024).

The novelty in this study lies in its use for complex materials such as those used in biotechnology. Although some developed biotechnology material modules, they were still conventional, not electronic or digital. When referring to the novelty of article topics that need to be developed in the Journal of Educational Technology Innovation related to skills, researchers only found one article on the development of an e-module to improve critical thinking skills in chemical law subjects (Leny et al., 2024). While this study examines creative thinking skills, of course, this is a new article that can increase the literacy of readers of the Journal of Educational Technology Innovation.

This study aims to develop and implement Google Sites-based e-modules to improve students' creative thinking skills. This study enriches the study of digital learning innovation by adding a new perspective on the use of Google Sites as an e-module platform that supports creative thinking skills. The use of Google Sites as an e-module offers a practical and easily accessible solution for digital-based learning so that it can be adopted in various educational contexts. The results of this study can be a reference for educators in developing more interactive and flexible digital teaching materials to improve students' creative thinking skills.

METHOD

This development research uses qualitative and quantitative research methods. Qualitative research is used in analyzing the needs of e-module products to obtain the e-module product format and e-module product design plan. Quantitative research is used to measure the practicality and effectiveness of the product based on validation from experts. This development research procedure is carried out by the stages of the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation) by Branch (Weldami & Yogica, 2023).
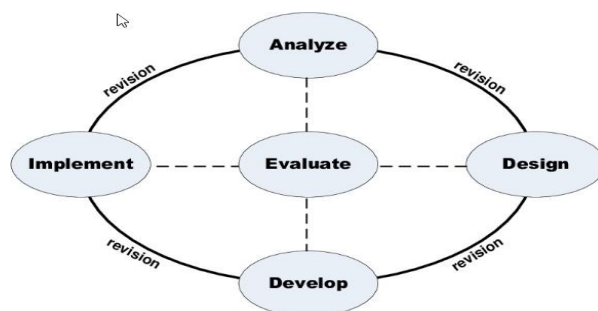
Figure 1. Model ADDIE development

Procedure study this use model study ADDIE, which consists of several stages, namely analyzing, designing, developing, implementing, and evaluating. The ADDIE research model is a systematic product development model that shows the basic details of development in educational products. Which is customized with technology, needs participant education, and content (Weldami & Yogica, 2023).

Activities carried out during the analysis process include identifying gaps or problems that occur. Design activities provide products that can be content/material. The development stage includes producing content or products, selecting or developing products, and conducting small/limited-scale tests or trials with 20 people and large-scale trials with a sample of 95 semester 3 students of the Biology Education Study Program, Sebelas Maret University. The implementation stage includes preparing lecturers and students and measuring the level of practicality and effectiveness. The last evaluation stage is revising the implementation results and determining the success of product development.

The analysis process uses descriptive analysis, analysis prerequisites, effectiveness tests, and practicality tests. Results from test validation are an analysis description of quantitative data, which begins with the conversion of quantitative data to a percentage form. The way to calculate it is by using the following Formula 1.

$$P = \frac{\sum xi}{\sum x} \times 100\% \qquad (1)$$

Information:
P   = Presentation mark
$\sum xi$ = Amount of value answer from tester
$\sum x$ = Amount mark answer highest

The results of the percentage calculation of all components, then a descriptive analysis was carried out to determine the decision to revise or not to revise, can be seen in Table 1 as follows.

Table 1. Descriptive Analysis

No.	Level of Achievement	Qualification	Information
1	81- 100	Very Good	No need for Revision
2	61- 80	Good	No need for Revision
3	41- 60	Enough	Revision
4	21- 40	Not Enough Good	Revision
5	0- 20	Very Good	Revision

(Irwan et al., 2018; Suwastono, 2011)

In large-scale trials, calculations were carried out through pretests and posttests to determine effectiveness. Data obtained from before and after learning using e-modules and learning without the use of e-modules in class are negative behavioral data and student learning outcomes reflected by pretest and posttest scores. After the experiment is conducted, the data obtained from the test results will be analyzed using a prerequisite test, namely, by using a normality test namely, the Kolmogorov-Smirnov test. In the Kolmogorov-Smirnov test, if the significance is below 0.05, it means there is a significant difference, and if the significance is above 0.05, there is no significant difference.

RESULTS AND DISCUSSION

Results

This development research produces a product in the form of a Biotechnology E-Module using Google Sites. The development of the Biotechnology E-Module using Google Sites is self-instructive with the hope that students can learn independently, and there is hyperlink access for each word that contains terms, words that are difficult to understand/unfamiliar, and words that require explanation. The purpose of this development research is to determine the feasibility, effectiveness, and practicality of the Biotechnology E-Module product using Google Sites. The variables to be achieved in this study are to improve students' creative thinking skills. The use of Google Sites makes it easy for students to learn anywhere and anytime, and various components in it make this product an interactive learning medium. Google Sites is in the form of a web, so that in its use, there is no need to download and can be accessed via laptop/computer and smartphone.

Analysis

The results of the initial analysis and observations in the field showed problems or gaps, including the absence of updates to electronic-based learning media that include creative learning, especially in biotechnology material, and biotechnology material seems boring because the material is complex and the studies are quite broad, resulting in low empowerment of students' creative thinking skills.

Design

The design of the biotechnology E-Module product using Google Sites is adjusted to the developer's objectives based on the analysis that has been carried out, namely to provide products that can provide biotechnology materials so that students' creative thinking skills increase. This design is made in the form of instructions for use, learning objectives, materials, student activities, videos, games, and bibliographies.

Development

The development stage is carried out to produce and validate the product. Activities carried out at the development stage include completing the media content and validating the media and content experts. Validation of media and content is selected based on expertise and experience in designing, creating, and developing technology-based learning software, and experts in biotechnology material, to determine the feasibility of the product. Furthermore, a small-scale product trial is carried out to determine the feasibility of the product. Then, the last procedure, a large-scale group test, is used to assess the effectiveness and practicality of the product on a wider scale.

The design of the Biotechnology E-Module prototype using Google Sites begins with the design of the E-Module storyboard. Then, it is continued with the design of the systematic presentation of the material and the learning objectives to be achieved during learning activities on biotechnology material. Here are some displays of the components in the Biotechnology E-Module.

Figure 1. Opening Page	Figure 2. Menu
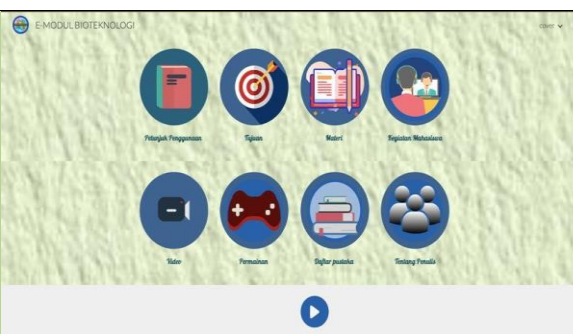
Figure 3. Material	Figure 4. Student Activities

The feasibility or validity of the media on the Biotechnology E-Module product using Google Sites was obtained through quantitative data conducted by a media expert lecturer, namely, Mr. Bowo Sugiharto, S.Pd, M.Pd, from the Biology Education Department of Sebelas Maret University by filling out a questionnaire. The following is a description and analysis of validity data based on the assessment indicators, which can be displayed in Table 2 below.

Table 2. Results Validation Expert Media

No.	Aspect	Indicator	$\sum xi$	$\sum x$
1	Screen Design View	Composition Color Writing to Color Background behind Already Appropriate and Readable with Clear	4	4
		Proportional order Location (Layout) (Text in the Picture) Page beginning Already Appropriate	3	4
		Proportional order Location (Layout) of every part in the E-module is Already Appropriate.	3	4
		Synchronization or Linkage between Illustrations, Graphics, Visuals, and Verbal Content	4	4
		Own Power Pull on Design E-module, which Displayed (Color, Images/Illustrations, and Letters)	3	4
2	Ease of Use	E-module served in a Coherent way according to the parts	4	4
		E-module is easy to Operate with a Laptop/PC/HP	4	4
		Content in the E-module is easily Accessed	3	4
		Operational buttons Work Properly	4	4
3	Consistency	The Words, Terms, and Sentences in the Learning Materials are Consistent	4	4
		The Shape and Letters are Consistent	3	4
		The Layout of the Display is Consistent	3	4
4	Graphics	Use the Color on the E-module Already Appropriate and no Excessive	4	4
		The Font Size used is easy to Read and Clear	3	4
		Type Letters which used easy to Read Clearly	4	4
		Illustration/Picture used on E-module is Clear (no Blurry/Broken)	3	4
		The Video that is on the E-module can run Smoothly and can be seen Clearly	4	4
		The Narration Video can be Heard as well as Understood	4	4
		Background Noise is not Disturbing to Learners	3	4
5	Benefits	The Steps in the E-module make it easier for Students to Learn Independently.	3	4
		Educators/Students can Interact using E-modules easily	4	4
		Improve Creative Thinking Skills	2	4
Amount			**76**	**88**
Percentage Value			**86.36%**	

Based on the validation conducted by media experts on the development of the Biotechnology E-Module product using Google Sites, a feasibility score of 76 was obtained from the maximum expected score of 88. In this regard, the Biotechnology E-Module product using Google Sites was assessed as very good by media experts, with a value obtained of 86.36% very worthy of continuing to the next stage.

The validity of the material in the Biotechnology E-Module product using Google Sites was obtained quantitatively by a material expert lecturer, namely Ir. Yudi Rinanto, M.P., from the Biology Education Department, Sebelas Maret University, used a questionnaire. The following is a description and analysis of the validity data of the material based on the assessment indicators shown in Table 3 below.

Table 3. Results Validation Expert Material

No.	Aspect	Indicator	$\sum xi$	$\sum x$
1	Content	Truth Draft Material Reviewed from Scientific Aspects	4	4
		Material in E-module is easy to Understand	4	4
		Clarity Topic Learning	4	4
		Completion of Material	3	4
		Suitability of the Level of Difficulty and Abstractness of the Concepts of Semester 3 Students	3	4
		The Relationship between Material Examples and Conditions in the Surrounding Environment	4	4
		Accuracy of Materials and Examples to Improve Creative Thinking Skills	4	4
		Suitability of Image/Video Illustrations to the Material Presented	3	4
2	Linguistics	All Information in the E-module is Readable	4	4
		Clarity of Information Delivery in E-modules	4	4
		Conformity of Sentences with Correct Indonesian Language Rules	3	4
		Use of Language that does not give Rise to Multiple Interpretations	3	4
		The Language does not Contain SARA, Pornography, or Biased meanings and Terms in Local/Regional Languages.	4	4
3	Presentation	Clarity of E-module Objectives	4	4
		The Overall Sequence of Material Descriptions in the E-module	4	4
		The Contents of the E-module are Interesting, so they can Motivate Students to Learn.	4	4
		Completeness of Information in the E-module (Summary of Material, Worksheets, Practice Questions)	4	4
		Student Learning Interactivity using E-modules	4	4
		Suitability of Image and Video Illustrations in E-modules	4	4
Amount			**75**	**80**
Percentage Value			**93.75%**	

Based on the validation conducted by material experts on the development of the Biotechnology E-Module product using Google Sites, it obtained a score of 75 out of the maximum expected score of 80. In this regard, the Biotechnology E-Module product using Google Sites was assessed as very good by material experts, with a value obtained of 93.75%, very worthy to continue to the next stage, namely, small group trials.

Before conducting trials on a large-scale group, a trial was first conducted on a small-scale group. This small group trial involved students of the Biology Education Study Program, semester 3, Sebelas Maret University, to measure the validity of the Biotechnology E-Module product using Google Sites, with a sample size of 20 students. The following is a description and analysis of the small group trial shown in Table 4 below.

Table 4. Results Small Group Trial

No.	Aspect	$\sum xi$	$\sum x$
1	Affective	70	80
2	Affective	66	80
3	Affective	65	80
4	Interactive	65	80

No.	Aspect	$\sum xi$	$\sum x$
5	Interactive	72	80
6	Efficient	69	80
7	Efficient	62	80
8	Creative	63	80
9	Creative	58	80
Amount		590/20	720/20
		29.5	36
Percentage Value			81.49

Based on the results of small group trials using samples from 3rd semester students of the Biology Education Study Program, they obtained a score of 29.5 out of the maximum score of 36. Therefore, it can be concluded that the Biotechnology E-Module product using Google Sites is considered very good, with a score of 81.94% very worthy to continue to the large group product test stage.

The product testing stage was carried out in large groups, or more precisely, by 3rd-semester students of the Biology Education Study Program with a sample size of 95 students. This stage was carried out to determine the effectiveness and practicality of the Biotechnology E-Module product using Google Sites. In addition, to find out whether the use of the Biotechnology E-Module using Google Sites can improve students' creative thinking skills or not. Meanwhile, data collection was carried out quantitatively with a test sheet. Data was seen from the results of the pretest and posttest scores, before and after using the Biotechnology E-Module product using Google Sites. The following is a description of the processing of data on the effectiveness and practicality of using the Biotechnology E-Module product using Google Sites to improve students' creative thinking skills.

Implementation

The product of the development is in the form of a Biotechnology E-Module using Google Sites, and then implemented for users. The researcher first prepares and explains the usage guide to the lecturer. This will help the lecturer in optimizing the use of the Biotechnology E-Module using Google Sites for students in the classroom. This stage is fully supervised from the learning preparation process to the implementation, to see the results of the use of the Biotechnology E-Module on a wider scale. Thus, it will provide implementation experience by lecturers with actual conditions. After implementation, the researcher will determine the level of practicality of the product based on the questionnaire distributed.

The measurement of effectiveness in testing the Biotechnology E-Module product using Google Sites is measured using a test sheet to determine students' creative thinking skills. The processing of this effectiveness data uses a prerequisite test first, namely the normality test using the Kolmogorov-Smirnov test. The following is a description and analysis of the normality test as a prerequisite test assisted by the SPSS application, which can be seen in Table 5 below.

Table 5. Results Normality Test

	Kolmogorov-Smirnov			Shapiro Wilk		
	Statistics	df	Sig.	Statistics	df	Sig.
Creative Thinking Pretest	.139	95	.000	.977	95	.087
Creative Thinking Posttest	.100	95	.020	.969	95	.022

Based on the results of the normality test above in the Kolmogorov-Smirnov table, the pretest and posttest significance values were 0.000 and 0.020, respectively, and the value obtained was less than 0.05. Thus, it can be said that the data is not normally distributed, so the prerequisite test is not met. Further processing can use a non-parametric test in the form of the Wilcoxon test. Meanwhile, the description and analysis of the results of data processing using a non-parametric test in the form of the Wilcoxon test can be seen in Table 6 below.

Table 6. Results Wilcoxon Test

Z	-8.254 [b]
Asymp. Sig. (2-tailed)	0.000

The significance value of the Wilcoxon test for the creative thinking variable obtained a value of 0.000, which is smaller than 0.05, so it can be concluded that Ha is accepted and H0 is rejected. Thus, it can be seen that there is a difference between the pretest and posttest results of the creative thinking skills of students in the Biology Education Study Program before and after using the Biotechnology E-Module. Based on the interpretation and explanation, it can be concluded that the Biotechnology E-Module product using Google Sites is effective in improving the creative thinking skills of students in the Biology Education Study Program.

Practicality data collection was carried out after the lecturer implemented the Biotechnology E-Module product using Google Sites to 95 students in the Biology Education Study Program. The practicality of the Biotechnology E-Module product using Google Sites was quantitatively. The following is a description and analysis of practicality data, which can be seen in Table 7 below.

Table 7. Results Practicality of Biotechnology E-Module

No.	Aspect	Indicator	$\sum xi$	$\sum x$
1	Effective	E-module can be used to Explain the Material	358	392
		The Test Contained in the Biotechnology E-module can be used to help Process Evaluation	327	392
		Overall Information on the E-module is Readable	349	392
2	Interactive	All knob on E-module can be used well	346	392
		All say which in Green can Already bring up Clarity	358	392
3	Efficient	E-modules can be used Anywhere and Anytime	357	392
		The Biotechnology E-module is easily Accessible via Smartphone or Laptop	363	392
4.	Creative	Presentation Task in the Form of a Leaflet to Interest Students in Finishing	326	392
		Presentation of the Quiz in the Form of Games Interests Students in doing it.	327	392
Amount			**3111**	**3528**
Percentage Value			**88.18%**	

Based on the results of the description and analysis of data on the practicality of the Biotechnology E-Module product using Google Sites, it obtained a practicality score of 3111 from a maximum score of 3528. Thus, it can be said that the Biotechnology E-Module product, using Google Sites to improve students' creative thinking skills, is considered very practical, with a practical value percentage of 88.18%. Users consider this product practical because it can be used anywhere and anytime, is easily accessible via smartphone/laptop, and there is a very interesting game-shaped quiz.

Evaluation

Based on the results of expert validation, small and large-scale trials, and effectiveness and practicality tests concluded that the development of Google Site-based e-module products on biotechnology material was declared successful without any revision. So it can be disseminated to be used in teaching and learning activities.

Discussion

The Biotechnology E-Module using Google Sites is said to be valid because it is a user-friendly platform for lecturers and students. So it can be easily used for educational purposes. There are collaborative features offered on the Google Sites platform in real time to facilitate effective learning (Jeyarajaguru, 2023). In addition, the Google Sites platform supports integration with various other Google tools, such as Google Forms, as a pretest, posttest, and assignment page activity that facilitates assignment collection. In addition, the Google Sites platform also facilitates text, images, videos, and links to become dynamic and interactive containers to support involvement in the teaching and learning process (Ramasundrum & Sathasivam, 2022; Songkhro et al., 2022). The Google Sites platform is very suitable/valid to be used as an educational learning medium for learning activities (Arova et al., 2024; Hardianti & Alyani, 2023; Lestari et al., 2024; Valfa et al., 2023).

The implementation of Biotechnology E-Modules using Google Sites is also quite good for improving students' creative thinking skills. This is indicated by a significant increase in pre-test and

post-test scores. In line with research conducted by Lativa et al., (2024), the implementation of E-Modules assisted by Google Sites can improve students' creative thinking skills because it helps lecturers in delivering the material being studied. Digital e-modules based on the Google Sites platform are expected to help students explain abstract concepts, increase absorption, and provide direct experience in learning so that they can improve students' mastery of concepts and creative thinking (Nasir et al., 2024; Ratnawati et al., 2023). Creative thinking skills are also related to novelty, the ability to create something, be creative in applying new forms, create imaginative skills, or innovate to add something that already exists into something more useful and valuable (Gcabashe, 2024; Hidayati et al., 2024; Nasution et al., 2023; Taş & Minaz, 2024). Thus, by improving creative thinking skills, it is hoped that students can come up with ideas, insights, perspective approaches, and new ways of understanding things.

The practicality of the Biotechnology E-Module using Google Sites is also quite good because it has a unique and attractive appearance. In addition, it makes it easier to understand the content and saves costs because it does not need to be printed and is easy to access via smartphones, laptops, and computers. Therefore, the Biotechnology E-Module using Google Sites is an alternative to improve creative thinking skills and student learning outcomes. Research conducted by Valfa et al., (2023) stated that the development of E-Modules based on Google Sites makes it easier for students to study material independently via cellphones, tablets, computers, or laptops and can solve problems concretely to train students' creative thinking skills. Then, research conducted by Lativa et al., (2024) found that the use of E-Modules based on Google Sites is very practical for educators and students to use in carrying out learning activities. E-Modules based on Google Sites can trigger, strengthen, and build students' interest in learning independently; the learning process is more effective and efficient and creates a more interactive learning environment (Nugroho et al., 2024; Yusha & Risnani, 2023). Thus, it can be said that using Google Sites-based E-Modules offers independent, interactive, and effective learning to improve students' creative thinking skills and facilitate the learning process in class.

CONCLUSION

The Biotechnology E-Module product, using Google Sites, is very valid/feasible, effective, and practical to improve critical thinking skills. This is because utilizing digital media and one of the 21st-century skills produces learning innovations that enable students to learn independently anywhere, anytime, generate ideas in solving problems, gain insight, perspective approaches, and new ways of understanding various things. Thus, it can be said that the implementation of the Biotechnology E-Module using Google Sites can provide a positive increase in creative thinking skills. Suggestions that can be used as input based on the results of the research that has been carried out for improvements in further research include researching Google Sites-based E-Modules with neurobiology material and critical thinking skills variables to be able to determine the validity, effectiveness, and practicality of the use of Google Sites-based E-Modules widely.

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Digitalization of learning media: A comparative study on metacognitive ability, learning interest, and activeness in Islamic High School 2 Banyumas Excellent Class

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ABSTRACT

The growing use of digital learning media calls for a deeper investigation into its effects on students' psychological aspects, particularly metacognitive ability, learning interest, and activeness. It aims to compare students' metacognitive ability, learning interest, and activeness before and after implementing digital learning media. This study focuses on 80 10th-grade students in the Excellent Class at Islamic High School (MAN) 2 Banyumas during the 2023/2024 academic year. Using a descriptive comparative quantitative approach with a survey method, data were collected through non-probability sampling with a saturation (census) technique. The results show significant differences in all three aspects after the implementation. Specifically, students' metacognitive ability improved by 19%, learning interest by 37%, and learning activeness by 31%. These findings confirm that digital learning media have a positive impact on students' learning experiences. It enhances their ability to monitor their learning, increases their engagement, and encourages more active class participation. The results highlight the value of digital tools in supporting modern education. However, further research is needed to identify specific causal factors contributing to these improvements, such as interface usability and the integration of interactive learning features. Additionally, long-term studies are recommended to examine the sustainability of these benefits over time and how digital media can be continually optimized to support student development.

INTRODUCTION

The technological development in Indonesia has undergone a rapid acceleration, particularly in the context of its digital transformation (Suryawijaya, 2023). Indonesia's performance in the Global Innovation Index (GII) serves as an indicator of the nation's progress in innovation, having exhibited consistent upward movement in its global ranking over the past three years (WIPO, 2023). Maharani & Meynawati (2023) assert that such swift technological advancement possesses the capacity to restructure societal frameworks and exerts profound effects across various domains,

namely the economic, socio-cultural, and educational sectors. The spread of COVID-19 further expedited this technological progression, positioning digital technologies as pivotal instruments in mitigating the challenges imposed by the pandemic (Akbar, 2023). Among the sectors profoundly impacted by COVID-19 was the educational field (Darmawan & Atmojo, 2020). A meta-analysis of studies conducted between 2000 and 2020 indicates that approximately 41% of them demonstrated a positive contribution of online learning to students' academic outcomes, although such findings diverge from earlier research that reported no statistically significant influence on academic achievement (Steven et al., 2021). The digitalization of education has thereby emerged as an unavoidable global phenomenon, deemed essential for maintaining instructional efficacy, efficiency, and relevance to contemporary demands (Hakim & Aziz, 2021). It follows that the realization of digital transformation in education necessitates not only adequate infrastructure and technological solutions but also the deployment of appropriate platforms and tools to support pedagogical delivery (Putri et al., 2021).

The School Digitalization Program initiated by the Ministry of Education, Culture, Research, and Technology through the use of information and communication technology has the hope of facilitating the teaching and learning process, making it easier for teachers and students to access teaching materials and exams, and making it easier for teachers to collaborate in creating daily test materials both offline and online (Firmansyah et al., 2023). Based on the existing phenomenon and supported by the School Digitalization Program, Islamic High School (MAN) 2 Banyumas took real steps by initiating the first digital class or excellent class in Banyumas Regency since the 2022/2023 academic year. The purpose of Islamic High School 2 Banyumas in providing this class is to familiarize students with digital-based learning so that students are more interested in learning. This statement is in line with research by Iskandar et al., (2022), which states that the digitalization of learning media will make students more enthusiastic in participating in ongoing learning, and can increase students' curiosity so that students are more creative and critical. Based on initial observation data, it was found that there were differences in students' attitudes towards digitalization between the leading class XI (Mathematics and Natural Sciences 1 and Social Science 1) and the leading class X (Research and Science). It was found that 71% of 10th-grade students in the Excellent Class reported feeling unfamiliar with the implementation of digital learning media facilitated by the school. In contrast, 81% of 11th-grade students in the same program stated that they were already familiar with such digitalization. This unfamiliarity among 10th-grade students may be attributed to several factors. As new students enrolled in the Excellent Class (Research and Science tracks), many had no prior experience with the program. Additionally, teachers often did not utilize the available digital facilities; their previous classrooms lacked adequate infrastructure, and the learning media previously employed were primarily conventional. These findings are consistent with the research by Diana & Rofiki (2020), which suggests that students' low receptiveness to technology in the learning process is influenced by several factors, including teachers' lack of technological competence, insufficient tools and infrastructure, and learning processes that are not aligned with technological developments.

According to Sarie et al., (2023), one of the reasons why students' psychological aspects, which determine the success of the learning process, are not well-implemented is the continued use of conventional teaching methods without being accompanied by proper development in the digitalization of learning media. This is supported by research from Jariyah & Ummah (2022), which states that the rapid development of the digital era must be balanced with students' abilities that enable them to develop their ways of facing various challenges. Isma et al., (2022), explain that when schools implement digitalization of learning media, the effort aims to help students learn through technology so they become familiar with it, meet the increasing demand for knowledge, improve the quality of learning, and equip students with critical, creative, communicative, and collaborative skills. In terms of definition, metacognitive ability, according to Lestari et al., (2019), is students' awareness in understanding how they learn, being able to evaluate the problems they face, identify their level of self-understanding, utilize various resources, and assess their learning progress.

Perdana et al., (2022) state that the learning process utilizing digital media can lead to improvements in students' metacognitive abilities, enabling them to manage and respond effectively to the digitalization facilitated by schools. In addition to enhancing metacognitive skills, one of the

goals of Islamic High School 2 Banyumas in providing excellent classes is to increase students' interest in learning. Hemayanti et al., (2020) argue that the learning process is also influenced by other psychological aspects of students, such as motivation, interest, activeness, talent, and intelligence, so the digitalization of learning media facilitated by the school contributes significantly to the success of the learning process. According to Kamaruddin (2022), one way to attract students' interest in classroom learning is to provide a variety of learning models, particularly interactive digital-based learning, which has been proven to have a positive impact on students. Students who have a strong interest in learning will tend to show greater activity in learning, which contributes to a more effective learning process (Farisi et al., 2023). Prasetyo & Abduh (2021) define learning activity as students' efforts to develop their potential through learning activities. Based on research by Reinita & Putri (2024), digital-based learning media such as digital modules are highly effective in the learning process and have great potential to help teachers facilitate students' understanding of the material while also increasing their participation, motivation, and activeness.

This study aims to analyze the differences in metacognitive ability, learning interest, and learning activeness of students in the Excellent Class of Research and Science (Grade X) at Islamic High School 2 Banyumas by comparing their conditions before and after being exposed to the digitalization of learning media implemented by the school. The literature indicates that although the adoption of educational technology is increasingly widespread, comparative studies that explore changes in these psychological aspects among the same students, specifically in the context of transitioning to a digitized excellent classroom environment using non-intervention survey data, remain very limited. Existing research generally focuses on experimental approaches with artificial treatments or momentary descriptive surveys. Therefore, this study is highly relevant and impactful, providing concrete empirical evidence as a foundation for the development of technology-based educational policies, a driver of innovation in learning media design, and a catalyst to raise stakeholders' awareness of the critical importance of digitalization for holistic learning quality. Direct comparative survey data from students also offers valuable insights for designing responsive learning environments in the digital era.

METHOD

This research is a descriptive comparative study using a quantitative approach. According to Paramita et al., (2021), descriptive research can provide an empirical overview or description of the data collected in a study. Meanwhile, Sugiyono (2019) explains that comparative research aims to compare the values of one or more independent variables across two or more populations, samples, or different or combined periods. The approach used in this study is a quantitative approach, which is based on numerical or statistical data (Suliyanto, 2018).

The population of this study consists of 80 students from the Grade X Excellent Class of Research and Science. The sampling technique used is total sampling (census). The characteristics of the respondents based on gender can be seen in the following Table 1.

Table 1. Respondent Characteristics Based on Gender

No.	Gender	Students Total	Percentage (%)
1	Male	19	23.75
2	Female	61	76.25
Total		**80**	**100**

Source: Primary data, processed in 2024

The table above shows that the research respondents were predominantly female, totaling 61 students or 76.25%, while the remaining 23.75% or 19 students were male. Suliyanto (2018) states that saturated sampling is used when the entire population is selected as the sample due to the relatively small population size (200 or fewer). Based on the total population in this study, the sample was determined using a non-probability sampling technique, consisting of 80 students.

Data collection was carried out using a closed-ended questionnaire with a Likert scale. The questionnaire data were then transformed into interval data using the Method of Successive Intervals (MSI) with the help of Microsoft Excel, in addition to interviews and documentation. All research

data were analyzed using SPSS version 26 for Windows. The Likert scale used in this study ranged from 1 to 4, deliberately omitting the neutral midpoint.

Data collection was conducted using two sets of questionnaires distributed in a single session. These questionnaires were designed to compare students' experiences before entering the excellent class with their conditions afterward, particularly about their exposure to the digitalization of learning media implemented by the school. The questionnaire instrument specifically measured three main variables: metacognitive ability, learning interest, and learning activeness. The research indicators can be seen in the following Table 2.

Table 2. Research Indicator

No.	Variables	Indicators
1	Metacognitive Ability	1. Students are aware of their thinking processes and can describe them; 2. Students can develop recognition of thinking strategies; 3. Students can reflect on procedures evaluatively; 4. Students can transfer knowledge and experiences to other contexts; 5. Students can connect conceptual understanding with procedural experiences. (Iskandar, 2014)
2	Learning Interest	1. A sense of enjoyment in learning activities; 2. Focus and concentration on learning; 3. Willingness to learn; 4. Intrinsic motivation to actively participate in learning; 5. Efforts made to realize the desire to learn. (Friantini & Winata, 2019)
3	Learning Activeness	1. Students pay attention to the teacher's explanation; 2. Students ask questions; 3. Students respond to questions; 4. Students engage in group discussions; 5. Students take notes summarizing lesson materials; 6. Students express ideas or thoughts; 7. Students present group work results. (Prasetyo & Abduh, 2021)

The data collection procedure involved asking students to reflect on and review their conditions before becoming students in the Grade X Excellent Class and then to review their conditions after being in the digitally integrated Excellent Class. This study is purely observational, focusing on students' perceived differences as a natural response to their new learning environment and their adaptation to the implementation of digitalized learning media. The data from both sets of questionnaire reflections were then compared to identify differences across the three variables.

The collected data were tested for validity using Pearson's product-moment correlation analysis. The criteria for determining validity are as follows: if the calculated correlation coefficient rcalculated ≥ rtabel, the data are considered valid; and if rcalculated < rtabel, the data are considered invalid.

Furthermore, a reliability test was conducted to assess the stability and consistency of respondents in answering the research questions (Sujarweni, 2021). The reliability test employed Cronbach's Alpha analysis, with the following criteria: if the Cronbach's Alpha value is ≥ 0.60, the data are considered reliable; if the Cronbach's Alpha value is < 0.60, the data are considered unreliable. The validity and reliability tests were conducted on a group of 33 students from the Grade XI Excellent Class in the Science Program (MIPA), who were not part of the research sample.

After the data were deemed valid and reliable, the next step of analysis involved conducting a normality test on the research data from the sample. The reason the researcher used only a normality test is that the analysis in this study requires only the assessment of the data distribution. According to Setiawan & Yosep (2020), a normality test is used to determine whether the sample data come from a population that is normally distributed. This was tested using the Kolmogorov–Smirnov method, with the following criteria: if the p-value or Sig. > 0.05, the sample data are considered normally distributed; if the p-value or Sig. ≤ 0.05, the sample data are not normally distributed.

To analyze whether there are differences before and after the implementation of digitalization of learning media in the Grade X Excellent Class, the researcher employed a difference test (comparative test) to conclude. A difference test is a comparative or statistical analysis technique used to identify differences between two or more data groups (samples), whether the groups are related or independent (Wulansari, 2023). This study used a paired sample difference test, with the assumption that the data may be normally or non-normally distributed. If the data are normally distributed, the analysis is conducted using the paired t-test; if the data are not normally distributed, the Wilcoxon signed-rank test is used (Lind et., 2024).

RESULT AND DISCUSSION

Result

Validity Test

Based on the responses from 33 students in the Grade XI Excellent Class (MIPA) and a significance level (α) of 5%, the r-table value was determined to be 0.344. It was found that among the 20 items in the metacognitive ability variable, 1 item was deemed invalid; among the 20 items in the learning interest variable, 1 item was also deemed invalid; and among the 28 items in the learning activeness variable, 2 items were found to be invalid. An item was considered invalid if its r-calculated value was lower than the r-table value. Therefore, these invalid items were excluded from the main data collection process of the research.

Reliability Test

All instruments for each variable obtained a Cronbach's Alpha value ≥ 0.60. Therefore, the items in the questionnaires for the variables of metacognitive ability, learning interest, and learning activeness can be considered reliable. The reliability results are presented in the following Table 3.

Table 3. Reliability Test Result

No.	Variables	Alpha Cronbach		Reliability Standard	Notes
		Before	After		
1	Metacognitive Ability	0.884	0.806	0.60	Reliable
2	Learning Interest	0.846	0.736	0.60	Reliable
3	Learning Activeness	0.907	0.859	0.60	Reliable

Source: Primary data, processed in 2024

Normality Test

The normality test was used as a prerequisite and determinant for the selection of the appropriate analytical tool in this study. The results of the normality test, as shown in Table 4, indicate that the p-value (Sig.) is less than 0.05. Therefore, the data for all three variables are considered not normally distributed, and the analysis was carried out using the Wilcoxon signed-rank test, as presented in Table 6.

Table 4. Normality Test Result

No.	Variables	Before the Digitalization of Learning Media	After the Digitalization of Learning Media	Result
1	Metacognitive Ability	0.004	0.034	Not Normal
2	Learning Interest	0.012	0.005	Not Normal
3	Learning Activeness	0.000	0.010	Not Normal

Source: Primary data, processed in 2024

Hypothesis Test

A hypothesis test was conducted using Wilcoxon signed-rank analysis, with the formulation of the research hypotheses as follows, as shown in Table 5.

Table 5. Hypothesis Formulation

No.	Variables	Hypothesis$_a$	Hypothesis$_o$
1	Metacognitive Ability	There is a difference in the metacognitive ability of Grade X Excellent Class students at Islamic High School 2 before and after the digitalization of learning media.	There is no difference in the metacognitive ability of Grade X Excellent Class students at Islamic High School 2 Banyumas before and after the digitalization of learning media.
2	Learning Interest	There is a difference in the learning interest of Grade X Excellent Class students at Islamic High School 2 before and after the digitalization of learning media.	There is no difference in the learning interest of Grade X Excellent Class students at Islamic High School 2 Banyumas before and after the digitalization of learning media.
3	Learning Activeness	There is a difference in the learning activity of Grade X Excellent Class students at Islamic High School 2 Banyumas before and after the digitalization of learning media.	There is no difference in the learning activity of Grade X Excellent Class students at Islamic High School 2 Banyumas before and after the digitalization of learning media.

The criteria for the Wilcoxon signed-rank test are as follows: if the Asymp. Sig. (2-tailed) < 0.05, it indicates a significant difference; whereas if the Asymp. Sig. (2-tailed) ≥ 0.05, it indicates no significant difference. The Wilcoxon test is used to examine the difference between two correlated samples when the assumption of normality is not met. The results of the Wilcoxon test, as shown in Table 6, indicate that the Asymp. Sig. (2-tailed) values for all three variables are less than 0.05, which suggests that there is a significant difference in the mean values before and after the digitalization of learning media for each of the three variables

Table 6. Wilcoxon Test Result

No.	Variables	Asymp. Sig. 2 tailed	Result
1	Metacognitive Ability	0.000	There is a Difference
2	Learning Interest	0.000	There is a Difference
3	Learning Activeness	0.000	There is a Difference

Source: Primary data, processed in 2024

Discussion

Comparative Analysis of Metacognitive Ability Before and After the Digitalization of Learning Media

The results of the Wilcoxon signed-rank test indicate that there is a significant difference in the metacognitive ability of Grade X Excellent Class students (consisting of the Riset and Science Class) at Islamic High School 2 Banyumas before and after the digitalization of learning media. The mean score of respondents' answers regarding metacognitive ability was 22.20 before the implementation of digitalized learning media and 26.34 after the implementation. The difference between the two mean scores is 4.14, indicating an increase of approximately 19% in the average metacognitive ability score after digitalization. Bintang et al., (2020) found in their study that students who used digital learning media demonstrated better metacognitive ability compared to those who did not use such media during learning. Similarly, Erayani & Jampel (2022) concluded that interactive learning media can enhance or positively influence students' metacognitive abilities and learning interest. This is further supported by Perdana et al., (2022), who also stated that students reported a noticeable improvement in their metacognitive skills after using digital learning media. Based on these previous findings and the results of the present study, it can be concluded that the digitalization of learning media, as facilitated by the school for Grade X Excellent Class students,

has proven beneficial in helping students develop the ability to understand, control, and regulate their thinking processes—thereby encouraging more critical and creative learning.

Comparative Analysis of Learning Interest Before and After the Digitalization of Learning Media

The results of the Wilcoxon signed-rank test show that there is a significant difference in the learning interest of Grade X Excellent Class students (consisting of the Riset and Science Class) at Islamic High School 2 Banyumas before and after the digitalization of learning media. The average score of respondents' answers regarding learning interest was 22.70 before the implementation of digitalized learning media and 31.13 after the implementation. The difference between these mean scores is 8.43, indicating an increase of approximately 37% in the average learning interest after the integration of digitalized media in the classroom. Hafzah et al., (2020) explained that the use of digital media in learning makes the classroom environment more effective, interactive, and engaging, thereby encouraging students to develop a stronger and growing interest in learning. Khairunnisa & Aziz (2021) concluded in their study that the implementation of digital learning media tailored to specific subject needs can significantly improve students' interest in learning. Similarly, stated that students' learning interest can vary positively when digital learning media are used. Based on previous research and the findings of this study, it can be concluded that the digitalization of learning media, as facilitated by the school for the Grade X Excellent Class, has proven beneficial in creating a dynamic learning environment and providing opportunities for students to explore their interests and talents more deeply.

Comparative Analysis of Learning Activeness Before and After the Digitalization of Learning Media

The results of the Wilcoxon signed-rank test show that there is a significant difference in the learning activity of Grade X Excellent Class students (consisting of the Riset and Science Class) at Islamic High School 2 Banyumas before and after the digitalization of learning media. The average score of respondents' answers related to learning activity was 31.41 before the digitalization of learning media and 41.20 after its implementation. The difference between these two means is 9.79, indicating an increase of approximately 31% in the average learning activeness score demonstrated in their study that students' learning activeness significantly improved when the learning materials were combined with digital learning media in the form of games. This integration helped create an engaging learning atmosphere and enabled effective two-way communication between teachers and students. Furthermore, Aini et al., (2022) concluded that there was a noticeable difference in the average level of learning activity before and after using digital learning media in the classroom. Similarly, Yanti et al., (2023) stated that digital learning media positively influenced classroom activeness and increased students' enthusiasm in participating in the learning process. Based on previous studies and the findings of this research, it can be concluded that the digitalization of learning media, as facilitated by the school for Grade X Excellent Class students, has provided clear benefits. It promotes a productive two-way interaction between teachers and students, fosters a more engaging and less monotonous learning environment, and stimulates students to participate actively during lessons according to their individual learning preferences.

CONCLUSION

Based on the results and discussion of the research, it can be concluded that: (1) students metacognitive ability increased by 19% after entering the excellent class and implementing the digitalization of learning media; (2) this study found a difference in students learning interest in Grade X Excellent Class at Islamic High School 2 Banyumas before and after the digitalization of learning media, amounting to 37%; (3) a difference in students learning activeness in Grade X Excellent Class at Islamic High School 2 Banyumas was also found before and after the digitalization of learning media, amounting to 31%, after students entered the excellent class and experienced the implementation of digitalized learning media.

This study implies that the digitalization of learning media implemented at Islamic High School 2 Banyumas has contributed to the improvement of metacognitive ability, learning interest,

and learning activeness of Grade X Excellent Class students in the 2023/2024 academic year. This finding indicates that the use of technology in education offers several benefits, including: (1) assisting in the development of students ability to understand, manage, and regulate their learning processes; (2) affirming that technology can stimulate students interest in learning; (3) showing that technology-based learning approaches can be a key factor in motivating students to learn with greater enthusiasm and engagement; (4) highlighting that interactivity and the diversity of resources available in digital media encourage students to be more actively involved in the learning process. As for recommendations for future research, it is suggested to identify specific triggering factors within the digitalization of learning media that most significantly contribute to the enhancement of metacognitive ability, learning interest, and activeness. Furthermore, longitudinal studies are recommended to monitor the sustainability of these impacts over the long term.

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Bridging the gap: Student perceptions of blended learning's promise and reality in higher education

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ABSTRACT

This study investigates students' perceptions of their learning experiences in a blended learning environment. It seeks to describe: 1) students' perceived learning effectiveness in blended learning, 2) key aspects of blended learning contributing to learning effectiveness, and 3) problems and constraints in blended learning. A cross-sectional survey design was employed, targeting undergraduate students from six departments and three different semester cohorts who had experienced blended learning. With a population of approximately 6.000 students, a sample of 509 students was selected using stratified random sampling to ensure proportional representation across departments and cohorts. Data were collected through a structured questionnaire and analyzed using descriptive statistics. Results indicate that while 60% of students strongly valued the flexibility to access materials anytime/anywhere, fewer than 40% reported effective self-paced learning or study planning. Interaction and collaboration were limited (25–38% agreement), and perceived impacts on motivation (27–35%) and material understanding (26–27%) were modest. Technical ability varied, with only 24% feeling highly competent in platform feature usage. Overall satisfaction was low (29%), aligning with suboptimal active engagement, interaction/collaboration, and perceived impacts. Findings suggest that blended learning implementation at this institution did not fully realize its potential for autonomy, collaboration, or enriched outcomes, highlighting the need for improved pedagogical design, user-friendly technology, and strategies to foster critical dialogue and self-regulation.

INTRODUCTION

Higher education institutions are considered pioneers in implementing blended learning, whether for individual subjects or degree/non-degree programs. A report from Straits Research (2024) highlights that 63% postsecondary institutions in the U.S. were offering blended learning programs by 2023, while around 68% of China's higher education offering blended learning programs by 2024. Arabasz & Baker (2003) identified a pattern where the percentage was higher among public institutions offering blended learning compared to private ones. The overall trend

indicates that blended learning implementation in higher education will continue to increase yearly in Western and Asian countries (Guppy et al., 2022; Tonbuloğlu & Tonbuloğlu, 2023). According to Garrison & Vaughan (2011), data on the growth trend of blended learning adoption in higher education is driven by increased awareness that blended learning can significantly enhance learning processes and outcomes.

In this context, higher education institutions need to provide learning experiences that actively engage students in acquiring quality academic and/or professional competencies (Anthony et al., 2022; Asmawi, 2005; Balakrishnan et al., 2021). Face-to-face learning, typically lecture-based, which has long dominated classroom practices, has been widely criticized as "impersonal" and ineffective for facilitating higher-order learning or more meaningful experiences, such as developing analytical critical thinking, problem-solving, and collaboration skills (Garrison & Kanuka, 2004; Garrison & Vaughan, 2011; Vo et al., 2017; Yu et al., 2025). Blending the potential of information, communication, and technology (ICT) facilities into face-to-face classrooms is believed to enrich and enhance learning processes and outcomes. Blended learning is generally understood as a teaching and learning modality combining online learning with direct face-to-face classroom instruction. Garrison & Vaughan (2011) defined blended learning as a teaching program that pedagogically integrates online learning into traditional face-to-face classrooms, where some face-to-face activities are replaced with online learning activities. Several blended learning models have emerged from implementation practices in higher education.

The first model, representing the traditional form of blended learning, is classroom teaching mediated by technological devices, typically computers and the internet (Freeman & Johanson, 2006). The second model combines face-to-face meetings and internet-based teaching, reducing face-to-face meeting durations to facilitate online learning or other online activities (Caner, 2012; Hoic-Bozic et al., 2008). According to Ocak (2011), in this model, direct face-to-face activities like lectures or instructor explanations are usually replaced with online formats (e.g., watching videos). The third model emphasizes integrating online learning into face-to-face classroom learning based on pedagogical utility. This means synchronous and asynchronous components of teaching and learning depend on pedagogical needs/goals and technological availability (Hoadley, 2009; Picciano, 2009). The fourth model views blended learning as using technology to complement face-to-face learning without reducing its duration or intensity (Mitchell & Forer, 2010). In this model, learners can choose to participate in online activities or attend face-to-face classes without reducing or eliminating either activity type. The final and widely used model is known as the flipped classroom. This blended learning model begins with online materials or activities followed by face-to-face meetings (Howitt & Pegrum, 2015).

Blended learning may sound simple, but it is also complex. At a basic level, educators see it as combining, integrating, or complementing classroom (offline) and digital online learning experiences. At a more advanced level, blended learning presents significant implementation challenges due to potentially limitless designs and applications, as well as diverse contextual implementation requirements (Garrison & Kanuka, 2004). Akyol et al., (2009) stated that blended learning is not easy to create, as a poorly designed blended learning environment can result in unsatisfactory learning experiences or unintended outcomes. Lim et al., (2019) warned that "in practice, it is complicated to implement", with issues ranging from aligning vision, infrastructure, staff capacity, and course redesign. Designing blended learning requires fundamental changes in concepts, the organization of teaching and learning dynamics, starting with diverse needs, and contextual contingencies such as discipline, developmental level, and resources (Garrison & Kanuka, 2004).

In blended learning literature, several potential advantages have been identified. With internet and technology facilitation, flexibility and accessibility are primary advantages of blended learning. Instructors have significant freedom to select and adapt materials and activities for both classroom and online settings (Howitt & Pegrum, 2015). Learners can access materials and activities anytime and or review, repeat, or move to other materials/activities at their own pace (Birbal et al., 2018; Fleck, 2012; Kaur, 2013). Blended learning fosters learner autonomy and personalization by allowing students to choose how, when, and where they engage with content. Chen (2022) found that learners

perceived blended learning as an effective way to develop their learning autonomy. Similarly, Waqqar et al., (2020) reported enhanced soft and management capabilities of health profession postgraduate students through the development of self-directed learning in a blended learning environment. Blended learning promotes autonomy and personalization in teaching and learning.

The power of the internet and technology to connect individuals strengthens cooperation or collaboration in a blended learning environment. Utilizing technology-based communication features or applications like email or social media platforms (e.g., Facebook or WhatsApp) enables close and intense online interaction among learners and between learners and teachers/lecturers. These platforms promote both synchronous and asynchronous engagement, allowing students to exchange ideas, seek feedback, and support one another across time and space. Lam (2015) reported that online collaboration through these social media networks often occurs through learner self-initiation rather than designed activities or instructor requests. Shaqour (2014) reported that blended learning facilitates interaction between male and female students through online forums, which may not occur in face-to-face settings in certain Arab contexts. Online interaction can be even more intensive with Learning Management Systems (LMS) like Moodle, as learners can communicate anytime and anywhere (Gil & García, 2011).

Digitally presented learning materials and activities promote active learner engagement. Based on the evaluation of the implementation of the "Professional and Creative Writing" course for two years, Freeman & Johanson (2006) reported that the assignments presented through blended learning effectively encourage students to make a series of writing revisions, based on improvement suggestions from both peers and editors. Generally, it is found that learners in blended learning are motivated to try new things, learn differently, learn from peers, and enthusiastically complete assignments and review supplementary materials provided by teachers/lecturers (Hoadley, 2009; Kintu & Zhu, 2016). Even when blended learning does not significantly impact learning outcomes, it creates higher cognitive engagement due to interactive technology use (Yang, 2016). In addition, according to Garrison & Kanuka (2004), blended learning facilitates the emergence of a "community of inquiry" where learners can freely and openly dialogue, debate critically, negotiate, and reach agreements, fostering reflection born from these dialogues. As stated by Hudson (2002), critical thinking is rooted in dialogue within a social context to cultivate meaningful ideas. Thus, interactive and diverse dialogue in blended learning promotes higher-order or critical thinking.

Regardless of the model applied, blended learning is considered successful if it enhances learner effectiveness. Learning effectiveness is a function of or result of effective pedagogical practices (Joy & Garcia, 2000). Therefore, technology use or integration into learning environments does not automatically improve processes or enhance learning outcomes. In principle, the expected learning effectiveness in blended learning is similar to other modalities, though potentially richer and stronger processes and outcomes are possible. Grades (cognitive outcomes) and attendance (participation) are commonly used frameworks for learning effectiveness in blended learning research (Anthony et al., 2019; Bouilheres et al., 2020; Bowyer & Chambers, 2017). However, social and emotional aspects like self-regulation, autonomy, or empathy are also crucial indicators of learning effectiveness in blended learning (Birbal et al., 2018; Broadbent & Fuller-Tyszkiewicz, 2018; Ustun et al., 2023; Vo et al., 2020). This research contribution is useful for improving the implementation of blended learning in higher education. This becomes one of the focuses of the study reported in this paper. To guide the study, the following research questions (RQ) are put forward:

RQ1: How do students perceive blended learning about their learning effectiveness?

RQ2: Which aspects of blended learning build students' learning effectiveness?

RQ3: What are the problems and constraints faced in blended learning courses?

METHOD

Research Type and Design

This research is quantitative. Following quantitative research traditions, its primary aim is to explain the opinions, attitudes, or behaviors of a sample or population towards specific phenomena, events, or social activities. To achieve this, the study uses a cross-sectional survey design (Creswell,

2008). A cross-sectional approach is used because it allows the collection of data from students across three different semesters at a single point in time, enabling efficient comparison of experiences and perceptions without the need for repeated measurement or longitudinal tracking. Data was collected simultaneously from respondents via a questionnaire to capture: student perceptions of blended learning implementation regarding learning effectiveness, aspects contributing to effectiveness, and problems/constraints in implementation.

Population and Sample

The population comprised all students from six departments in the Faculty of Education, Makassar State University. The sample, a subgroup of the target population, was selected for generalization. Given varying student numbers per department and level, stratified sampling ensured proportional representation of each department. The target sample size was 600 respondents (10% of active students).

Data Collection

Data was collected via a 32-item questionnaire divided into seven dimensions, such as personal data, blended learning experience, ability to perform blended learning activities, and satisfaction with blended learning. A Likert scale measured responses (Strongly Disagree to Strongly Agree, Highly Incompetent to Highly Competent, and Very Dissatisfied to Very Satisfied). The questionnaire was distributed online via Google Forms. The survey-item specification is shown in Table 1.

Table 1. Survey-Item Specification

No.	Dimensions	Indicators/Measures	Item No.	Total
1	Respondent Data	Department, semester, gender	1, 2, 3	3
2	Flexibility & Accessibility	Freedom to study anytime, anywhere	4, 6	2
		Freedom to study at own pace and understanding level	5,7	2
3	Interaction & Collaboration	Intensity of interaction/dialogue with peers and/or lecturers	8, 9, 15, 16, 17	5
4	Active Engagement	Blended activities encourage active class participation & task completion	10, 11, 12	3
5	Impact of Blended Learning	Motivation and learning facilitation	13, 14, 19	3
		Understanding course material	18, 20	2
6	Ability to Perform Blended Activities	Using features to access, communicate, and complete tasks	21, 22, 23, 24	4
7	Learning Experience Satisfaction	Adequacy, suitability, and variety of materials/activities/assignments	25, 26, 29	3
		Clarity of instructions and activities	27, 28	2
		Instructor's activeness and teaching quality (including feedback)	30, 31	2
		Overall satisfaction with the learning experience	32	1
Total				**32**

Data Analysis

Data was analyzed using descriptive statistics to summarize and simplify data with measures like mean, frequency, percentage, and central tendency (Gravetter & Wallnau, 2007). Data was presented in tables, graphs, and diagrams to illustrate respondent characteristics, attitudes, opinions, and perceptions of research variables. Nominal and ordinal data were calculated using the frequency measure Formula 1.

$$P = \frac{f}{N} \times 100\%$$ (1)

Information:

f = Frequency for which percentage is calculated
N = Total frequency used as data
100% = Constant value

RESULTS AND DISCUSSION

Results

This research captured perceptions of third, fifth, and seventh-semester students regarding their blended learning experiences in completed or ongoing semesters. 509 students from six departments in the Faculty of Education, Makassar State University, completed the survey conducted over three months. Respondent distribution by department and semester is shown in Figure 1. Subsequent findings are presented based on the dimensions forming the constructs of the survey items.

Department	Total & Percentage	
Elementary School Teacher Education	270	53,00%
Early Childhood Teacher Education	105	20,63%
Guidance and Counseling	57	11,20%
Educational Administration	53	10,40%
Educational Technology	16	3,14%
Out-of-School Education	8	1,57%
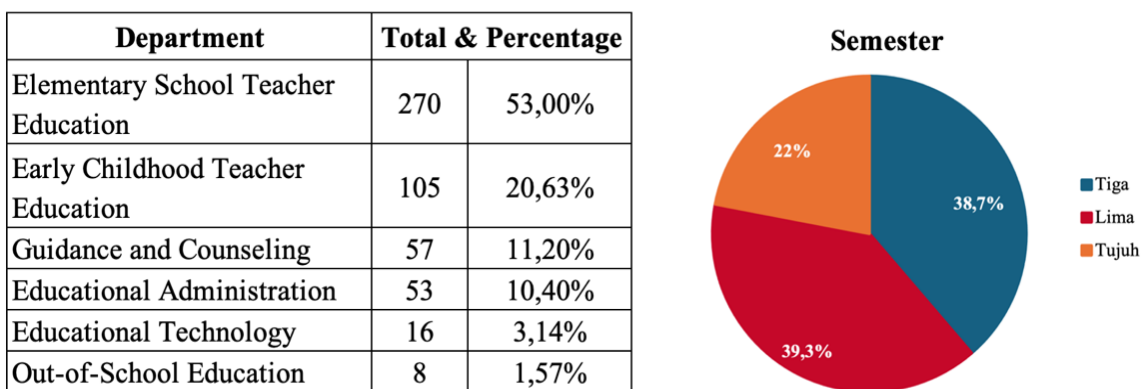
Figure 1. Respondent Distribution

Flexibility and Accessibility

Online materials on the blended learning platform provided students with time and place flexibility to study and review the not fully understood course materials. As can be seen in Figure 2, approximately 60% of respondents strongly agreed they could learn and review prepared materials anytime and anywhere. However, although blended learning was acknowledged for providing flexibility and accessibility, less than 40% strongly agreed that 1) it facilitated learning at their own pace, and 2) it made them plan time to study the materials. Flexibility and accessibility for accessing materials/tasks were perceived as a primary advantage of blended learning, but this did not necessarily lead students to plan their study according to their own pace and time availability.

Figure 2. Perception of Flexibility and Accessibility

Interaction and Collaboration

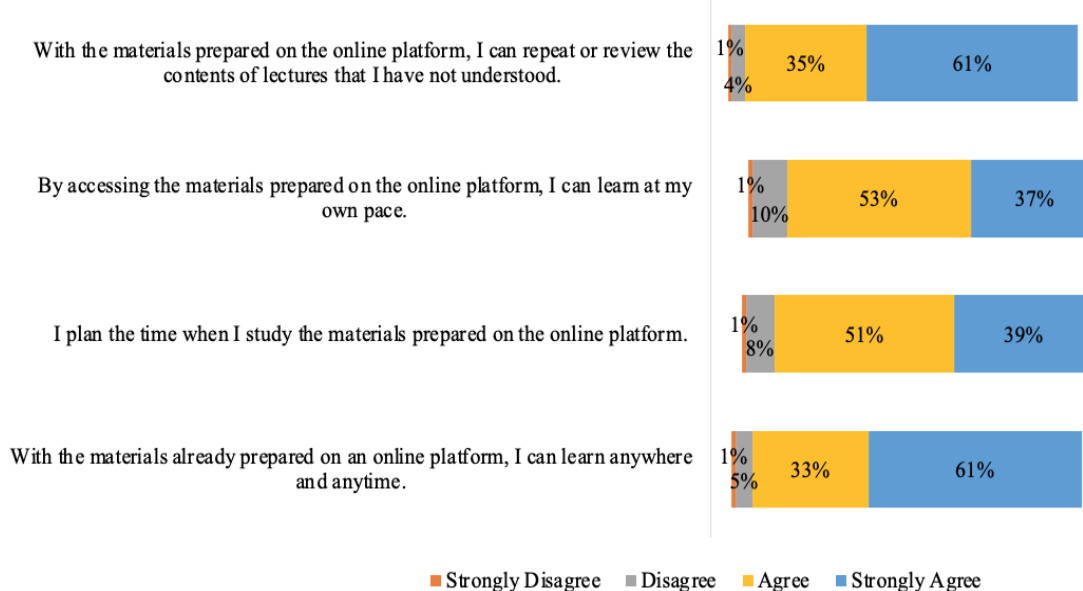Five items assessed students' perceptions of interaction and collaboration in blended learning. Two items measured the frequency of student-student interaction (dialogue/discussion), and one item measured student-lecturer interaction frequency. Regarding student-student interaction frequency, Figure 3 shows that only about 30% strongly agreed that blended learning increased dialogue/discussion frequency. Responses were lower for student-lecturer interaction (25%). Collaboration was represented as the need to cooperate and seek peer help in completing activities/assignments. 34% and 38% of respondents strongly agreed they felt a need for peer help and that blended learning encouraged cooperation in completing activities/tasks, respectively.
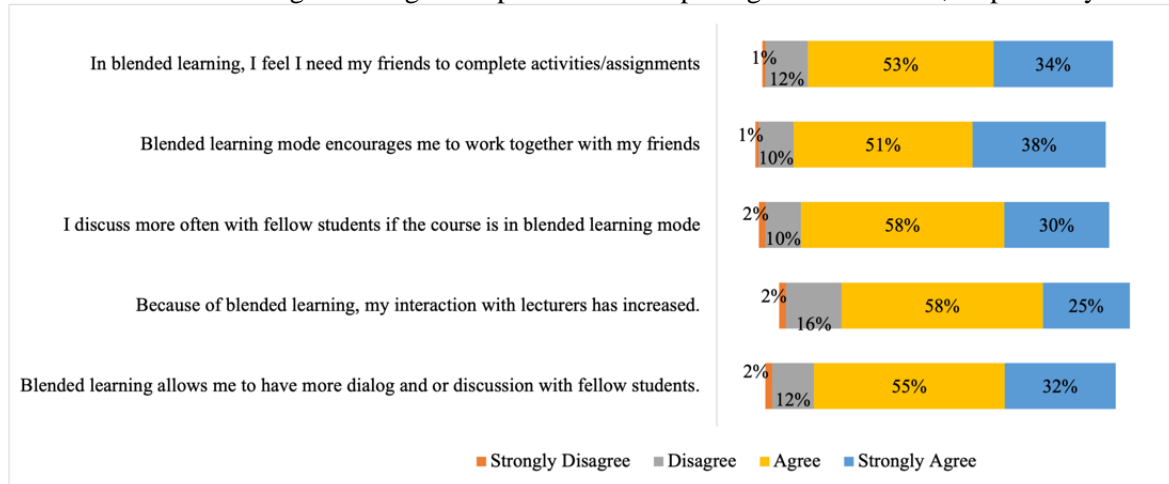
Figure 3. Perception of Interaction and Collaboration

Active Engagement

Active engagement was represented as the willingness/effort to participate in course activities, complete assignments, and seek help related to courses/tasks in online or offline sessions. Three survey items aimed to gauge perceptions of whether blended learning made students more active. As shown in Figure 4, less than 30% strongly agreed that online activities encouraged active participation in synchronous classes. However, 42% strongly agreed they felt more effort to complete tasks, and 44% strongly agreed they sought help when facing difficulties in blended learning tasks.

Figure 4. Perception of Active Engagement

Impact of Blended Learning

Respondents' perceptions of blended learning impact were measured through two indicators. The first indicator assessed motivation and learning facilitation (three statements). The second indicator assessed understanding of course material (two statements: increased material understanding and helpfulness of online materials/tasks). Figure 5 shows that the percentage of respondents strongly agreeing with blended learning to motivate them and to facilitate their learning ranged between 27% and 35%. Only 27% strongly agreed they understood the material better with the blended system, while 26% strongly agreed they felt online materials/tasks helped them understand course content.
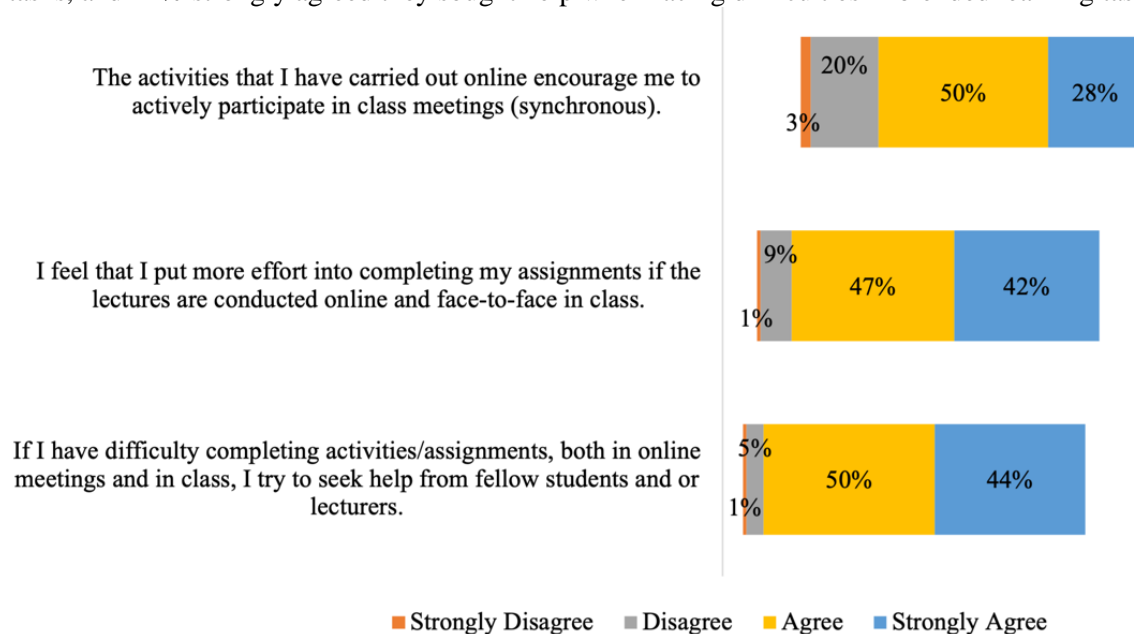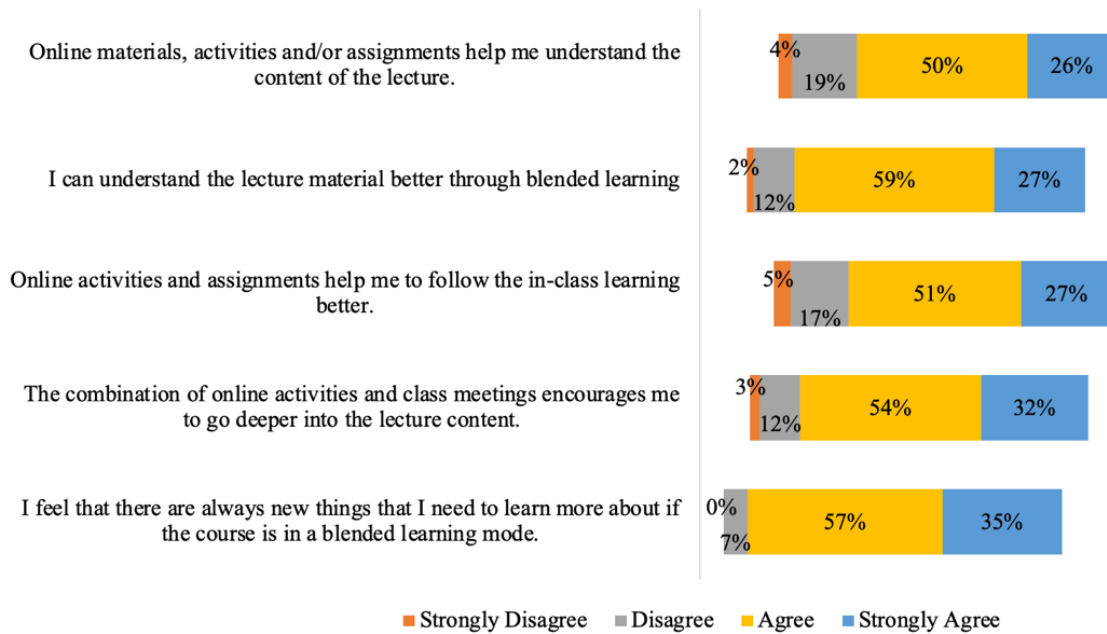

Figure 5. Perception of Impact of Blended Learning

Ability to Perform Blended Learning Activities

This research also explored student' perceptions of their ability level to perform online/offline activities and use blended learning platform features (Figure 6). Respondents generally reporting very high ability in using platform features were only around 24%. A bit lower percentage (23%) reported very high ability in communicating via platform features. Slightly higher percentages were seen for the ability to access materials and complete tasks on the online platform, with over 40% reporting very high ability in each.
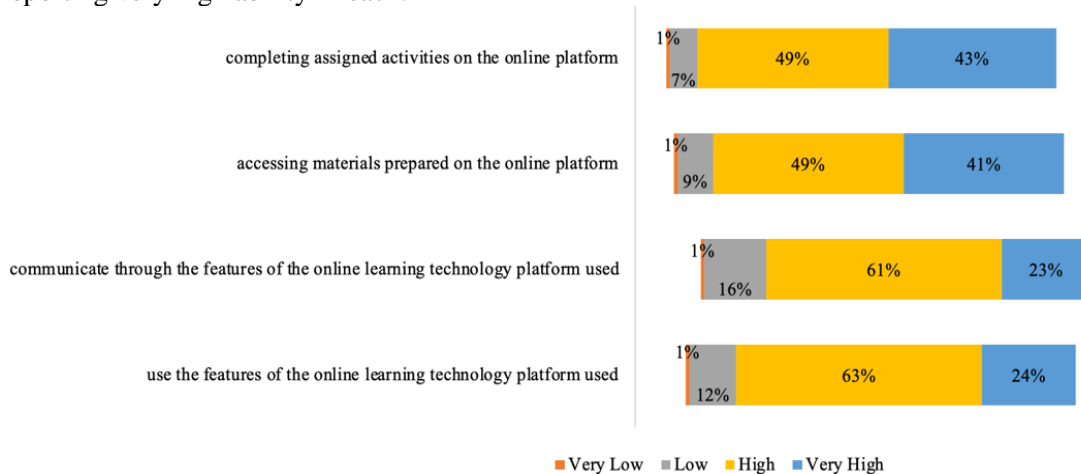
Figure 6. Perception of Ability to Perform Blended Learning Activities

Satisfaction with Blended Learning Experience

The final survey section assessed student satisfaction with the blended learning experience. Three main indicators were used: 1) Adequacy, suitability, and variety of materials/activities/assignments, 2) Clarity of instructions and activities, and 3) Instructor quality (teaching and activeness in providing feedback). One item measured overall satisfaction. Figure 7 shows that respondents reporting very high satisfaction with indicator one ranged from 28-29%. For indicator two, around 30% were very satisfied. For indicator three, 35% and 32% were very satisfied with the quality of online/offline teaching and instructor activeness in providing feedback, respectively. Overall, only 29% reported being very satisfied with their blended learning experience and outcomes.

Figure 7. Perception of Learning Experience Satisfaction

Discussion

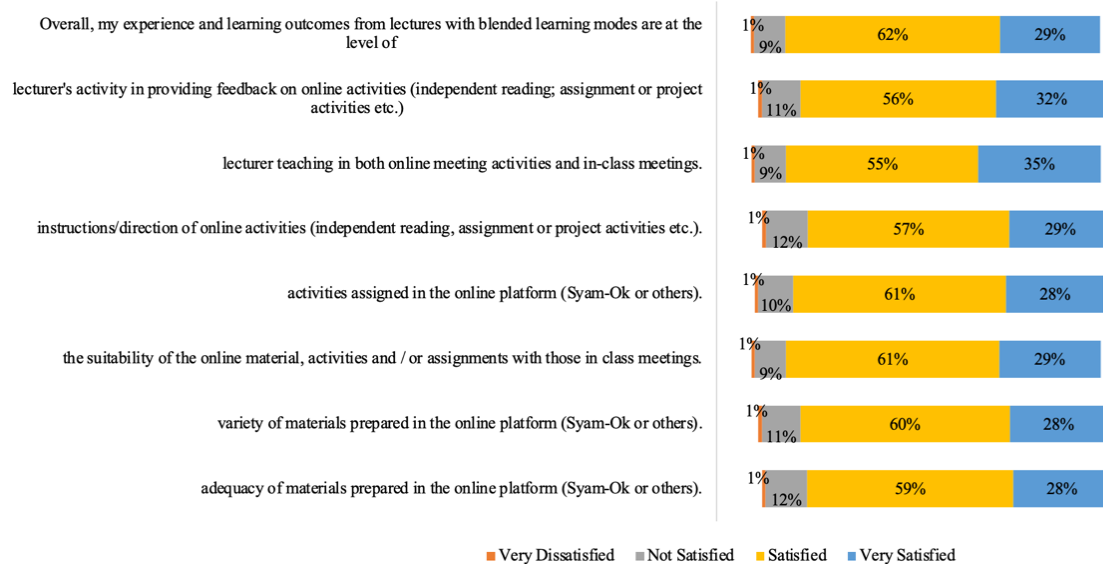The results presented show diverse findings across the seven dimensions of student learning experiences in blended learning at the Faculty of Education, Makassar State University. Some findings even differ from previous research. These varied and contrasting results are discussed below and organized in accordance with the three research questions of the study.

Student Perceptions of Blended Learning's Relation to Learning Effectiveness

The commonly identified main advantage of blended learning is the ease and convenience for learners to access course materials and activities anytime, anywhere. This advantage was strongly felt by the majority of students in this study. Howitt & Pegrum (2015) asserted that this flexibility and accessibility should foster autonomy and personalization for instructors and learners. Learner autonomy/personalization includes planning study time and activities to review material at their own pace or understanding level (Birbal et al., 2018; Fleck, 2012; Kaur, 2013). However, it appears the flexibility offered did not encourage the majority of respondents in this study to independently manage or self-regulate their learning (Ustun et al., 2023). Blended learning fails to promote students with autonomy and personalization in their learning (Bonk et al., 2005).

Similarly, collaboration among students for studying material and completing activities/assignments was expected to be well-facilitated in blended learning (Han & Ellis, 2021; Islam et al., 2022). Collaboration requires a "sense of need" for others, prompting cooperation. In other words, collaboration doesn't automatically arise just because features/channels are designed into blended learning. If learners feel a high need to seek peer help in understanding material or completing tasks, high collaboration is more likely to occur. Since students in this study did not report a strong need for peer help, collaboration was likely low.

Students perceived blended learning's flexibility (valued anytime/anywhere access) as its primary strength. However, the strength or potential offered by blended learning does not translate into effective learning outcomes, as seen from unsuccessful self-paced learning or improved study planning, low impacts on motivation and material understanding, as well as modest collaboration perceived by students. In addition, overall low satisfaction aligns with suboptimal engagement and limited critical dialogue. This indicates a significant gap between the potential of blended learning (e.g., autonomy, enriched outcomes) and its perceived reality. The findings contradict literature (Chen, 2022; Waqqar et al., 2020), suggesting that flexibility alone is sufficient to enable students to direct and or regulate their learning. This finding might point to a need for structured pedagogical support to convert access into autonomous and meaningful learning.

Aspects Contributing to Learning Effectiveness

Blended learning is chosen partly for its potential richness and variety of materials and activities, both online and offline. This richness could stimulate learning motivation, strategy adaptation, or exploration of new ideas (Hoadley, 2009; Kintu & Zhu, 2016). In blended learning, the internet and technology facilitate unlimited utility for connecting individuals, while face-to-face meetings enable dynamic and deep communication. Frequent dialogue/discussion among students or with instructors was expected to facilitate open and critical dialogue stemming from higher-order thinking (Garrison & Kanuka, 2004; Jaswal & Behera, 2024). The fact that only one-third of respondents strongly perceived increased learner-learner and instructor-learner communication and interaction in blended learning may indicate insufficient deep dialogue/discussion and weak critical thinking among students. In addition, blended learning's impact on the learning process and effectiveness is mediated by the user's technical ability. Sophisticated technology alone cannot guarantee success if lecturers and learners lack savvy digital skills.

Interaction/communication, active engagement, and technical competence are key aspects expected to drive effectiveness, which are underrealized by the students in this study. These deficiencies directly undermine learning effectiveness, as interaction fuels critical thinking (Garrison & Kanuka, 2004), and technical barriers hinder engagement (Lim et al., 2019; Sharma et al., 2022). The study highlights that pedagogical design (e.g., collaborative tasks, intuitive platforms) and learner self-regulation are critical drivers absent in the current implementation. Without intentional design and user-friendly technology, blended learning fails to leverage its core advantages, facilitating and developing higher-order learning such as analytical critical thinking, problem-solving, and collaboration skills (Vo et al., 2020; Yu et al., 2025).

Problems and Constraints in Blended Learning

Several factors pose problems and constraints in blended learning. First, students' inability to regulate their learning and to collaborate effectively in a blended learning environment reflects a weak digital learning attitude. Ustun et al., (2023) argued that blended learning demands strong self-regulation; students lacking digital self-management skills fail to convert flexibility into autonomous learning. While Han & Ellis (2021) explicated that collaboration in blended learning rarely emerges organically as it requires "designed interdependence" (e.g., relying on others to achieve shared goals), which is absent in students with low digital engagement attitudes. Without addressing this attitude, digital tools remain in use (Broadbent & Fuller-Tyszkiewicz, 2018). Second, low technical proficiency in platform usage undermines learning effectiveness in blended learning as it restricts engagement with materials and tasks, despite their online availability (Fleck, 2012; Sharma et al., 2022). Last, evidenced by low satisfaction with instructional clarity and lecturer feedback, the poor technological-pedagogical competency of lecturers compounds these challenges. Garrison & Kanuka (2004) asserted that blended learning requires "a fundamental redesign of the instructional model" beyond "replicating traditional classroom practices."

CONCLUSION

This study reveals critical insights into blended learning effectiveness through the perspectives of 509 students at the Faculty of Education, Makassar State University. While flexibility

in accessing materials is highly valued, its potential to foster self-regulated learning remains unrealized, with fewer students leveraging it for personalized pacing. Interaction and collaboration as the cornerstones of meaningful blended pedagogy prove lacking, with technical barriers further hindering progress. Consequently, impacts on motivation, content mastery, and overall satisfaction fall below expectations. These findings underscore a misalignment between technological convenience and pedagogical execution, suggesting that current implementations fail to harness blended learning's full capacity to enrich cognitive and social outcomes. It also points out that blended learning's success hinges not merely on technology integration but on intentional design prioritizing active collaboration, critical dialogue, and learner empowerment. To bridge the gap between promise and reality, it is recommended that 1) institutions must prioritize pedagogical redesign that embeds structured collaborative tasks (e.g., scaffolded online debates, peer feedback loops) to transform flexibility into self-directed growth as well as to stimulate critical dialogue and 2) technical accessibility should be elevated through simplified platform interfaces and mandatory digital literacy training for both students and lecturers.

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The effectiveness of augmented reality in enhancing learning outcomes in a microcontroller course

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ABSTRACT

One significant challenge in technical and vocational education is students' difficulty in achieving a deep conceptual understanding, particularly in complex subjects such as microcontrollers. Traditional methods often lack interactivity and real-world context, leading to low engagement and learning outcomes. Augmented Reality (AR) provides an immersive and interactive learning experience that enables students to visualize abstract concepts. This study examined the impact of AR-based instructional media on learning outcomes in a Microcontroller course, using a true experimental design (Solomon Four Group Design). Four student groups from four vocational higher education institutions in Makassar participated (total N = 143). Two groups received AR-based instruction, and two received conventional teaching; two of the groups also completed a pretest. Learning outcomes were assessed through essay-format pretests and posttests aligned with microcontroller learning indicators. Learning improvement was measured using normalized gain scores, and data were analyzed with normality tests, homogeneity tests, ANCOVA, independent t-tests, and N-Gain analysis. Results showed that AR significantly improved learning outcomes, with experimental groups achieving a mean gain score of 0.75 (in the high category), compared to 0.16 (in the low category) in control groups. Statistical tests confirmed significant differences between groups (p < 0.05), while comparisons among control groups indicated no substantial pretest effect. This confirms that the learning improvement resulted from the AR intervention. The findings suggest AR-based instructional media effectively enhance conceptual understanding, learning quality, and student engagement in technical education. The study concludes that AR is a viable instructional tool in vocational learning and recommends its broader use and further development in similar educational contexts.

INTRODUCTION

The rapid advancement of digital technology has driven significant transformations in the field of education, particularly in teaching and learning methods within technical and vocational domains. One of the major challenges in vocational education lies in effectively delivering complex technical concepts in a manner that is accessible and comprehensible to students, especially in courses such as

Microcontrollers. Conventional instructional approaches often fall short in facilitating deep conceptual understanding due to limitations in visualization and interactivity.

The advancement of digital technology in education has created significant opportunities to transform classroom learning experiences (Mahendru et al., 2024). Despite these developments, the instructional practices in many educational institutions remain predominantly conventional, characterized by teacher-centered approaches and the use of static instructional media such as textbooks and whiteboards (Koumpouros, 2024). This dependency on traditional methods often results in passive, non-interactive, and decontextualized learning environments, which in turn lead to low student motivation and limited conceptual understanding, particularly in science, technology, engineering, and mathematics (STEM) related disciplines (Tiwari et al., 2024).

A fundamental issue within conventional instruction lies in the inability of traditional media to effectively represent abstract or complex concepts visually and interactively (Quang & Duc, 2023). Concepts such as molecular structures, mechanical systems, human anatomy, and natural phenomena are often challenging to comprehend through verbal explanation or two-dimensional illustrations alone (Naithani & Guleria, 2024). Consequently, students struggle to develop comprehensive conceptual frameworks and are susceptible to learning loss, especially when dealing with spatially demanding content that requires advanced visual imagination (González et al., 2025).

Simultaneously, the current generation of learners, commonly referred to as digital natives, demonstrates learning preferences that are markedly different from those of previous generations (Zhao et al., 2025). They are more engaged with learning environments that are digital, visual, interactive, and technologically enriched. Unfortunately, many instructional systems in schools and universities have not adequately adapted to these evolving learner characteristics (Kiesler et al., 2025). This misalignment has created a pedagogical gap between students' learning styles and the teaching approaches commonly employed, thereby intensifying the need for innovative learning strategies that bridge this divide (Zou et al., 2025). Digital technology, in this context, offers motivational appeal and captures the interest of young learners through various digital platforms and multimedia content (Efremova & Huseynova, 2021).

In response to these challenges, Augmented Reality (AR) has emerged as a promising instructional innovation (Turkcan et al, 2023). AR enables the real-time integration of digital content into the physical environment, creating immersive, interactive, and contextualized learning experiences (Tatić & Tešić, 2017). Through AR, students can directly engage with 3D models, simulations, and dynamic information that enhance the exploration and understanding of concepts more practically and visually. Empirical studies have consistently reported that AR-based learning significantly enhances student motivation, active participation, and conceptual comprehension when compared to traditional media (Singh & Ahmad, 2024).

Despite the promising potential of AR in education, there remains a notable gap in rigorous empirical research examining its effectiveness, especially within the context of formal education settings (Laumann et al., 2024). Much of the existing literature is descriptive or limited to single-group experimental designs, thus lacking robust evidence of AR's impact when compared through more methodologically sound frameworks (López-Bouzas et al., 2024). To validate that improvements in learning outcomes are a result of AR and not merely due to novelty effects or participant expectancy, a more comprehensive and controlled research design is required (Chen et al., 2024).

To address this methodological gap, this study employed the Solomon Four Group Design, an experimental approach widely regarded as rigorous and capable of controlling for pretest effects and other external threats to validity (Covvey et al., 2023). This design not only measures the impact of AR on learning outcomes but also examines whether the administration of a pretest influences those outcomes (Mokmin et al., 2023). Ensuring such internal validity is essential for generating reliable findings that can inform educational policy and guide the development of AR-based learning models in the future (Chang et al., 2022; Jičínská et al., 2021).

This study addresses the pressing need for adaptive, learner-centered, and technology-integrated instructional innovations that align with the characteristics of contemporary vocational learners. Augmented Reality (AR) is positioned not merely as a technological novelty but as a strategic pedagogical tool capable of addressing the limitations of traditional instructional methods

by enhancing interactivity, visualization, and learner engagement. The primary aim of this research is to examine the effect of AR-based instructional media on student learning outcomes in the Microcontroller course within vocational higher education. Utilizing a true experimental design with the Solomon Four Group Design, the study provides robust empirical evidence on the efficacy of AR in fostering conceptual understanding in technical education. The significance of this study lies in its threefold contribution: (1) offering empirical data on the pedagogical impact of AR in vocational education, where such studies remain limited; (2) presenting a replicable instructional model for integrating AR into microcontroller instruction; and (3) informing educators, curriculum developers, and policymakers on the potential of immersive learning technologies to enhance learning effectiveness and student engagement. As such, this research contributes both to the theoretical discourse on educational technology and to practical improvements in vocational teaching practices.

METHOD

This study employed a true experimental design using the Solomon Four Group Design model, which consists of four student groups with different combinations of pretest and treatment. This design enables the researcher to objectively measure the effect of using AR media on student learning outcomes while eliminating potential testing bias (i.e., the influence of the pretest on posttest performance). The study was conducted across four polytechnic institutions, involving second-semester students enrolled in the microcontroller course.

Table 1. Model of the Solomon Four Group Design

No.	Group	Pretest	Treatment	Posttest	Polytechnic	Students
1	Experiment 1	O_1	X_1	O_2	Polytechnic A	37
2	Control 1	O_3		O_4	Polytechnic B	35
3	Experiment 2		X_2	O_5	Polytechnic C	36
4	Control 2			O_6	Polytechnic D	35
Total						**143**

Description:
O_1 = Pretest Experiment 1
O_2 = Posttest Experiment 1
O_3 = Pretest Control 1
O_4 = Posttest Control 1
O_5 = Posttest Experiment 2
O_6 = Posttest Control 2
X_1 = Treatment Experiment 1
X_2 = Treatment Experiment 2

Experimental Group 1 and Control Group 1 received a pretest, while Experimental Group 2 and Control Group 2 did not. Both Experimental Groups 1 and 2 received treatment in the form of learning using AR-based instructional media, whereas Control Groups 1 and 2 underwent conventional learning as previously implemented. The data collection technique in this study focused on measuring students' learning outcomes through a series of tests designed to assess conceptual understanding and applied skills in the Microcontroller course. The primary instrument used was an essay-type test, developed based on learning outcome indicators and a blueprint of core microcontroller topics. The test items were constructed to evaluate students' abilities in analyzing, synthesizing, and applying concepts and the working principles of microcontroller systems in various technical contexts.

Table 2. Microcontroller Knowledge Test Instrument

No.	Intrument Test	Indicator
1	Explain the fundamental differences between a microcontroller and a microprocessor.	C2 – Understanding
2	Describe the main components found in the architecture of a microcontroller.	C2 – Understanding

No.	Intrument Test	Indicator
3	Illustrate and explain the working principle of the input-output (I/O) system in a microcontroller.	C3 – Applying
4	Explain the working process of the Analog to Digital Converter (ADC) in a microcontroller.	C2 – Understanding
5	Write and explain the steps for programming a microcontroller to make an LED blink every 1 second using the C programming language.	C3 – Applying
6	Analyze the differences between serial and parallel communication in microcontrollers.	C4 – Analyzing
7	Explain the concept of interrupts in microcontrollers and provide an example of its application in a sensor-based system.	C4 – Analyzing
8	A microcontroller system uses a temperature sensor to automatically activate a fan. Create a logic flow (flowchart or narrative explanation) that describes the process.	C5 – Creating
9	Describe the steps for connecting a microcontroller to a 16x2 LCD module. Explain how data is displayed on the screen.	C3 – Applying
10	In an automatic control system project based on a microcontroller, how do you determine the appropriate type of microcontroller? State the technical criteria that should be considered and justify your choices.	C6 - Evaluating

The data obtained were analyzed using several statistical techniques, namely: (1) Analysis of Covariance (ANCOVA) – This was used to examine the effect of AR-based learning treatment on posttest scores while controlling for pretest scores as a covariate. The purpose was to determine the pure effect of Augmented Reality on learning outcomes after accounting for initial differences in student ability; (2) Independent Samples t-Test – this test was conducted to compare learning outcomes between groups to assess the statistical significance of differences between the experimental and control groups on the posttest. It was also used to detect whether the pretest had any effect on posttest results; and (3) N-Gain Score Analysis - this analysis was employed to measure the improvement in students' learning outcomes by comparing pretest and posttest scores in the groups that received the treatment.

$$\text{N-Gain Score} = \frac{\text{Postest Score} - \text{Pretest Score}}{\text{Score Max} - \text{Pretest Score}} \tag{1}$$

The N-Gain results were classified into three categories: high (> 0.7), medium (0.3–0.7), and low (< 0.3). Before analysis, the data were tested for assumptions of normality using the Kolmogorov-Smirnov test and for homogeneity of variances using Levene's Test to ensure that the data met the requirements for parametric statistical analysis.

Table 3. Categorization of Normalized Gain Score (N-Gain)

No.	N-Gain Coefficient	Category
1.	n > 0.7	High
2.	$0.3 \leq n \leq 0.7$	Medium
3.	n < 0.3	Low

(Leny et al., 2024)

RESULTS AND DISCUSSION

Results

This study employed the Solomon Four Group Design, an experimental method involving four groups to measure the effect of a treatment while controlling for potential pretest effects. The design consisted of two experimental groups that received instruction using AR and two control groups that underwent conventional instruction without AR. Experimental Group 1 and Control Group 1 were administered a pretest, whereas Experimental Group 2 and Control Group 2 were not. The instructional approach for the experimental groups was designed to be interactive, utilizing AR media to explain key concepts in the Microcontroller course. In contrast, the control groups were taught using traditional lecture methods and static media such as presentation slides and whiteboards. Following the intervention, all groups were given a posttest in the form of essay-based assessments

to evaluate learning outcomes. Figure 1 presents the average learning outcomes across the four groups, serving as the basis for evaluating the effectiveness of AR integration in technical vocational education.
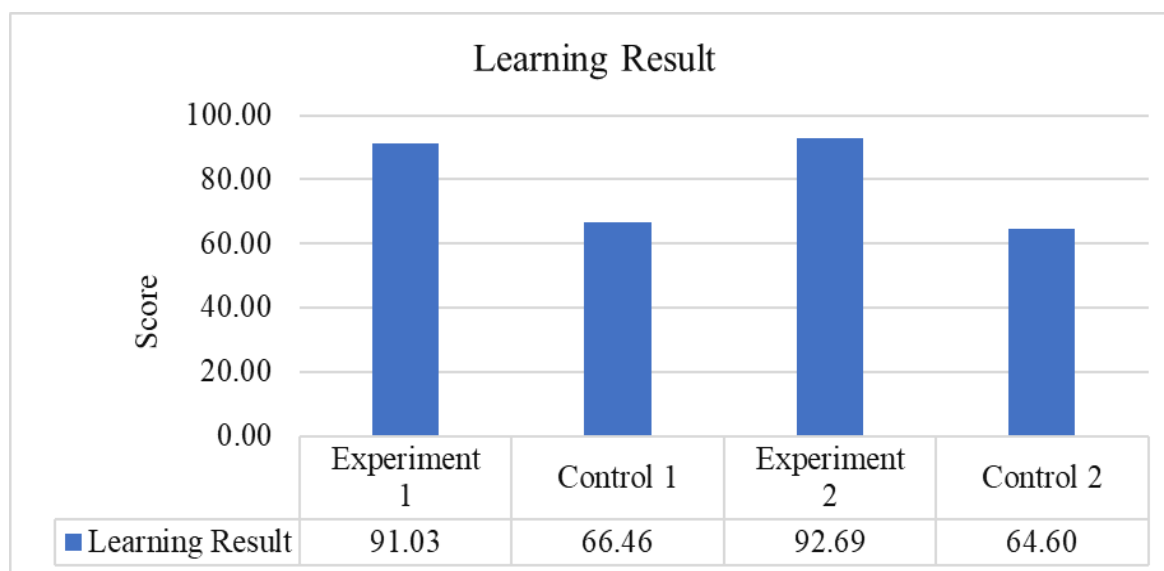

Figure 1. Average Learning Outcomes in the Microcontroller Course

Based on the Learning Result graph presented, there is a notable difference in learning outcomes between students in the experimental groups and those in the control groups. Experimental Group 1, which received AR-based instruction and a pretest, achieved an average score of 91.03. Meanwhile, Experimental Group 2, which also received AR-based instruction but without a pretest, recorded a slightly higher average score of 92.69. These results indicate that AR-based learning consistently has a positive impact on student performance, regardless of the presence or absence of a pretest.

In contrast, Control Group 1, which underwent conventional instruction with a pretest, achieved an average score of 66.46, while Control Group 2, which received neither a pretest nor AR-based instruction, obtained an average score of 64.60. These values are significantly lower than those of the experimental groups, suggesting that traditional instructional methods are less effective in fostering a deep conceptual understanding of microcontroller content.

The differences in scores between the experimental and control groups demonstrate that the use of AR media significantly enhances student learning outcomes and that the pretest itself does not exert a meaningful influence on final performance. This reinforces the conclusion that the observed improvement in learning is primarily attributable to the integration of AR as an interactive instructional tool, rather than to repeated exposure to test content. Thus, the findings support the effectiveness of AR technology as an innovative solution in education, particularly in the context of technical learning.

Normality Test of the Data

In this study, the normality test was conducted to ensure that the pretest and posttest scores in each group met the assumption of normal distribution. The One-Sample Kolmogorov-Smirnov Test was employed, which is a commonly used statistical test to determine whether the distribution of a sample significantly deviates from a normal distribution. The results of this test served as the basis for determining whether subsequent data analysis could be carried out using parametric statistical techniques or whether non-parametric alternatives would be required. The results of the normality test are presented in Table 4.

Table 4. Normality Test Results for Experimental Group 1 and Control Group 1

		Pretest Experiment 1	Posttest Experiment 1	Pretest Control 1	Posttest Control 1
N		37	37	35	35
Normal Parameters[a,b]	Mean	63.6486	91.0270	63.0857	66.4571
	Std. Deviation	4.04294	4.27191	3.95840	4.75483
Most Extreme Differences	Absolute	.126	.135	.143	.140
	Positive	.126	.083	.114	.140
	Negative	-.125	-.135	-.143	-.126
Test Statistic		.126	.135	.143	.140
Asymp. Sig. (2-tailed)		.147[c]	.088[c]	.068[c]	.079[c]

Table 5. Normality Test Results for Experimental Group 2 and Control Group 2

		Posttest Experiment 2	Posttest Control 2
N		36	35
Normal Parameters[a,b]	Mean	92.6944	64.6000
	Std. Deviation	3.90472	4.62856
Most Extreme Differences	Absolute	.131	.131
	Positive	.107	.131
	Negative	-.131	-.077
Test Statistic		.131	.131
Asymp. Sig. (2-tailed)		.123[c]	.138[c]

Based on the results of the normality test analysis using the One-Sample Kolmogorov-Smirnov Test, it was found that the data from all research groups met the assumption of normal distribution. This test was conducted to ensure that the data from each group intended for analysis using parametric statistical techniques conformed to a reasonable distribution, thereby allowing for valid interpretation of the results. For Experimental Group 1, the significance value for the pretest was 0.147, and for the posttest, it was 0.088. Both values exceed the critical threshold of 0.05, indicating that the data for both pretest and posttest in this group are normally distributed. Similarly, in Control Group 1, the pretest yielded a significance value of 0.068, and the posttest yielded 0.079—both above the 0.05 threshold, suggesting that the data in this control group also meet the normality assumption. Furthermore, for Experimental Group 2 (which did not receive a pretest but was given the AR-based treatment), the posttest produced a significance value of 0.123, and in Control Group 2, the posttest yielded 0.138. As with the previous groups, these values indicate that the data in both groups are normally distributed.

Accordingly, for all six datasets tested, Pretest Experimental Group 1, Posttest Experimental Group 1, Pretest Control Group 1, Posttest Control Group 1, Posttest Experimental Group 2, and Posttest Control Group 2, the significance values were all greater than 0.05. This confirms that there were no significant deviations from normal distribution across any of the groups. Therefore, the assumption of normality is fulfilled, meaning that the data may be further analyzed using parametric statistical techniques such as ANCOVA, the Independent Samples t-test, and N-Gain Score analysis to assess the improvement in learning outcomes. Meeting this assumption is essential to ensure that interpretations regarding the effect of AR-based instruction in the Microcontroller course are scientifically accurate and defensible.

Homogeneity Test

After the normality test was conducted and the data were confirmed to follow a normal distribution, the next step before performing parametric statistical analysis was to examine the homogeneity of variances. The purpose of this test is to determine whether the variances or the spread of data across the groups being compared are statistically equivalent. The homogeneity of variance was assessed using Levene's Test, which identifies whether there are significant differences in variance among the groups. If the significance value (Sig.) exceeds 0.05, the variances are considered homogeneous, and the assumption of homogeneity is deemed to be met. The results of the homogeneity test are presented in Table 6.

Table 6. Results of the Homogeneity Test

Levene Statistic	df1	df2	Sig.
.295	3	139	.829

Based on the results of the homogeneity of variance test using Levene's Test, as presented in the table, a significance value (Sig.) of 0.829 was obtained. This value is substantially higher than the critical threshold of 0.05, indicating that there is no significant difference in variance among the groups compared in this study. Therefore, it can be concluded that the learning outcome data across the four groups exhibit homogeneous or equal variances. Homogeneity of variance is a fundamental assumption that must be met before performing parametric statistical analyses such as ANCOVA or the Independent Samples t-test. When this assumption is satisfied, the results of inferential analyses are considered more valid and unbiased, as the equal distribution of data across groups ensures the integrity of statistical comparisons. Based on the results of Levene's Test, further analysis may proceed using parametric statistical approaches, as both the normality and homogeneity assumptions have been statistically satisfied. This strengthens the validity of hypothesis testing regarding the impact of using AR media in the teaching of the Microcontroller course.

ANCOVA Analysis

In this study, Analysis of Covariance (ANCOVA) was employed to compare the posttest scores between the experimental groups, which utilized Augmented Reality (AR) media, and the control groups, which received instruction through conventional teaching methods, while controlling for pretest scores as a covariate. Accordingly, ANCOVA not only measures the differences in learning outcomes between groups but also ensures that these differences are not attributable to variations in prior knowledge or initial ability, but rather to the treatment administered during the learning process. The results of the ANCOVA analysis are presented in Table 7.

Table 7. ANCOVA Analysis Results

No.	Source	Type III Sum of Squares	df	Mean Square	F	Sig.
1	Corrected Model	11245.593[a]	2	5622.796	525.972	.000
2	Intercept	219.035	1	219.035	20.489	.000
3	Pretest	704.436	1	704.436	65.895	.000
4	Model	10003.233	1	10003.233	935.730	.000
5	Error	716.250	67	10.690		
Total		**445835.000**	**70**			
Corrected Total		**11961.843**	**69**			

Based on Table 7, which presents the results of the ANCOVA analysis on the posttest as the dependent variable, it was found that there is a statistically significant effect of the independent variable on students' learning outcomes after controlling for pretest scores. The F-value for the model variable was 935.730, with a significance level (Sig.) of 0.000. This value is well below the critical threshold of 0.05, indicating that the instructional model had a highly significant effect on posttest performance. In other words, the use of AR-based instructional media made a substantial and meaningful contribution to improving student learning outcomes in the Microcontroller course.

Thus, the results of the ANCOVA provide strong evidence that AR-based learning is significantly more effective than conventional instruction in improving student learning outcomes, even after controlling for prior ability. These findings support the notion that the integration of Augmented Reality technology in vocational education, particularly in the Microcontroller course, can yield both statistically and practically significant impacts on student achievement.

Independent Sample t-test Analysis

This test was employed to determine whether there is a statistically significant difference in learning outcomes between two independent groups, namely the experimental group and the control group. The results of the Independent Samples t-Test are presented in Table 8.

Table 8. Results of the Independent Samples t-Test Analysis

T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
27.67	69	.000	28.09	1.015	26.06	30.11
27.60	66.43	.000	28.09	1.017	26.06	30.12

Based on Table 8, which presents the results of the Independent Samples t-Test analysis, it was found that there is a highly significant difference between the two groups being compared in terms of their mean learning outcomes. The t-value was 27.67 with 69 degrees of freedom (df), yielding a two-tailed significance value (Sig.) of 0.000. This value is well below the significance threshold of 0.05, indicating that the difference in mean scores between the two groups is statistically significant. Overall, these findings suggest that the group receiving the treatment (e.g., the use of AR-based instructional media or another targeted intervention) achieved significantly higher learning outcomes than the group that did not receive the intervention. This indicates that the instructional intervention had a positive and effective impact on improving students' academic performance.

Pretest Effect Analysis

To determine whether the pretest affected learning outcomes, a comparison was conducted between Control Group 1 (which received a pretest) and Control Group 2 (which did not receive a pretest). Both groups were taught using conventional instructional methods and did not receive the AR-based learning intervention. The results of the pretest effect analysis are presented in Table 9.

Table 9. Results of the Pretest Effect Analysis

T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
1.65	68	.102	1.85	1.12	-.38	4.09
1.65	67.95	.102	1.85	1.12	-.38	4.09

Based on Table 9, which presents the results of the pretest effect analysis between Control Group 1 and Control Group 2, the t-value was found to be 1.65 with 68 degrees of freedom (df), and a two-tailed significance value (Sig.) of 0.102. Since this value is greater than the significance threshold of 0.05, it can be concluded that there is no statistically significant difference between the two control groups. This result indicates that administering a pretest did not have a significant effect on the learning outcomes of students who did not receive the instructional intervention. In other words, the presence of the pretest did not meaningfully influence student performance on the posttest, suggesting that no significant pretest effect occurred within the control condition. This finding is particularly important as it supports the assumption that any differences in learning outcomes observed in the experimental groups can be attributed to the treatment (e.g., the use of AR) rather than to the influence of the pretest. Consequently, it reinforces the internal validity of the Solomon Four Group Design employed in this study.

Normalized Gain Score Analysis

Table 10. Results of the N-Gain Score Analysis

No.	Group	Mean Pretest	Mean Posttest	Mean Gain Score
1	Experiment 1	63.46	91.02	0.75
2	Control 1	63.08	66.45	0.16

Based on Table 10, which presents the comparative results of the mean pretest, posttest, and gain scores between Experimental Group 1 and Control Group 1, a substantial difference in learning improvement was observed. Experimental Group 1, which received AR-based instruction, had a mean pretest score of 63.46, which increased significantly to 91.02 in the posttest. This improvement resulted in a mean gain score of 0.75, classified as high according to the normalized gain score criteria.

In contrast, Control Group 1, which received conventional instruction, recorded a mean pretest score of 63.08, with only a slight increase to 66.45 in the posttest. This yielded a mean gain score of 0.16, which falls into the low category ($g < 0.3$). These results indicate that although both groups began with relatively similar initial abilities, the group exposed to technology-enhanced learning demonstrated a significantly greater improvement in learning outcomes.

Therefore, the gain score data provide strong evidence that the integration of Augmented Reality (AR) into the learning process substantially enhances instructional effectiveness and students' conceptual understanding compared to traditional teaching methods. This finding reinforces the conclusion that the use of interactive digital technology not only boosts learning motivation but also leads to more optimal cognitive outcomes. The high gain score achieved by the experimental group serves as a clear indicator of the success of this innovative, technology-driven instructional intervention.
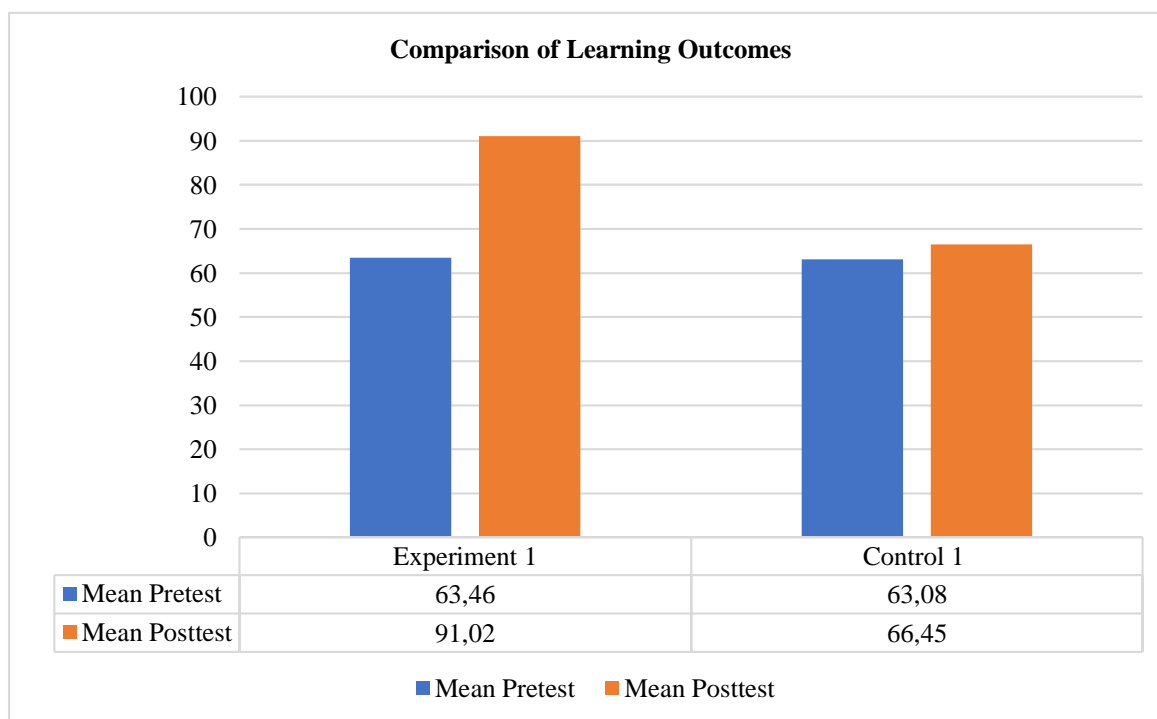
Comparison of Learning Outcomes

	Experiment 1	Control 1
Mean Pretest	63,46	63,08
Mean Posttest	91,02	66,45

■ Mean Pretest   ■ Mean Posttest

Figure 2. Comparison of Learning Outcomes Experimental 1 and Control 1

Discussion

This study addresses the issues and gaps identified in the background, namely the continued dominance of conventional teaching methods that are not adaptive to the learning characteristics of digital-native students, as well as the limitations of instructional media in presenting abstract concepts visually and interactively (Mukhlisin, et al., 2022). Through the integration of AR in the teaching of the Microcontroller course, the study demonstrates that AR can provide a more immersive and contextual learning experience, significantly enhancing students' learning outcomes (Palada et al., 2024). This is evidenced by the substantial difference in posttest scores between the experimental and control groups, with the experimental group achieving a normalized gain score of 0.75 (high category), compared to only 0.16 in the control group. These findings suggest that AR not only captures student attention but is also effective in deepening their conceptual understanding of complex technical content (Gargrish et al., 2021).

The rapid advancement of technology has brought significant changes to educational media, which were traditionally rooted in conventional methods but can now be implemented more practically using digital tools (Handani et al., 2020). Among the technologies gaining increasing attention in education is Augmented Reality (Alamsyah & Krisdiawan, 2021). AR represents a sophisticated paradigm of human-computer interaction, wherein three-dimensional virtual elements

are seamlessly integrated with the user's perception of the real world, allowing for responsive and intuitive interaction (Mukhlisin et al., 2023; Mukhlisin et al., 2022).

Furthermore, by employing the Solomon Four Group Design, this study was able to confirm that the improvement in learning outcomes was not attributable to pretest effects, but rather resulted purely from the effectiveness of the AR-based learning media. This is supported by the lack of significant differences between Control Group 1 (with pretest) and Control Group 2 (without pretest), as well as the consistently high performance observed in both experimental groups, regardless of pretest administration (Lichtenberger et al., 2025). This design enhances the internal validity of the study and places the findings on solid ground to inform educational policy and the development of future digital learning models (Thohir et al., 2021).

The primary contribution of this research lies in providing robust empirical evidence that the use of AR significantly enhances learning effectiveness in vocational education, particularly in mastering science- and technology-based content (Jeffri & Rambli, 2021). Amid the growing demand for adaptive and contextual learning, this study offers a strategic solution through the implementation of digital technologies that align with the learning preferences of the current generation of students (Efremova & Huseynova, 2021). Moreover, the rigorous methodological approach adopted in this study contributes to the academic literature by addressing the existing gap in experimental research on AR within the context of formal education. Accordingly, these findings not only enrich the discourse on technology-enhanced learning but also provide a strong foundation for policy innovation and instructional practice in the digital era (Alonzo et al., 2024).

Through the outcomes of this research, the application of AR in education opens new opportunities to create more personalized and adaptive learning environments, where each student can learn at their own pace and according to their individual learning style (Namkoong et al., 2023). AR enables the embedding of virtual information into the physical world, displayed through devices such as computers and smartphones (Aditya et al., 2020). Consequently, the implementation of AR not only facilitates deeper conceptual understanding but also has the potential to foster intrinsic motivation and active student engagement in the learning process, ultimately leading to enhanced overall academic performance (Laumann et al., 2024).

CONCLUSION

Based on the findings of this study, which employed the Solomon Four Group Design, it can be concluded that AR-based instructional media has a significantly positive effect on students' learning outcomes in the Microcontroller course. The experimental groups that received AR-based learning interventions demonstrated higher improvements in learning outcomes compared to the control groups, as evidenced by both posttest scores and gain scores. The average gain score in the experimental groups reached 0.75, classified as high, while the control groups achieved only 0.16, categorized as low, despite having relatively equivalent baseline abilities. These results confirm that AR contributes substantially to enhancing the effectiveness of the learning process.

The use of AR has proven to be superior in presenting instructional content in a visual, interactive, and contextualized manner, effectively bridging abstract concepts and making them more accessible to learners. Moreover, the application of the Solomon Four Group Design provided strong methodological rigor in controlling for potential sources of bias, particularly the pretest effect. The finding that pretesting did not significantly influence learning outcomes strengthens the validity of the results and confirms that the observed improvements are due solely to the effectiveness of the AR-based intervention. Based on the findings of this study, it is recommended that future research be conducted to further explore the use of AR-based instructional media across a wider range of courses and areas of expertise within vocational education, to examine the consistency of its impact on student learning outcomes. Subsequent studies are also encouraged to integrate AR with active pedagogical approaches such as Problem-Based Learning (PBL), Project-Based Learning (PjBL), or flipped classroom models. Such integration would provide a more comprehensive understanding of the effectiveness of AR in fostering critical thinking, collaboration, and creativity skills among vocational learners.

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Strategic development of Islamic religious educators in enhancing the pedagogical excellence of junior high school teachers

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ABSTRACT

Improving the professional competence of educators is crucial in enhancing the quality of education. However, many educational institutions still face challenges in consistently implementing development strategies, especially in integrating pedagogical, technological, and managerial skills to meet global demands. This study aims to explore educator development strategies to improve professional competence at Bani Hasyim Islamic Junior High School, Singosari, Malang. Using a qualitative descriptive method, data were collected through interviews with the school principal, three vice principals, the head of the national exam committee, and teachers of Indonesian, English, Arabic, and Islamic Religious Education. Data were analyzed using Miles and Huberman's interactive model, which includes data collection, condensation, display, and conclusion drawing. The findings reveal three key strategies: (1) Educational Strategy, offering free higher education for teachers; (2) Training Strategy, structured in three levels- Level I for new teachers, Level II for quality improvement, and Level III for prospective vice principals; and (3) Responsibility Internalization Strategy, aimed at building a professional attitude and commitment. These strategies are expected to enhance curriculum relevance, learning quality, and educator readiness in facing global educational challenges. Future research should expand the scope to other educational levels and examine the role of technology integration in educator development outcomes.

INTRODUCTION

Educator development strategy is a series of steps or approaches designed to improve the quality and ability of educators to carry out their duties professionally (Steinert et al., 2019). This strategy includes efforts to provide training, further education, and ongoing coaching for educators (Wahyudi et al., 2025). MacPhail, in his research, explained that the main purpose of this strategy is to ensure that educators are able to master teaching materials, use effective learning methods, and utilize technology to support the educational process (MacPhail et al., 2019). With the right development strategy, educators can face new challenges in the world of education, such as curriculum changes and the growing needs of learners (Sancar et al., 2021).

Warren adds that educator development also includes improving skills in leadership, communication, and classroom management (Warren, 2021). These competencies are important so that educators can create a conducive and enjoyable learning environment (Kurniawati & Siswanto, 2024). This strategy often involves formal training, such as seminars and workshops, as well as informal coaching, such as mentoring and group discussions (Chan-Anteza, 2020). In practice, Adrianto added that this strategy must be tailored to the needs of individual educators and the goals of the educational institutions where they work (Andrianto, 2019). Thus, educators not only teach but also become facilitators who are able to empower students.

As for improving professional competence, according to Qobilovna, it is an effort made to develop a person's abilities, skills, and knowledge in the field of work pursued (Qobilovna, 2023). Professional competence includes technical ability, mastery of material, and special expertise relevant to job duties and responsibilities (Napitupulu, 2020). Suchyadi added that this improvement effort aims to ensure that individuals are able to work effectively, productively and meet applicable professional standards (Suchyadi et al., 2020). With improved competencies, a professional can face job challenges that are increasingly complex and change with the times (García-Pérez et al., 2021).

In line with Ridei's statement, improving professional competence usually involves various activities, such as training, further education, certification, or direct experience in the field (Ridei, 2021). This process not only helps individuals to improve their work performance but also opens up wider career opportunities. Professional competence also involves aspects such as critical thinking, problem-solving, and appropriate decision-making (Cruz, 2020). Thus, the definition of educator development strategies and the improvement of professional competencies are important steps to ensure educators are able to face the evolving challenges of education. Through training, coaching, and continuous development, educators can improve their teaching quality and become effective facilitators. This approach also opens up wider career opportunities and ensures the relevance of expertise to the future demands of the profession.

As stated by Budiharso that educators have an important role in producing a quality and competitive generation in society (Budiharso & Tarman, 2020). However, it is slightly different in application or in practice according to Simamora et al, where many educators face various challenges, such as limited ability to master technology, lack of renewal of learning methods, and lack of access to relevant training (Simamora et al., 2020). This often causes a gap between the competence of educators and the growing demands of education. In the presentation of Beribe research results that in the era of globalization, education requires educators who are able to adapt to curriculum changes, digital technology, and the increasingly complex and diverse needs of students (Beribe, 2023).

According to Szabo, educator development strategies are the main solution to overcome various problems in education (Szabo, 2020). Through continuing education, training, and ongoing coaching, educators can improve their abilities professionally (Hullinger & DiGirolamo, 2020). In contrast to Teachers' submissions that the implementation of this strategy is often not optimal due to various obstacles, such as the lack of budget, the lack of appropriate training programs, and the low motivation of educators to develop themselves (Villa & Manalo, 2020). This statement is reinforced by Rossoni that the lack of collaboration between educational institutions, the government, and the community is also an inhibiting factor in the implementation of this development strategy (Rossoni, 2024).

The strategy of developing educators and improving professional competence has a gap that lies in the difference between ideal needs and reality in the field (Jamil & Thohir, 2023). Based on the explanation, various studies above emphasize the importance of continuous training, coaching, and adjusting strategies to the needs of individual educators. However, its implementation often faces obstacles such as budget constraints, a lack of relevant training programs, and low motivation of educators to participate. In addition, factors such as lack of technological mastery, curriculum changes, and diverse learner needs pose major challenges. This gap shows that although strategies have been formulated, their implementation has not been able to effectively address the demands of globalization and the complexity of education.

Based on this explanation, it can be inferred that the problem of educator development strategies and improving professional competence also occurs at the research location to be studied, namely at Bani Hasyim Islamic Junior High School, Singosari. This school is in an educational environment that continues to develop and is exposed to the demands of globalization, such as the implementation of an independent learning curriculum, the use of learning technology, and the diverse characteristics of students. However, in practice, there is still a gap between the ideal demands of educator competence and the reality on the ground. Some teachers experience limitations in accessing relevant professional training, a lack of renewal of teaching methods, and low motivation to develop themselves continuously. In addition, support from the school and external collaboration, such as from the education office or professional community, still need to be strengthened so that teacher development strategies can run optimally and sustainably following current educational dynamics. Thus, this study is relevant to examine in depth what strategies have been and can be implemented at Bani Hasyim Islamic Junior High School, Singosari, in order to bridge the gap between ideal needs and reality in developing educators.

Thus, further research is needed to explore new approaches that are not only theoretically effective but also applicable and able to answer the needs of educators in various social and cultural contexts. This research is presented to formulate effective educator development strategies in order to improve professional competence. This research focuses on identifying the needs of educators, mastering technology, updating learning methods, and increasing collaboration between schools, government, and the community. Thus, it is expected that the results of the research can provide applicable solutions that support the quality of learning, curriculum relevance, and educators' ability to face educational challenges in the era of globalization.

Currently, educator development strategies are an important focus in improving professional competencies to face educational challenges in the era of globalization. Various efforts, such as training, continuing education, and coaching, continue to be carried out to strengthen teachers' capacity in mastering subject matter, learning methods, technology, and classroom management. However, on the ground, there are still many obstacles faced, such as limited access to training, lack of updates in methods, and low motivation among teachers to develop continuously. Additionally, institutional support and external collaboration are also not yet optimal. The gap between ideal needs and reality is the main obstacle to achieving the goals of teacher professional development. Therefore, this study aims to identify practical strategies that have been and can be implemented at Bani Hasyim Islamic Junior High School, Singosari, to bridge this gap. The research focuses on an approach that is contextual, sustainable, and relevant to the current dynamics of education.

METHOD

This research is related to the Development Strategy of Educators in order to Improve Professional Competence. This research uses a descriptive qualitative approach in the form of a case study with a single case study design (Creswell, 2010). The location of the research is Bani Hasyim Islamic Junior High School under the Bani Hasyim Foundation's Masjidil Ilmi, located at Persada Bhayangkara Singosari Housing Complex, Block L-K, Pagentan, Singosari, Malang. The data source in this research is all the facts and figures that can be used as material to compile information. While the main data sources in research are words and actions, the rest are additional data, such as documents, photographs, and others that are closely related to this research. The method that researchers use to determine informants is to use probability techniques (sampling is not based on chance) with the types of "purposive sampling and snowball sampling".

Furthermore, the informants in this study are the Principal, Vice Principal for Curriculum, Vice Principal for Student Affairs & Facilities and Infrastructure, Head of National Examinations & Indonesian Language Teacher, English and Arabic Teachers, and Religion Teachers. Data collection is done through three ways, namely, in-depth interviews to collect information in the form of verbal words (verbal), participant observation to understand the attitudes/actions that occur, and document analysis in the form of writings, pictures, recording, and so on. Furthermore, the informants in this study consist of 23 individuals, including the Principal, Vice Principal for

Curriculum, Vice Principal for Student Affairs & Facilities and Infrastructure, Head of National Examinations & Indonesian Language Teacher, as well as teachers of English, Arabic, and Islamic Religion. Data collection is carried out through three techniques, namely:

a. In-depth interviews to collect verbal information from key informants,
b. Participant observation to understand real-time actions, behaviors, and attitudes,
c. Document analysis, including writings, photos, and recordings relevant to educator development and professional competence.

Table 1. Informants in the Study

No.	Position / Role	Number of Informants
1	Principal	1
2	Vice Principal for Curriculum	1
3	Vice Principal for Student Affairs & Infrastructure	1
4	Head of National Examinations & Indonesian Language Teacher	1
5	English Teacher	5
6	Arabic Teacher	7
7	Islamic Religion Teacher	7
Total		**23**

Table 2. Interview Guideline Instrument

No.	Focus Area	Sample Interview Questions
1	Educator Development Strategies	What efforts have been made by the school to improve teachers' professional competence?
2	Challenges in Implementation	What obstacles do you face in implementing teacher development programs?
3	Training and Coaching	Are there continuous training or mentoring programs provided by the school or externally?
4	Motivation and Participation	How motivated are the teachers in participating in self-development activities?
5	Role of Stakeholders	How is the collaboration between the school, government, and community in teacher training?
6	Impact on Teaching Quality	In your opinion, how does professional development affect the teaching and learning process?

The data analysis used is interactive model analysis as proposed by Miles and Huberman, that data analysis begins with the process of data collection, data condensation, data presentation, and then ends with verification or conclusion drawing. The stages in this research are in the form of research stages that researchers fully carry out by working inductively. Researchers first explored the field. For more details, the stages in question can be seen in the following Figure 1.
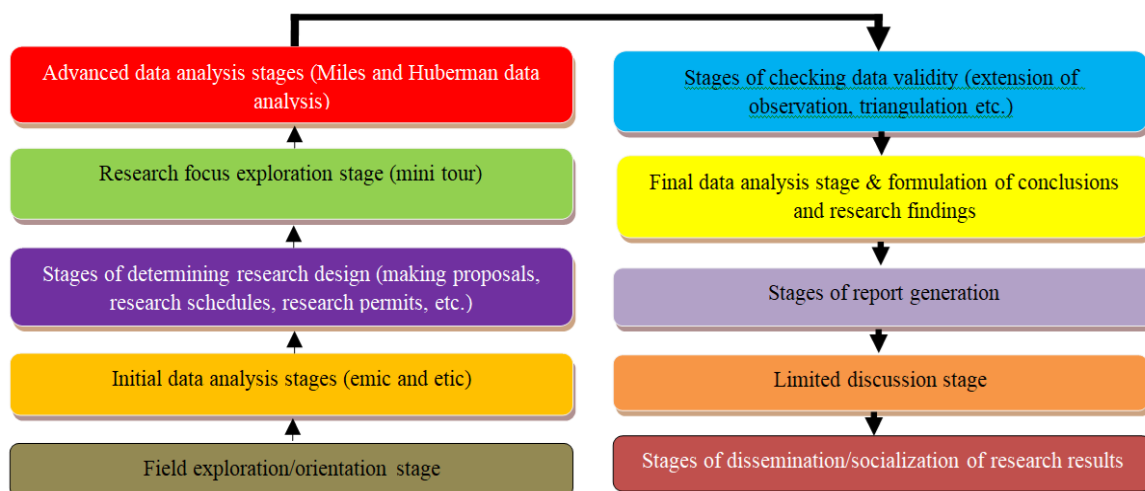

Figure 1. Research Stages

RESULTS AND DISCUSSION

Results

This study found that in order to improve the professional competence of teaching staff, Bani Hasyim Islamic Junior High School, Singosari, Malang, implemented several strategies, namely education and training. This is done because educators are positioned as role models, protectors, and mentors for students. Educators are required to be compassionate to students, treat them with high care, and assist them in the learning process as a whole. In addition, teachers also have the responsibility to continue to direct, give advice, and instill moral messages about the importance of knowledge and the future of students. Students should not proceed to a higher level of education before they have mastered the previous lessons and have good morals. Therefore, teachers must be able to maintain a balance between the development of knowledge and the formation of moral character in the learning process.

Training, on the other hand, is more focused on developing practical skills that are relevant to specific needs, both for individuals and organizations. Training is designed to deepen specific abilities, such as technical, managerial, or soft skills like communication and teamwork. In the world of work, training is an effective tool to improve employee productivity and the quality of their performance. The combination of strong education and proper training allows a person to not only have a solid theoretical foundation but also be able to implement it effectively in real situations. Further, the following description of the educator development strategy applied by Bani Hasyim Islamic Junior High School, Singosari, to improve professional competence, the strategy is categorized in the following Figure 2.
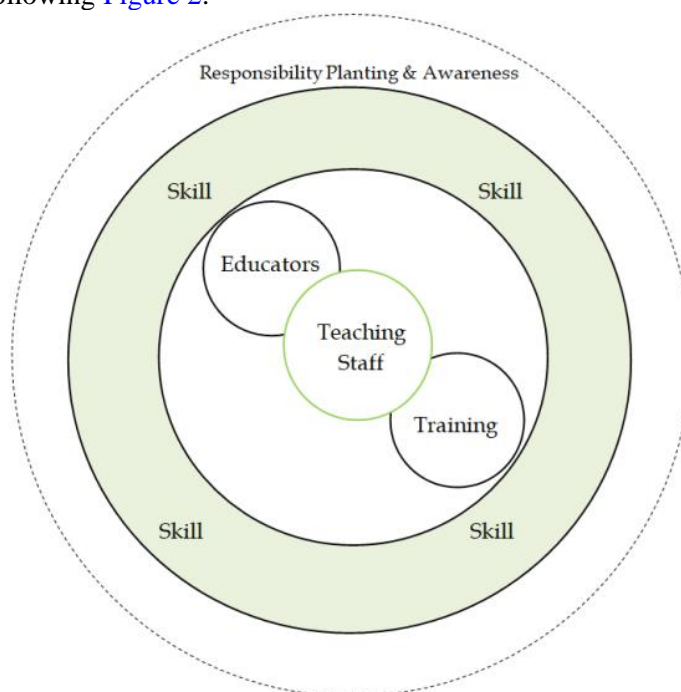
Figure 2. Classification of Educator Development Strategies (Continuous Development)

In Figure 2 above, it can be understood that the roles of educators and trainers are complementary in shaping the skills and competence of teaching staff, especially in instilling and realizing a strong sense of responsibility. Educators play a crucial role in providing a solid foundation of ethical values, moral character, and professionalism, which are essential in guiding students effectively. On the other hand, training plays a vital role in equipping educators with practical skills, such as innovative teaching techniques, effective communication strategies, and the ability to motivate and engage learners. Through the integration of strong educational values and continuous training, educators are better prepared to carry out their duties professionally and to contribute meaningfully to the improvement of the quality of education.

Education

Education in organizations plays an essential role as a process to develop individual abilities that are in line with the organization's goals. Through education, members of the organization can enhance their knowledge, broaden their insights, and sharpen skills that support the achievement of institutional missions. Structured educational efforts not only help individuals master technical competencies but also foster an understanding of organizational values and work culture. This ensures that each member is aware of their responsibilities and roles within the system. In practice, education also functions as a bridge that connects personal potential with organizational expectations. With proper implementation, education becomes a strategic tool to increase employee productivity and institutional effectiveness. Ultimately, this contributes to the overall success and sustainability of the organization.

In facing the increasingly complex realities of the world of work, organizations need human resources who not only have technical skills but are also able to think strategically and adaptively. Education is key in building this capacity by equipping organizational members with the latest knowledge and innovative approaches. With the right education, organizations can create a productive work environment, increase job satisfaction, and strengthen employees' commitment to common goals. In addition, education helps individuals understand their values, work culture, and responsibilities within the organization. This promotes synergy between individual competencies and organizational needs. A structured education process also enables employees to contribute optimally to achieving the organization's vision and mission. Therefore, education is not only a means of development but also a strategic investment for long-term success.

Based on the results of the study, it was found that the strategy of developing teaching staff at Bani Hasyim Islamic Junior High School through education is implemented by providing free opportunities for educators to pursue further studies. Educators who have received this educational support are expected to enhance their quality and capacity to contribute to the school's future progress. Education within the organization is positioned as a strategic element that supports both personal and professional growth of teaching staff. It ensures that the abilities of educators align with the institution's vision, mission, and developmental goals. Through structured educational programs, teachers are better prepared to face dynamic educational demands. This alignment helps create a productive, responsive, and sustainable school environment. Thus, education becomes not only a tool for competence building but also a means of institutional transformation.

Educator Training

From the results of the researcher's analysis based on information obtained from several informants, it was found that one of the main reasons for the implementation of educator development strategies is that Bani Hasyim Islamic Junior High School is a newly established private institution that is still in the development stage. Therefore, efforts to improve the quality of educators are considered essential in order to build a strong educational foundation. The school recognizes that the competence of educators plays a central role in determining the success of the learning process. High-quality educators are those who not only master the teaching materials but also have good pedagogical skills. They are expected to be able to apply various learning methods that suit the needs of students. In addition, educators are required to understand and utilize technology to support effective learning. These various aspects are crucial in creating a quality and future-oriented educational environment.

The urgency of improving the quality of educators is increasingly felt in the midst of the growing dynamics of the world of education. The ever-changing curriculum, the diverse needs of students, and the demands of globalization require educators to continue to learn and adapt. In this context, training, workshops, and further education are important means to support the improvement of teacher competence. Good quality educators can create an inclusive, creative, and inspiring learning atmosphere. This not only has an impact on improving student learning achievement, but also on the image and competitiveness of the educational institution as a whole. Educational institutions that have qualified educators will be better prepared to face the challenges

of the times and be able to produce competent graduates. Therefore, improving the quality of educators is a priority to realize relevant and sustainable education.

The second finding reveals that the knowledge of educators at Bani Hasyim Islamic Junior High School continues to be upgraded in line with the development of globalization and advances in science and technology. This ongoing improvement is seen as a crucial step to ensure that educators remain relevant and responsive to the evolving demands of education. Despite these changes, the school remains committed to maintaining its unique characteristics and Islamic values. Educators are encouraged to enhance their competencies, especially in mastering new teaching tools and methods that support engaging and effective learning. The goal is to integrate technological advancements without losing the school's identity. This balance is essential in shaping educators who are both modern and rooted in moral values. Continuous development ensures they are ready to face global challenges while fostering a meaningful learning environment.

The urgency of improving educators' knowledge is closely related to the need to face future challenges and seize opportunities in the education sector. Changes in curriculum, educational policies, and the demands of the job market require educators to be adaptable and responsive. Training, workshops, and continuous education programs serve as effective tools to help educators stay updated with current developments and teaching innovations. Mastery of digital technology also enables teachers to optimize distance learning, manage classrooms more efficiently, and conduct assessments effectively. With these competencies, educators can create engaging learning environments and enhance student learning outcomes. Continuous knowledge upgrading also contributes to building a more competitive and progressive educational institution. Therefore, improving educators' capabilities is not just a necessity but a strategic effort to ensure educational relevance in the global era.

As for the training held at Bani Hasyim Islamic Junior High School, based on the research findings, it can be seen in the following table of educator training categorization:
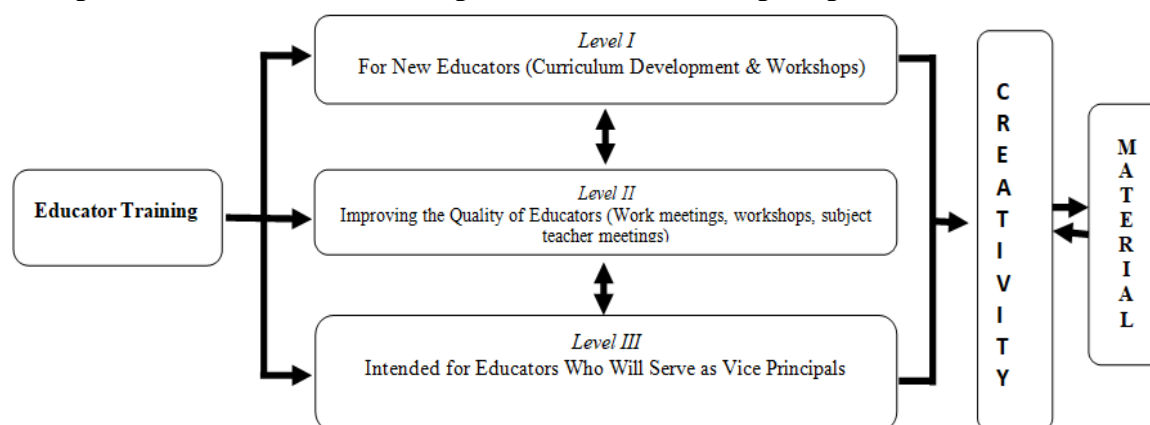
Figure 3. Forms of Training

a.   Level I: New Educators (Curriculum Development & Workshops)

New educators require development through targeted training programs to ensure that the quality of education remains relevant and sustainable. Such training allows them to continuously update their knowledge and teaching skills, particularly in adapting to changes in curriculum, technological advancements, and the evolving needs of learners. Educators are expected to master effective teaching methods, utilize digital tools in the classroom, and apply creative as well as inclusive learning strategies. Training also plays a vital role in enhancing communication skills, improving classroom management, and strengthening problem-solving abilities. As education becomes increasingly global, teachers must be prepared to face international standards and challenges. Therefore, well-structured training is essential in building professional educators who are adaptable and competent. This development ensures that they can contribute effectively to creating a responsive and forward-looking educational environment.

For new educators, curriculum workshops are conducted as part of training activities that provide space to discuss learning objectives, materials, methods, and evaluation collaboratively. These workshops aim to produce a curriculum that is more applicable and adaptive to current educational needs. Through these activities, educators gain a deeper understanding of the curriculum's structure and implementation in the classroom. They are also trained to align curriculum content with the use of educational technology, as well as to consider both local and global educational contexts. This process strengthens their ability to plan and deliver learning effectively. Participation in such workshops helps educators develop their professional competence in a practical way. Ultimately, this contributes to the creation of higher-quality education that meets future challenges.

b. Level II: Educator Quality Improvement

Improving the quality of educators is a crucial step in ensuring the quality of education by the demands of the times. Qualified educators not only master the teaching material in depth but are also able to apply innovative and relevant learning methods. This enables them to create learning that is effective, engaging, and able to respond to the increasingly diverse needs of learners. In addition, quality improvement also includes the ability to utilize technology and keep up with the latest developments in science and education. That way, the learning process not only produces academically intelligent students but also equips them with the competence to compete at the global level. Educators who continue to develop themselves will be able to create an adaptive, creative, and transformative classroom atmosphere. Therefore, investment in improving the quality of educators is very strategic for the progress of education.

Improving the quality of educators in the form of working meetings (Raker) is done by providing a space for educators to collectively discuss challenges and opportunities in the implementation of learning. In this forum, teachers can share best practices, evaluate the curriculum, and design learning strategies that are more effective and relevant to students' needs. Working meetings are also a means to update teachers' understanding of the latest education policies, technological developments, and modern pedagogical approaches. Through this collaboration, educators can improve their communication, coordination, and innovation skills in carrying out their duties. In addition, this activity is also used to align the vision and mission of education adopted by the school with the learning practices carried out. The aim is to create an education system that is adaptive, high-quality quality and able to respond to the challenges of the times. Thus, working meetings are an important element in efforts to improve the quality of educators sustainably.

Improving the quality of educators through workshops provides an interactive and applicable learning experience, where educators can understand firsthand the latest learning methods. In this activity, teachers are engaged in discussions, simulations, and practical sessions designed to develop pedagogical skills as well as the utilization of technology in the learning process. In addition, creative approaches to teaching are honed through collaborative activities. Workshops provide a space to exchange ideas, experiences, and solutions to challenges faced in teaching. Through direct experience gained during the training, educators become more confident in implementing effective learning strategies. This activity also strengthens the spirit of cooperation and innovation among fellow teachers. Thus, the workshop is an appropriate means of improving the quality and professionalism of educators.

Improving the quality of educators through Subject Teacher Conferences is carried out by providing space for teachers to engage in discussions with fellow educators from outside the foundation or from different schools. In these forums, teachers can share teaching experiences, exchange ideas, and work together to find solutions to challenges in delivering subject materials. This activity is seen as effective in fostering innovation and creativity in the teaching process, making learning more interesting and responsive to the needs of students. Teachers also gain new insights into various teaching strategies that can be applied in the classroom. Besides that, Subject Teacher Conferences help build professional collaboration among educators, enabling mutual support and idea exchange. Teachers are also able to stay updated with the latest developments in curriculum and educational regulations. Through this

collaborative effort, the professional competence of teachers continues to develop dynamically and sustainably.

c. Level III: Intended for Educators who will serve as Vice Principal

Educator training for prospective Vice Principals plays an important role in preparing individuals for more complex tasks and responsibilities. The training aims to improve managerial, leadership, and decision-making competencies that are needed to support successful school management. Training materials usually cover curriculum management, education administration, human resource management, learning supervision strategies, as well as communication and negotiation skills. By attending this training, prospective vice principals can hone their ability to perform their roles with more confidence and professionalism. This is very important so that they are able to create a quality and sustainable educational environment. In addition, the training also provides a broader understanding of school organizational dynamics and quality improvement strategies. Thus, this training is a strategic step in producing educational leaders who are ready to face the challenges of the times.

Cultivating and Realizing a Sense of Responsibility

Increasing the professional competence of educators through education and training is then realized in real terms through the cultivation and awareness of responsibility. The responsibility that is instilled and realized is not solely oriented towards material benefits, such as salary, money, or other luxuries. However, it is more of a moral responsibility based on sincere intentions in educating and guiding students. Educators understand that their job is a mandate that must be carried out with dedication and sincerity. This responsibility is born from self-awareness to do good and right things in educating the next generation of the nation. In practice, this responsibility is reflected in the diligence, patience, and concern of educators for the development of their students. Therefore, the success of learning is not only measured by academic results, but also by the character and personality of the students.

Based on the results of the research, it can be concluded that the value and meaning of responsibility from the perspective of Bani Hasyim Islamic Junior High School are presented in the following Figure 4.
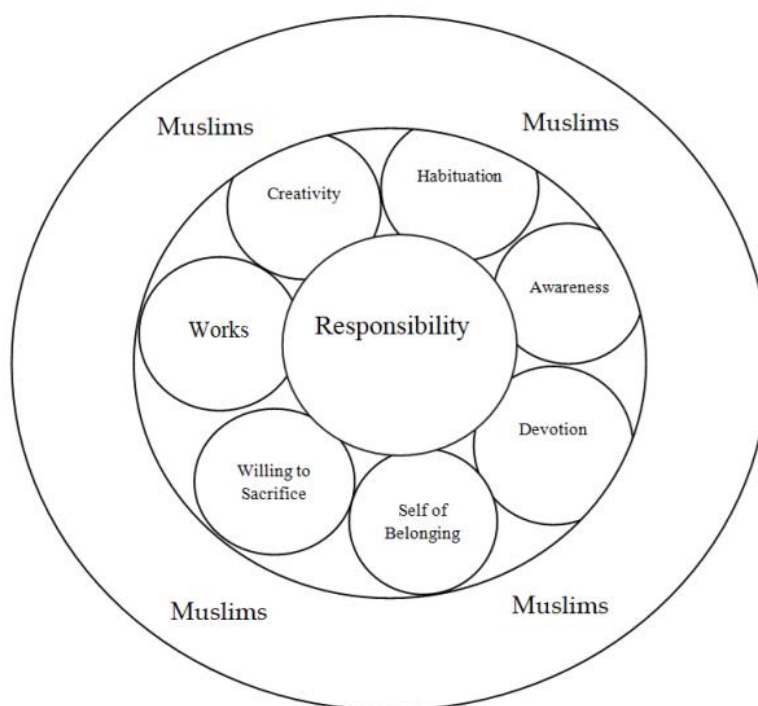

Figure 4. The Value and Meaning of Responsibility from the Perspective of Bani Hasyim Singosari Islamic Junior High School

In Figure 4 above, it can be understood that planting and awareness of responsibility in educators has been cultivated in Bani Hasyim Islamic Junior High School, this is because educators realize and believe that educating and teaching is a responsibility as Muslims. The impact of the cultivation of responsibility in educators is to facilitate the teaching and learning process. Meanwhile, the benchmark for knowing whether educators are responsible can be seen from the smooth learning and teaching process. So that learning activities, starting from preparation to evaluation, are left entirely to educators, activities managed by educators emphasize how to develop the creativity, personality, and mindset of students, not just their competence. So that indirectly, the knowledge and personality of the santri are formed.

The duties of an educator can be described coherently based on their roles and dominant levels. First, educating by teaching is the most dominant form, as it involves the direct transfer of knowledge and shaping students' understanding. Second, educating by encouraging plays an important role in motivating students and building their self-confidence. Third, educating by example is essential, as teachers become role models through their behavior and attitudes. Fourth, educating by praise helps reinforce positive behavior and build a supportive learning environment. Fifth, educating by habituation forms consistent routines and discipline that shape student character. Sixth, educators also play a role in educating through other means, such as storytelling, discussions, and reflection. All of these duties reflect the comprehensive function of educators in developing students' intellectual, emotional, and moral qualities.

Discussion

Education plays a crucial role in organizational development as it serves as a means to align individual competencies with institutional goals. As Soomro states, through education, members of an organization can enhance their knowledge, insight, and skills in ways that support the organization's vision and mission (Soomro et al., 2020). Structured educational programs allow individuals not only to understand the values and culture of the institution but also to fully embrace their responsibilities within it (Akpa et al., 2021). This alignment is essential for optimizing each individual's contribution to organizational advancement, as emphasized by Lomis (Lomis et al., 2021).

The need for strategically-minded and adaptable human resources is increasingly urgent in today's complex and dynamic work environment. Education becomes a vital mechanism to build this capacity, equipping individuals with current knowledge and innovative strategies, as noted by Ishak and Mansor (Ishak & Mansor, 2020). When carried out effectively, education fosters a productive work environment, enhances job satisfaction, and increases commitment to shared goals (Basalamah & As'ad, 2021). Moreover, Sitopu highlights that education must be seen not only as a development tool but also as a strategic investment that ensures an organization's long-term sustainability (Sitopu et al., 2024).

This discussion is supported by findings that highlight the use of education as a core strategy in developing teaching staff through facilitating access to further studies. This approach is based on the belief that advanced education improves the quality and capacity of educators, ensuring they are better equipped to face future educational demands. Such a model confirms Rojak assertion that with structured education, organizational members are more likely to internalize institutional values, adapt to its culture, and fulfill their responsibilities effectively, thus contributing optimally toward achieving the organization's broader goals (Rojak et al., 2024).

The findings of this study highlight that educator training is an essential strategy in improving the professional competence of teachers, particularly in schools that are still in the development phase. This is in line with the view of González-Pérez & Ramírez-Montoya, who emphasize that educators are the central pillar of the learning process, and their competence significantly influences students' academic success (González-Pérez & Ramírez-Montoya, 2022). Supporting this, Akram noted that educator quality encompasses mastery of teaching materials, pedagogical expertise, and the integration of technology into instructional practice (Akram et al., 2021).

The urgency of training is amplified by the rapid transformation within the education sector, driven by curriculum changes, diversified student needs, and globalization pressures. Smeplass stresses that training programs, workshops, and continued education play a critical role in enabling educators to respond to such challenges (Smeplass, 2023). These developmental interventions empower teachers to create inclusive, creative, and inspirational classroom environments. Similarly, Díez points out that high-quality educators not only elevate student outcomes but also strengthen institutional competitiveness (Díez et al., 2020).

Another important discussion point is that educators' knowledge must be continuously updated in response to globalization and technological advancement. Rosa & Mujiarto argue that educators must adapt swiftly to remain relevant (Rosa & Mujiarto, 2020). Goodwin further states that globalization reshapes educational contexts, demanding globally competitive teachers (Goodwin, 2020). Fischer adds that mastering emerging educational technologies is necessary for providing engaging and modern learning experiences. Law emphasizes that rapid shifts in curriculum and job market expectations necessitate educators who are flexible and up to date (Law, 2022), while Oliveira highlights the importance of digital fluency for distance learning and classroom efficiency (Oliveira et al., 2021).

To support these needs, the categorization of training into structured levels proves strategic. At Level I, new educators participate in curriculum development and workshops to equip themselves with updated knowledge, modern teaching methods, and inclusive strategies (Kjellgren & Richter, 2021; Ozen & Yildirim, 2022; Sorochan et al., 2024). Curriculum workshops also help educators align content with local and global contexts while encouraging collaborative reflection (Makumane & Khoza, 2020; Shonfeld et al., 2021).

At Level II, efforts focus on educator quality improvement through working meetings, interactive workshops, and Subject Teacher Conferences (MGMP). Lukman et al., (2021) and Fawait, et al., (2024) underline the importance of innovative methods and technological adaptation to meet evolving student expectations. Meetings provide collaborative forums to share best practices and respond to educational shifts (Ahmed & Opoku, 2022; Tesema & Fathoni, 2023). Similarly, interactive workshops foster real-world teaching confidence (Ledger & Fischetti, 2020; Munna & Kalam, 2021), while MGMP supports interschool professional networks and the dissemination of updated policies (Ismail et al., 2022; Miranda & Chapman, 2024).

Level III training, designed for teachers assuming leadership roles such as vice principal, is equally important. Leadership development in education requires managerial, supervisory, and decision-making training to effectively manage academic environments (Hayes & Burkett, 2021; Nuha & Musyafa'ah, 2022). These trainings build confidence and competence in navigating the complexities of school leadership. Beyond training and education, a unique aspect revealed is the internalization of moral and religious responsibility as a foundation for professional conduct. This sense of duty is not oriented toward material gain but is rooted in ethical and spiritual values. Torelli explains that moral responsibility reflects ethical awareness (Torelli, 2021), while Yatim contextualizes this as a form of Islamic worship when actions are carried out with sincerity and according to Sharia principles (Yatim et al., 2023). This moral grounding enhances educators' commitment to nurturing student character and competence.

The manifestation of responsibility can be observed in the autonomy educators have over the entire learning process, from planning to evaluation. The emphasis is not only on competence but also on developing the personality, creativity, and mindset of students. Educators embody responsibility by their consistent actions and ethical modeling, which aligns with the following categorized roles: (1) educating by teaching (most dominant), (2) educating by encouraging (ordinary), (3) educating by example (normal), (4) educating by praise (moderate), (5) educating by habituation (dominant), and (6) educating by other means (dominant), as described by Crompton & Burke, Hanafi, Rapanta, Glerum, and Gunowa (Crompton & Burke, 2023; Glerum et al., 2020; Hanafi et al., 2021; Gunowa et al., 2021; Rapanta et al., 2021). In conclusion, the integration of training, education, and moral responsibility forms a holistic framework for enhancing educator professionalism. These findings affirm that both structural interventions and internal values are necessary to address the dynamic demands of modern education.

CONCLUSION

Based on the various reviews that the researchers have described in the results and discussion, the researchers draw a conclusion related to the Educator Development Strategy in the Framework of Improving Professional Competence at Bani Hasyim Singosari Islamic Junior High School, Malang. Based on the focus of the research problem, namely: the strategy of developing educators in order to improve professional competence is categorized into three strategies, namely: First, the Education Strategy is promoted through the form of free lectures for educators, as a form of organizational goals, strategic and adaptive thinking resources; Second, the Educator Training Strategy, this training is carried out in three stages, namely: Level 1; which is intended for new educators, Level II; in order to improve the quality of educators, and Level III: intended for educators who will serve as Vice Principals. Third, the Strategy of Cultivating and Realizing a Sense of Responsibility, which is applied in its operational level, is applied in real terms through: Educating by teaching, Educating by encouraging, Educating by example, Educating by praising, Educating by familiarizing, and Educating in other ways. As a recommendation for further research, it is suggested to conduct a comparative study between educator development strategies in Islamic-based private schools and public schools, or to explore in-depth the impact of these strategies on measurable outcomes such as student academic performance, teacher retention, and organizational innovation. Furthermore, future studies could also analyze the role of digital-based training platforms in enhancing teacher professional competence in the post-pandemic educational landscape.

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Students and lecturers' perspectives on MOOCs as an educational innovation for sustainable learning

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ABSTRACT

The integration of Massive Open Online Courses (MOOCs) into higher education in Indonesia continues to face significant challenges, particularly regarding their effectiveness in supporting sustainable learning. Most prior studies have predominantly focused on technical aspects such as platform usage and user participation rates. At the same time, limited attention has been given to the impact of MOOCs on long-term skill development, learner autonomy, and their formal integration into academic curricula. This study offers a novel contribution by deeply exploring the perspectives of both students and lecturers on MOOCs as an educational innovation for sustainable learning in higher education. Employing a mixed-methods approach, the research utilized the MOOC Integration Perception Scale (MIPS) for quantitative data and the MOOC Sustainability Interview Protocol (MSIP) for qualitative inquiry. A total of 120 students and 20 lecturers from diverse Indonesian universities participated as respondents. Quantitative data were analyzed using descriptive statistics and independent samples t-tests, while qualitative data were examined through thematic analysis. Findings reveal that both students and lecturers highly value the flexibility and accessibility of MOOCs, especially in overcoming geographic and temporal barriers. However, concerns remain about the lack of direct interaction and the limited provision of personalized feedback, which hinders the pedagogical depth of these platforms. This study recommends the development of blended learning models and improvements in digital infrastructure, especially in underdeveloped regions, as strategic efforts to enhance MOOC integration in higher education. Future research should adopt longitudinal approaches to assess the long-term effects of MOOCs on learning outcomes, skill development, and learner autonomy.

INTRODUCTION

The rapid advancement of digital technologies over the past decade has profoundly transformed educational systems worldwide, notably through the emergence of Massive Open Online Courses (MOOCs), which offer unprecedented access to learning opportunities beyond geographical limitations. Observations by the author suggest that MOOCs are no longer merely

utilized as emergency alternatives during crises such as the COVID-19 pandemic; rather, they are increasingly considered integral components of long-term learning strategies in higher education institutions. MOOCs provide temporal and spatial flexibility, enabling learners to access thousands of modules from prestigious universities either for free or at low cost. However, in practice, the integration of MOOCs into formal education remains suboptimal, particularly in fostering sustainable learning outcomes. While many institutions have begun to adopt MOOCs, there remains a lack of clarity regarding how these courses contribute to the long-term development of student competencies or address the demands of 21st-century skills, including critical thinking, collaboration, and complex problem-solving. This study, therefore, aims to critically examine students' and lecturers' perceptions of MOOC integration in higher education and to explore how these platforms can be strategically leveraged to support sustainable learning and the development of future-relevant skills.

Online Courses (MOOCs) and their actual implementation in supporting sustainable learning. While MOOCs are envisioned as tools to bridge educational access gaps and enhance learning quality, several persistent challenges continue to hinder the realization of these goals. According to UNESCO data, over 60% of MOOC participants in developing countries do not complete their courses, and fewer than 10% report applying the knowledge gained to real-life or professional contexts (Senevirathne et al., 2022). This shortfall is further exacerbated by the fact that most MOOCs remain predominantly informative in nature, lacking the integration of active and reflective learning approaches necessary for sustainable learning outcomes (Zhou et al., 2025). Additionally, many MOOCs are not contextually adapted to the specific needs and learning characteristics of students in higher education, calling into question their alignment with national curricula and local educational priorities (García-Peñalvo et al., 2018). Another critical concern is the absence of standardized assessment systems to evaluate the long-term educational impact of MOOCs, particularly in fostering the internalization of sustainability values, interdisciplinary collaboration, and the development of lifelong learning dispositions. These gaps underscore the urgent need for a more strategic and pedagogically grounded approach to MOOC integration within higher education systems.

The novelty of this study lies in its conceptual departure from prior research that predominantly emphasizes the technical dimensions of MOOCs, such as user interface design or platform engagement, toward positioning MOOCs as integral components of sustainable learning systems in higher education. Unlike previous studies, such as Li et al., (2024), which primarily focused on user experiences and platform usability, this research aims to critically examine the role of MOOCs in fostering long-term educational transformation. Similarly, works by Aparicio et al., (2019) and Hughes (2025) assessed MOOCs through the lenses of gamification and learning retention rates, while Wei & Taecharungroj (2022) concentrated on business models and patterns of technological adoption. Hendriks et al., (2024) explored students' motivations for enrolling in MOOCs but did not address their broader impact on sustainable learning outcomes. Even comprehensive global reviews by Berde et al., (2024) and Ruipérez-Valiente et al., (2022), despite mapping the evolution of MOOCs, fell short of investigating how these platforms can be systematically integrated into higher education to cultivate sustainable competencies. This study, therefore, fills a critical gap in the literature by exploring both student and lecturer perspectives on MOOC integration as a strategic mechanism for promoting sustainable learning within the higher education landscape.

Departing from the predominantly technical, institutional, and motivational approaches adopted in previous studies (Rivera et al., 2025; Harnadi et al., 2024; Gao, 2024), this research offers a holistic perspective that integrates user perceptions with an analysis of curriculum policy implementation and the long-term potential for capacity development in learning. By bridging individual experiences with systemic educational frameworks, the study contributes significantly to the existing body of literature. It introduces a conceptual model for the integration of MOOCs into higher education curricula grounded in the principles of sustainable learning. Furthermore, it provides strategic, context-specific, and actionable recommendations for higher education institutions navigating the challenges and opportunities of digital transformation. This dual

emphasis on pedagogical relevance and institutional alignment positions the study as a timely and impactful contribution to advancing educational innovation in a rapidly evolving global landscape.

Building on the aforementioned discussion, this study aims to critically explore and analyze students' and lecturers' perceptions of the integration of Massive Open Online Courses (MOOCs) into higher education, with particular emphasis on their role in supporting sustainable learning and the development of long-term skills. The objective is not only to generate empirical findings, but also to contribute theoretically by proposing an adaptive framework for MOOC implementation that responds to the evolving challenges of future education. The outcomes of this study are expected to serve as a foundation for institutional policymaking in developing hybrid learning models grounded in the principles of sustainable education and aligned with the competencies required in the 21st century.

METHOD

Type of Research

The approach in this study uses a mixed method, combining quantitative and qualitative methods. The quantitative aspect focuses on measuring students' and lecturers' perceptions through structured questionnaires. The qualitative component involves in-depth interviews in exploring lecturers' and students' perspectives comprehensively. Identifying the challenges and opportunities of MOOCs and their role in supporting continuous learning in higher education is the aim of this study.

Research Subjects

This study focused on two groups of participants with direct experience in the use and integration of Massive Open Online Courses (MOOCs) within the context of higher education. The first group consisted of 120 undergraduate students from Nurul Jadid University who had participated in MOOC-based learning for at least one academic semester. The second group comprised 20 faculty members who had integrated MOOCs into their teaching practices for a minimum of one semester.

Participants were selected purposively using a purposive sampling technique, based on their active involvement and the relevance of their experience to the research objectives. This sampling strategy was chosen to ensure the collection of rich and contextually grounded data, allowing for an in-depth exploration of perceptions, effectiveness, as well as the challenges and opportunities associated with MOOC implementation in higher education.

Research Procedure

The research procedure began with the collection of quantitative data through questionnaires distributed to students and lecturers at Nurul Jadid University. After quantitative data were collected, in-depth interviews were conducted with selected respondents based on questionnaire responses to gain deeper insight into perceptions and experiences of MOOCs.

The research procedure follows the following steps, 1) Developing a questionnaire and interview guide; 2) Distributing the questionnaire to selected respondents; 3) Analyzing the questionnaire results to select interview participants; 4) Conducting in-depth interviews with students and lecturers of Nurul Jadid University; 5) Analyzing interview data and triangulating with the questionnaire results; 6) Writing a research report based on the findings.

Instruments and Data Collection

The primary data collection instruments employed in this study consisted of a structured questionnaire titled MOOC Integration Perception Scale (MIPS) and a semi-structured interview guide referred to as the MOOC Sustainability Interview Protocol (MSIP). The MIPS was developed to assess both students' and lecturers' perceptions of the effectiveness of MOOCs in supporting sustainable learning. It focused on key indicators such as flexibility, accessibility, self-paced learning, lack of direct interaction, and limited feedback mechanisms. Complementing the quantitative tool, the MSIP was used to gain deeper insights into participants' experiences and

opinions regarding MOOCs. The interviews explored themes including the sustainability of learning, the long-term benefits of MOOCs, and the pedagogical and institutional challenges lecturers face when integrating MOOCs into formal higher education settings.

Table 1. The Key Aspects of the Instrument

No.	Instrument	Type	Measured Indicators	Usage
1	Questionnaire	Structured Survey	Accessibility, Flexibility, Learning Outcomes, Challenges	Distributed to students and lecturers
2	Interview Guide	Semi-Structured	Sustainability of learning, Long-term benefits of MOOCs	Used for in-depth interviews

For data analysis, both quantitative and qualitative approaches were utilized. Quantitative data collected through the MIPS were analyzed using descriptive statistics, with independent sample t-tests conducted to compare perceptions between students and lecturers. This analysis aimed to identify prevailing trends and potential differences in attitudes toward MOOC effectiveness. Meanwhile, qualitative data obtained from the MSIP interviews were examined using thematic analysis. Interview transcripts were systematically coded according to recurring themes such as flexibility in learning, access to digital resources, the self-paced nature of MOOCs, limitations in direct interaction, and constraints in receiving timely and personalized feedback.

Instrument Validity and Reliability

To ensure the appropriateness and robustness of the research instruments used to measure students' and lecturers' perceptions of MOOC integration in sustainable learning, a comprehensive validity and reliability assessment was conducted. Content validity was established through expert judgment involving two specialists in the fields of instructional technology and MOOC research. These experts were invited to evaluate the relevance and alignment of each questionnaire item with the targeted indicators. Their feedback and recommendations were systematically incorporated to refine the wording and clarity of selected items, thereby enhancing the instrument's precision and construct alignment.

Table 2. Summary of Content Validity Assessment

No.	Area of Expertise	Feedback on Instrument Items	Information
1	Instructional Technology and e-Learning	The items in the MIPS scale are aligned with the indicators of sustainable learning and MOOC practices.	Valid
2	MOOC Research and Digital Curriculum	The instrument adequately covers key aspects such as flexibility, interaction, and digital accessibility.	Valid, with minor editorial revisions recommended for 2 items

Subsequently, a reliability test was conducted to evaluate the internal consistency of the questionnaire using Cronbach's Alpha coefficient. The results revealed that all dimensions of the MOOC Integration Perception Scale (MIPS) achieved $\alpha > 0.7$, indicating that the instrument items were consistently reliable. The overall Cronbach's Alpha score reached 0.882, which is categorized as highly reliable and demonstrates strong internal coherence across all measured constructs.

Table 3. Reliability Test of the MOOC Integration Perception Scale (MIPS)

No.	Theme	Item	Cronbach's Alpha	Information
1	Flexibility in learning	7	.821	Reliable
2	Accessibility to resources	6	.792	Reliable
3	Self-paced learning	7	.809	Reliable
4	Lack of direct interaction	6	.745	Quite Reliable
5	Limited opportunities for feedback	9	.857	Very Reliable
Total		**35**	**.882**	

Decision-Making Criteria

To ensure the trustworthiness of the qualitative interview data, validation procedures were carried out using triangulation and member checking techniques. Triangulation was employed to compare and cross-verify data obtained from interviews with the quantitative findings and relevant secondary sources, thereby enhancing the credibility of the interpretations. Member checking was conducted by soliciting feedback from participants on the accuracy of the researcher's interpretations, ensuring that the analyzed data authentically represented their perspectives and experiences.

For quantitative data analysis, decision-making will be based on the results of the t-test. Significant differences in student and lecturer perceptions will be considered if the p-value is less than 0.05. In qualitative analysis, decisions are made by the main themes that emerge from the data, considering the frequency and consistency of findings across respondents.

RESULTS AND DISCUSSION

Results

The research results are presented in both quantitative and qualitative forms to align with the mixed-methods approach of the study. The findings are displayed using descriptive statistics, tables, and graphical representations to provide clear insights into the data collected from the questionnaires and interviews.

Data collected through surveys and interviews revealed that both groups acknowledged the flexibility and accessibility that MOOCs provide, particularly in overcoming geographical barriers. However, a marked difference in perception emerged between the two groups. Students generally rated MOOCs better in terms of accessibility and flexibility, while lecturers expressed concerns about the lack of interaction and personalized feedback. To investigate whether the differences in perceptions between students and lecturers were statistically significant, an independent samples t-test was conducted.

Table 4. Independent t-Test Results: Students' and Lecturers' Perceptions of MOOCs

No.	Variabel	N	Mean	Std. Dev	t-value	p-value
1	Students' Perceptions	120	4.23	0.56	2.45	0.015*
2	Lecturers' Perceptions	20	3.85	0.65		

*Significant at $p < 0.05$

As shown in Table 4, the t-value of 2.45 with a p-value of 0.015 indicates a significant difference in perception between students and lecturers ($p < 0.05$). Students had higher mean scores (M = 4.23) than lecturers (M = 3.85), indicating that students were more satisfied with the flexibility and accessibility provided by MOOCs. The significant differences in students' and lecturers' perceptions indicate that although both groups acknowledge the advantages of MOOCs in terms of flexibility and accessibility, students tend to view these aspects more positively. Relevant to previous research, which found that students could access learning from anywhere according to their abilities (Zakaria et al., 2024). On the other hand, lecturers were critical of the lack of interaction and the inability to provide feedback, which are essential components of effective and personalized learning.

These findings highlight the potential of MOOCs to democratize education by expanding access. However, they also underscore the importance of addressing pedagogical challenges, such as increasing interaction and feedback mechanisms. Providing integrated MOOCs with traditional or hybrid learning can increase the effectiveness of learning in higher education environments. Qualitative data processing was obtained through in-depth interviews with selected students and lecturers. Thematic analysis revealed the following main themes:

Research Question 1: How do Students Perceive the Role of MOOCs in Supporting their Learning?

Through thematic analysis of interviews, students highlighted the flexibility, accessibility, and self-directed learning provided by MOOCs as the main benefits. Most students (85%) stated that MOOCs enable them to manage their time effectively and independently, balancing academic responsibilities. Students stated that MOOCs have opened the door to high-quality education.

Table 5. Key Themes from Student Interviews

No.	Theme	Frequency (N = 20)	Example Quotes
1	Flexibility in Learning	17	"I can access courses anytime, anywhere."
2	Accessibility to Resources	15	"MOOCs provide access to material not available in my local university."
3	Self-paced Learning	12	"I can take my time to understand difficult topics, which helps my learning process."

Research Question 2: What are the Lecturers' Concerns Regarding MOOCs as a Sustainable Educational Tool?

Lecturers expressed concerns about the lack of interaction and personalized feedback in MOOCs. Although MOOCs are useful for delivering content, the absence of direct discussion and feedback poses challenges in assessing student understanding and engagement. Approximately 70% of lecturers interviewed emphasized that the passive nature of MOOCs limits critical thinking and student engagement.

Table 6. Key Themes from Lecturer Interviews

No.	Theme	Frequency (N = 10)	Example Quotes
1	Lack of Direct Interaction	7	"There's no way to gauge whether students are truly engaged with the material."
2	Limited Opportunities for Feedback	6	"Without feedback, it's difficult to know if students are mastering the material."
3	Passive Learning Environment	5	"MOOCs tend to make students passive learners; they don't engage in discussions."

The findings reveal a dichotomy in perception between students and lecturers. While students emphasized the convenience and autonomy that MOOCs offered, lecturers had concerns about the lack of active learning elements and interaction, which they said were important for student success. These differing perspectives highlight the need for improvements in the pedagogical design of MOOCs to address flexibility and engagement.
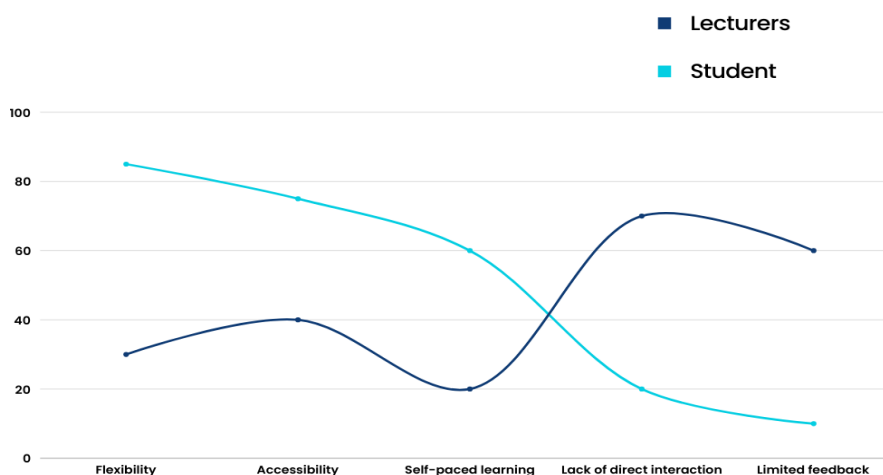

Figure 1. Comparison of Perceived Benefits of MOOCs between Students and Lecturers

Visually, the diagram above compares the differences in perceptions of students and lecturers. Students are more inclined towards the benefits of accessibility and flexibility, while lecturers' views are towards the challenges of interaction and engagement.

This qualitative analysis provides insights into the strengths and limitations of MOOCs from the perspectives of students and lecturers. MOOCs present significant opportunities to expand access to education, but require further pedagogical refinement to meet expectations.

Discussion

The discussion in this study focuses on several key findings about students' and lecturers' perceptions of MOOCs (Massive Open Online Courses), while answering the research questions and objectives. The discussion in this study aims to contextualize the results in existing literature and theory, and explore the potential contributions of the study, limitations, and implications for future research and practice.

The findings of this study indicate that both students and instructors hold favorable perceptions of Massive Open Online Courses (MOOCs), particularly in terms of accessibility and flexibility. The consistently high mean scores (above 4.0) in these categories reinforce the core strengths of MOOCs, as previously identified (Shah et al., 2023; Ivone et al., 2024; Putra et al., 2024). These studies emphasize that MOOCs provide unparalleled opportunities for learners to access educational content asynchronously, from virtually any location with internet connectivity. Such features are especially critical in geographically diverse nations like Indonesia, where significant disparities exist in access to quality education between urban centers and remote or underdeveloped regions.

In this context, MOOCs emerge not merely as a technological innovation but as a strategic mechanism for expanding equitable access to higher education. The alignment of these findings with global trends further underscores the transformative potential of MOOCs to support inclusive and sustainable learning ecosystems. As Iniesto & Rodrigo (2024) and Putra et al., (2024) have argued, MOOCs can serve as an essential supplement to traditional educational systems, particularly in areas where institutional resources and infrastructure remain limited or underdeveloped. Therefore, the strategic integration of MOOCs into national higher education policy may serve as a critical step toward building long-term learning capacity, promoting educational inclusion, and responding to the evolving demands of the Fourth Industrial Revolution and 21st-century skills development. This study contributes to the growing body of knowledge on MOOCs by reinforcing their relevance not only as flexible learning tools, but also as instruments for structural educational transformation.

However, a closer examination of the qualitative data reveals the complexity of the challenges to this potential. Students and lecturers complained about digital infrastructure issues, particularly internet access. This reflects the findings of Cabanlit & Domingo (2024), Huang & Quan (2025), and Connolly et al., (2025), who noted the "digital divide" as a persistent barrier to MOOC adoption. While MOOCs have inherent accessibility, local context, particularly digital infrastructure, significantly impacts their effectiveness. These findings suggest that MOOCs are addressing certain educational gaps, but that they must be implemented in conjunction with efforts to improve digital infrastructure to realize their full potential.

Another important finding was the lower scores for learning outcomes, especially from the lecturer's perspective. In line with Javed et al., (2023), who concluded that despite MOOCs' wide accessibility and flexibility, students and lecturers expressed concerns about the lack of personalized interaction and feedback. Zhang's study also highlighted the success of MOOCs in delivering content, but they also often fail to foster deep learning and engagement due to limited interaction between lecturers and students. In this study, lecturers expressed difficulty in maintaining the same level of engagement and support that they could offer in a traditional learning environment. Qualitative interviews further confirmed that participants perceived a lack of personal connection, which may hinder the overall effectiveness of MOOCs in achieving meaningful educational outcomes (Sebbaq & Faddouli, 2024).

The challenges of fostering engagement and interaction in MOOCs have been widely discussed in the literature, and previous research has shown. Celik & Cagiltay (2024), Lexman &

Baral (2024), and Smiling & Hollebrands (2025) argued that while MOOCs excel in content delivery, their pedagogy lacks the richness of a face-to-face learning environment, particularly in areas such as critical thinking and personalized support. The findings of this study are in line with Bali's findings and suggest the need for future MOOCs to incorporate more interactive elements, such as live discussions, virtual office hours, or AI-driven feedback systems to increase engagement. These enhancements would address the gap between content delivery and meaningful learning experiences, making MOOCs not only a tool for knowledge dissemination but also a platform for comprehensive learning.

Another important aspect of this discussion was the sustainability of MOOCs as a long-term learning solution. Students and lecturers identified self-paced learning as a key benefit, allowing students to revisit content as needed and engage with the material at their own pace. This aligns with the concept of lifelong learning, which Cagiltay et al., (2024) identified as an important benefit of MOOCs. However, challenges with maintaining motivation and self-discipline were recurring themes in the qualitative data. Watted & Barak (2024) indicated that high dropout rates were a significant problem with MOOCs, and this study supports these findings, with students citing a lack of external accountability as a reason for disengagement. To address this issue, future MOOC designs could incorporate gamification strategies or more structured learning paths that help maintain student motivation and foster a sense of community (Nanjundaswamy et al., 2021).

These findings also have significant implications for the education system. While most research on MOOCs has focused on global or Western contexts, this study provides unique insights into the opportunities and challenges of MOOCs in Indonesia (Iniesto & Rodrigo, 2024). The high rankings for accessibility and flexibility suggest that MOOCs could play a significant role in addressing educational disparities across the country (Zakaria et al., 2024). However, the findings also highlight the need to adapt MOOCs to local contexts (Li et al., 2024), and improving digital infrastructure and finding ways to integrate MOOCs with traditional classroom settings could enhance their effectiveness (Kamble et al., 2024). By contextualizing MOOCs within the specific educational needs and challenges of Indonesia, this study offers valuable insights that can inform future policy and practice.

This study is one of the few studies that includes both student and lecturer perspectives on MOOCs, providing a more comprehensive view of their potential and limitations. While most of the literature focuses solely on student experiences, this study highlights the important role of lecturers in shaping the success of MOOCs (Nanjundaswamy et al., 2021; Javed et al., 2023). The results suggest that lecturer engagement and support are important factors that influence MOOC learning outcomes. These findings add a new dimension to the discourse on MOOCs and suggest that future research should explore ways to better integrate instructors into the MOOC learning experience.

However, this study also has limitations. First, the sample size was limited to students and lecturers from a single university, which may limit the generalizability of the findings to other contexts. Second, while this study explored perceptions, it did not measure actual learning outcomes. Future research should address this gap by examining the impact of MOOCs on students' academic performance and educational achievement. Furthermore, while this study focused on the Indonesian context, further research could compare its findings with those from other developing countries to gain a broader understanding of the challenges and opportunities associated with MOOCs.

This study contributes to the growing body of research on MOOCs by providing specific insights into the higher education system in Indonesia. This study highlights the potential of MOOCs to increase accessibility and flexibility in education, while identifying key challenges related to digital infrastructure, engagement, and learning outcomes. The findings suggest that for MOOCs to reach their full potential, they must be adapted to local contexts, both in terms of infrastructure and pedagogical design. By offering a balanced view of the benefits and limitations of MOOCs, this study provides valuable implications for educators, policymakers, and researchers interested in the future of online education.

CONCLUSION

This study adequately addresses the research objectives by demonstrating that MOOCs have provided significant benefits in terms of accessibility and flexibility for students and lecturers. However, MOOCs also present challenges related to personalized interaction and feedback. The findings suggest that MOOCs can play a significant role in expanding access to education, particularly in areas with limited physical infrastructure. The lack of face-to-face interaction and inadequate feedback mechanisms limit their effectiveness in fostering deeper student engagement and understanding. These insights are consistent with previous research and highlight the need for better pedagogical strategies. From these findings, MOOCs should be equipped with more interactive and personalized elements to enhance students' learning experiences. For practical implications, educational institutions and policymakers should focus on integrating MOOCs with traditional learning approaches or developing hybrid models that combine online and face-to-face interactions. Additionally, improving technological infrastructure, particularly in underserved areas, is essential to maximizing the potential of MOOCs in higher education. Finally, future research should explore the long-term impact of MOOCs on student learning outcomes and investigate methods to enhance the interactivity and effectiveness of these platforms to support sustainable and comprehensive learning.

Based on these insights, several recommendations are proposed: First, higher education institutions should consider adopting blended learning models that integrate MOOCs with traditional classroom approaches. By doing so, institutions can leverage the strengths of both modalities (flexibility from MOOCs and interpersonal engagement from face-to-face learning) to improve educational outcomes. Second, the design of MOOCs should be enhanced to include more interactive and personalized learning components. This includes incorporating moderated discussion forums, adaptive feedback systems, and live tutorial sessions or mentoring components to better support student comprehension and motivation. Third, policymakers and educational stakeholders should prioritize improving technological infrastructure, especially in underserved areas. Ensuring equitable access to stable internet connections, digital devices, and technical support is essential to enable the effective implementation of MOOCs across diverse learning environments. Fourth, Future research is encouraged to employ longitudinal methodologies to rigorously assess the long-term impact of MOOCs on learning outcomes, skill acquisition, and learner autonomy. Further empirical investigations are also warranted to identify best practices in the design of interactive and personalized features that enhance the pedagogical effectiveness of MOOC platforms. By addressing these critical areas, MOOCs have the potential to transcend their current limitations and evolve into transformative instruments for inclusive, sustainable, and forward-looking higher education.

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Developing a Bogamon-Talk (board game of monopoly talking) to improve students' English speaking skills

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ABSTRACT

The rapid development of technology emphasizes the importance of effective learning media. Students often struggle with English speaking due to limited practice and monotonous learning methods. This study aims to develop BOGAMON-TALK (Board Game of Monopoly Talking) to enhance student motivation and speaking skills. Using the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation), this Research and Development (R&D) study involved 33 eighth-grade students from Darul Ulum Purwogondo Junior High School. Data collection used interviews and tests, and was analyzed quantitatively. Validation by material experts yielded a score of 4.6 (very feasible), while media experts rated it 4.0 (feasible). The product's effectiveness was shown by a significant increase in student performance: pretest (52.03) and posttest (88.03). These results suggest BOGAMON-TALK is both valid and effective in improving students' English speaking skills. It is recommended that subsequent researchers consider the adaptation of this board-based educational game into non-print or electronic media to enhance its accessibility and facilitate the enhancement of English speaking skills.

INTRODUCTION

English serves as a standard international communication language, which also serves to unlock educational opportunities and career growth options and networking potentials as well and information resources. Research shows English functions as the principal worldwide communication language while being utilized on a global scale (Khalmurzayevna & Zairjanovich, 2024; Nuriyanti, 2024; Rao, 2019). People value effective English communication skills in today's world to the same degree (Dewi, 2023; Leong & Ahmadi, 2017).

Ancient education systems have incorporated English into their curriculum for multiple years. Students in Indonesian public education systems learn English from elementary school until they reach college, and English functions as their primary official foreign language (Chotimah & Astiyandha, 2022; Crisianita & Mandasari, 2022). Speaking, listening, reading, and writing are the four components of English proficiency. Speaking is regarded as the most crucial of these four abilities for learning English (Rao, 2019; Suadi, 2020; Ginkel et al., 2017). Speaking is very important, as stated in Oktanisfia & Susilo (2021), as speaking in English is used by countries in the

world in various aspects such as education, culture, and politics. The ability to communicate orally in English is referred to as speaking the language. Harmer Miranda & Wahyudin (2023) define speaking ability as the capacity to articulate ideas clearly and fluently. This includes the ability to effectively communicate ideas, form cohesive sentences, and pronounce words correctly. Language learners of English experience substantial hurdles because their first language exists outside their native speech area (Mandasari & Aminatun, 2020). The collected personal communication data demonstrates that students face ongoing challenges with mastering English verbal skills. According to Zuhriyah (2017), student difficulties with verbal communication stem from three primary sources. The lack of speaking practice and difficulty with vocabulary acquisition and rote teaching techniques result in lower student interest in speaking. Accordingly, a lot of students believe that learning English is difficult and complicated (Al-Roud, 2016; Ork et al., 2024).

Classroom management excellence proves essential for creating speaking practice opportunities for students based on the above analysis. Miranda & Wahyudin (2023) investigated speaking proficiency development by showing that "practice makes perfect". The researchers, including Arfani & Sulistia (2019) and Ati & Parmawati (2022), maintain that constant practice is necessary for outstanding speaking abilities. Dewi (2023) states that the language teaching process requires instructors to deliver instruction, ask questions, and answer them while making introductions and extending invitations and expressing agreement or dissent, and giving commendations.

In general, teaching is conducted using traditional methods. As stated by Pandya et al., (2024), the majority of instruction is carried out through textbook reading and preaching. As a result, this makes students feel bored and disinterested in learning. To enhance students' motivation to learn and practice speaking, it is essential to adopt innovative approaches that integrate the use of learning media. Recent studies show that media implementation serves as a strategic teaching method to develop English language competency skills for second language students (Candraloka & Rosdiana, 2022; Choirunnisa & Sari, 2021; Chotimah & Astiyandha, 2022; Oktaviani & Desiarti, 2017; Suningsih et al., 2024). The media that can be used is highly diverse. Constantika et al., (2022) classified learning media into two categories: print and non-print. Print media consists of images (visual media). Non-print media consists of sounds (audio media) and videos (audio-visual media). Puspitasari (2019) found that the use of printed teaching materials is effective in supporting 21st-century language learning, while the use of non-print teaching materials is very effective in increasing student interest in learning. However, as Rustamana et al., (2024) have demonstrated, the use of non-print teaching materials necessitates the availability of electronic devices and internet access, which may not be universally guaranteed for all students.

On the basis of these reasons, the researcher's objective is to develop a learning medium that can facilitate the enhancement of students' speaking abilities. The application of game elements in learning activities has been shown to increase engagement, motivate students to engage more actively, and minimize stress during training sessions (Arfani & Sulistia, 2019; Kaur & Aziz, 2020; Anggraeni et al., 2022). As a result, the researcher is interested in creating BOGAMON-TALK (Board Game of Monopoly Talking), a learning tool that combines classic Monopoly with English language content. BOGAMON-TALK is an educational game that employs a game board, dice, and question cards as its primary tools. Various development studies have been performed by previous researchers to both support English language acquisition and enhance students' command of the language. The board game REV-OPOLY, developed by Nordin et al., (2022), enhances learning interest along with student inspiration to learn. The Plinko Speaking Game represents a game development project by Nurhaya & Destianingsih (2021), which enhances students' speaking capabilities. This research presents an innovation by utilizing the monopoly board game as an educational game designed to stimulate oral communication between students through English dialogue instructions.

The study aims to create innovative and interesting learning media, BOGAMON-TALK, to improve students' motivation in learning English, especially in speaking. In addition, this research would evaluate the effectiveness of BOGAMON-TALK in improving the students' ability in oral English. The results of this study are expected to improve the teaching and learning process, especially English speaking skills.
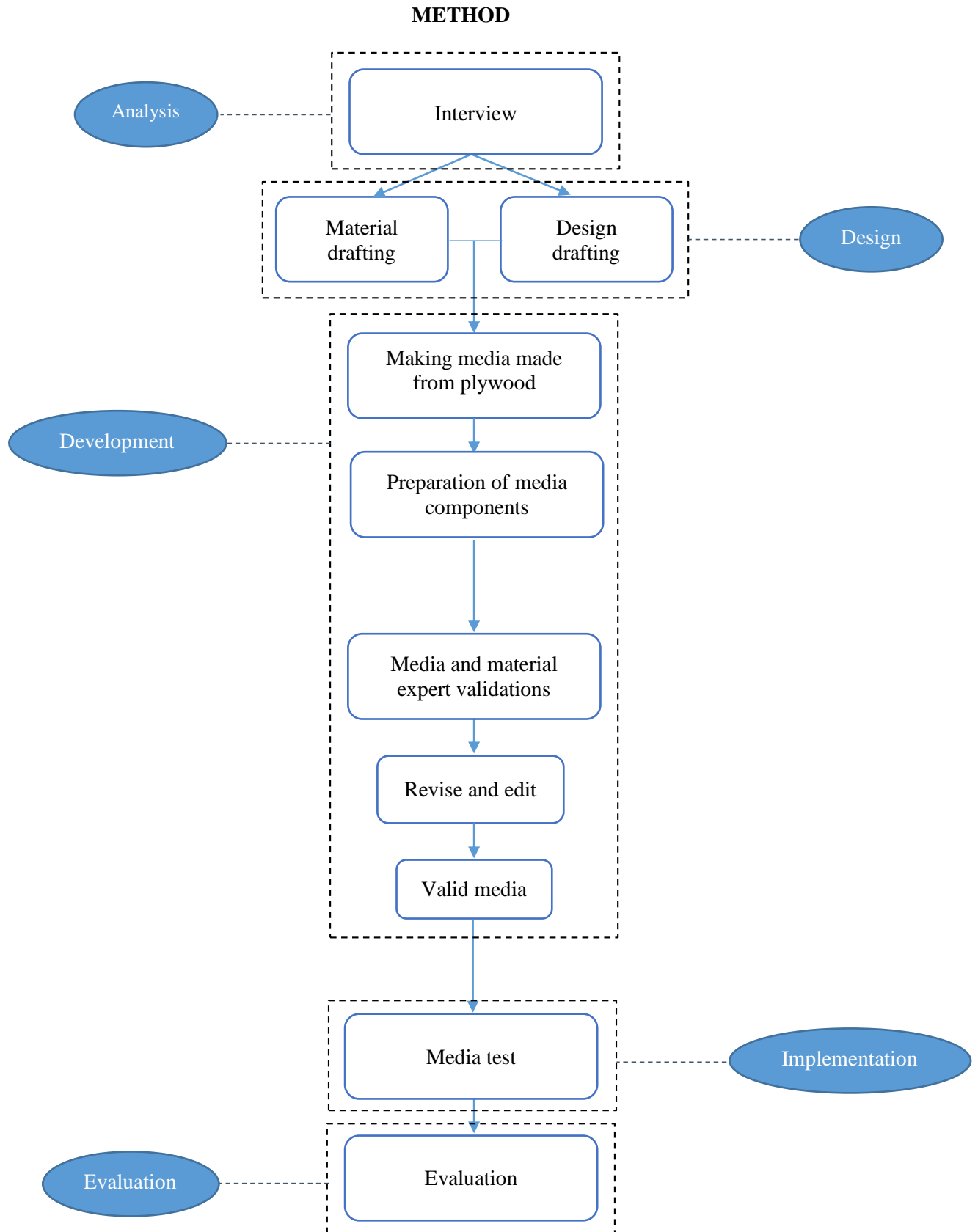
METHOD

Figure 1. ADDIE Model

This study followed an R&D (Research and Development) method to develop a learning media product. Manning explains in Novaliendry et al., (2020) that the readily identified learning design model involves a systematic and structured approach used to develop educational products, including learning media. Anggraini & Putra (2021) also explained that with the R&D method, researchers can be responsible for the products developed. This method includes five steps: (1) Analysis, (2) Design, (3) Development, (4) Implementation, (5) Evaluation (Najuah et al., 2021; Surya & Witaharahap, 2017). The researchers conducted this study at Darul Ulum Purwogondo Junior High School. The researchers used the Pretest-Posttest Control Group t-test design to find out the effectiveness of the product. The employment of experimental design facilitates the acquisition of more quantifiable data (Rustamana et al., 2024). This study focuses on a sample of 33 students from a total population of 97 students. The selection of the sample was conducted using the Simple Random Sampling technique, wherein students were chosen randomly.

As shown in Figure 1, conducting a needs analysis is the first step in this research process. Needs analysis using interviews with English teachers and 8th students of Darul Ulum Purwogondo Junior High School. It was found that English language materials were less well received because they were based on the LKS book media that seemed boring and difficult to understand. In response to these findings, the researcher created the BOGAMON-TALK learning tool, which uses game components to increase accessibility and engagement in the educational process. BOGAMON-TALK media was developed based on the findings of the needs analysis. The appropriate curriculum becomes the basis for media design. Beyond initial creation, the experts in learning design, together with those specializing in instructional materials, verify BOGAMON-TALK media for final recommendations. BOGAMON-TALK media implementation takes place in class VIII Darul Ulum Purwogondo Junior High School while teachers guide student learning processes. The evaluation process examines the effectiveness of BOGAMON-TALK media in supporting student speaking skill development. Implementing the BOGAMON-TALK media intervention results in administering a posttest to students to examine changes in their speaking ability between the start and end of the study.

Interview sheets, validity sheets, and test sheets served as the instruments for data collection. The researchers evaluated data from interviews and validation using quantitative descriptive analytic procedures. The analysis of pretest and posttest values through a paired sample t-test demonstrated the magnitude of students' speaking skill improvements.

RESULTS AND DISCUSSION

Results

Analysis

The present analysis stage constitutes a needs analysis, the objective of which is to collect data that will serve as the foundation for the subsequent creation of a product. According to Prihandoko & Yunianta (2021), a needs analysis is developed to identify the best way to achieve educational objectives. The needs analysis was conducted by conducting interviews, which is an important way of collecting data. The results of these interviews have been summarized in the table below.

Table 1. Statements and Percentages

| No. | Statements | Answer | | Percentage |
		Yes	No	
1	English is a difficult subject	28	5	85%
2	The most difficult English material is speaking	25	8	76%
3	Students have difficulty understanding English material	28	5	85%
Average				**82%**

Data from Table 1 shows that 33 students and some English teachers were interviewed, and a good number of students, approximately 85% referred to as the sample, were found to have difficulty in reading comprehension in English lessons. The students struggled mostly in speaking, which was

at a rate of 76%. This means that the students have problems when it comes to using English 'on the spot', which is a skill that requires speaking practice at a more intensive level. On the other hand, the interview results reveal that teachers most of the time used the student worksheet (LKS) book for learning purposes. The findings of the present study demonstrated that students exhibited a decline in motivation and an inability to effectively engage with the English language when provided with student worksheet (LKS) books. According to Tiing & Yunus (2021), students experience both cognitive and emotional changes during board game activities in educational settings. The collection of board games stands wide-ranging from ludo to snakes and ladders to monopoly to Scrabble to chess. Studies by Astrida (2024) showed that students achieved better average scores when using the Monopoly board game. Therefore, the researchers want to modify the monopoly board game to be used as a learning tool for improving students' speaking ability.

Design

The second phase in the development process is designing. As Alex et al., (2024) and Nugroho (2021) imply, this phase deals with the development of material design, media design, and other supporting component designs that will be the blueprint to the development process.

a. Designing Material

Design The building of the material design is founded on the education level and the curriculum used. According to Matsum & Sarmita (2022), in this stage, there is the collection of materials related to the learning experience. In this particular instance, the selected material is English-language focused. As Pitriani et al., (2021) noted, the selection of materials was driven by students' challenges in comprehending the existing materials. Consequently, it is imperative for researchers to accurately and appropriately determine the material. The material was collected through various sources, including the results of interviews with English teachers, school textbooks, and the internet. The resultant material was then arranged into a questionnaire, as illustrated in Figure 2.

Figure 2. Material on the Question Card

b. Designing Media

This research product is the result of a monopoly game developed to facilitate speaking acquisition. Consequently, the product has been designated "BOGAMON-TALK" (Boardgame of Monopoly Talking). The design plan is illustrated in Figure 3. The media is designed with an appealing cartoon figure and is integrated with the Snakes and Ladders game. The set contains 44 boxes, which include a start box, 20 boxes with landmarks whose names are countries, 16 question boxes, 4 instruction boxes, 1 free parking box, and 2 jail boxes. There are also four additional quiz boxes, distinguished by various colours, which categorize four different categories of speaking materials. Media is printed in the form of 50x50 stickers and then stuck on a wooden board in the resized dimensions. The wooden board is foldable, as indicated in Figure 4.

Figure 3. Media Design   Figure 4. Board Design

c. Supporting Component Design

Figures 5 and 6 show that BOGAMON-TALK media includes components such as dice, player markers, question cards, play money, landmark buddy cards, playhouses, and game clue books.
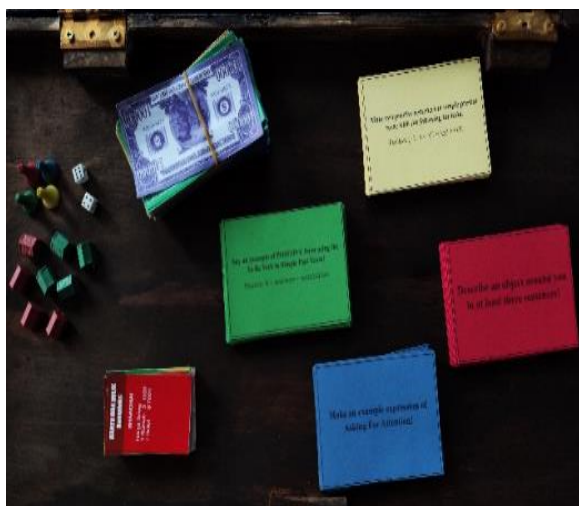

Figure 5. Supporting Component   Figure 6. Game Clues of BOGAMONT-TALK
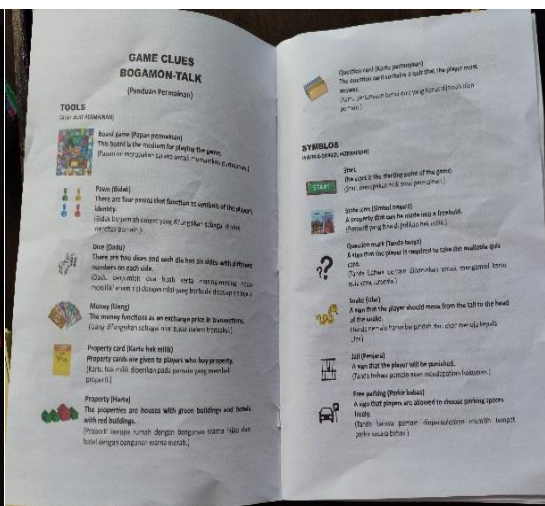
Development

The third stage of this research is development. During this phase, the researcher implements the product according to the designed design. Before conducting a product trial on the research subjects, the researcher conducted a validation test, namely validation by material experts and validation by media experts. Ningsih et al., (2023) have asserted that the objective of this validation is to ascertain the feasibility of the media, and it is conducted by experts proficient in the domains of English language proficiency and learning media. Khotimah & Wahyuningtyas (2023) further emphasize that the outcomes of this validation can serve as a foundation for enhancing the quality of the developing media. According to Gusmida & Islami (2017), the validation test was carried out in four aspects: design, material, content, and usefulness. The findings from the material expert validation test and the media expert validation test are presented in Tables 2 and 3.

Table 2. Validity Test Results by a Media Expert

No.	Aspects	Score	Description
1	Accuracy of Material	5	Very good, the material is by the curriculum and grade level.
2	Content Suitability	5	Very good, the content of the material is English-speaking material.
3	Media Usefulness	4	Good, the media supports learning objectives.
Average		**4.6**	

Table 3. Validity Test Results by a Material Expert

No.	Aspects	Score	Description
1	Media Visual Design	4	Good, the visual design of the media is attractive.
2	Media Diversity (Layout, Background, Color Proportion, Font, Text Size, Icons)	4	Good, variations in media support learning.
3	Easy to Use	4	Good, the media is easy for students to use.
Average		**4**	

An expert in the field reviewed the evaluated materials, which demonstrate proper alignment with both curriculum expectations and specific grade-level standards. An expert assessment confirmed that the selected materials demonstrated their suitability for student speaking instruction at each academic grade level. Experts have judged the material to be sufficiently accurate. An evaluation by the materials expert suggested adjusting the wording structure of the question cards to enhance clarity. The researcher should make the language on the question cards simpler and more user-friendly. Visual design met good evaluation standards, but the design expert suggested additional enhancements to improve visual attractiveness. Students appreciate diverse aspects of media resources because their interactive elements capture attention and boost student interest in educational content. A media expert praised the educational materials positively because the booklet with game clues presents clear instructions effectively. While the media provides excellent instructional benefits, students need an individual who understands both the BOGAMON-TALK game and the subject content to offer guidance. The experts within the field consider this medium successful in developing students' speaking skills positively.

Implementation

The researchers assess media implementation based on its practicality and effectiveness to serve as educational learning tools. The researchers measured media effectiveness using a Pretest-Posttest Control Group Design to conduct experimental research. A pretest measuring student understanding occurred before the researchers distributed the BOGAMON-TALK educational tool. The pretest serves to determine the starting knowledge level of students. The assessment features 19 validated multiple-choice questions that measure classroom speaking competence. Analysis of the pretest revealed an average score of 52, which demonstrated that students had minimal understanding of speaking interactions. Results from the pretest establish baseline student abilities, which makes it possible to evaluate student growth after media intervention and measure BOGAMON-TALK effectiveness. The students receive classroom treatment immediately after pretest administration and progression to the next research phase. The researchers deploy BOGAMON-TALK media during this implementation phase.

Evaluation

After treatment, researchers conducted an evaluation through a posttest to determine the effect of BOGAMON-TALK media on students' speaking skills. The results of the product effectiveness test are shown in Table 4.

Table 4. The Result of Pretest and Posttest Analysis

No.	Indicators	Pretest	Posttest
1	**Mean**	**52.03030303**	**88.03030303**
2	Variance	541.280303	82.46780303
3	Observations	33	33
4	Pearson Correlation	0.36119104	
5	Hypothesized Mean Difference	0	
6	Df	32	
7	t Stat	-9.527772868	
8	P(T<=t) one-tail	0.00000000004	
9	t Critical one-tail	1.69388874838	
10	**P(T<=t) two-tail**	**0.00000000007**	
11	t Critical two-tail	2.03693334346	

The findings from the t-test analysis of BOGAMON-TALK media data appear in Table 4. Results from the t-test revealed a value of 0.00000000007 that falls below the 0.05 significance threshold. The test results are enabled to accept the alternative hypothesis (H1) because the findings show significant performance improvements among students after using BOGAMON-TALK media. Students achieved significantly improved scores according to results showing pretest scores at 52.03, rising to 88.03 in the posttest assessment. The research data shows that integrating BOGAMON-TALK media leads to improved student speaking skills.

Discussion

The results of the study demonstrated that the implementation of BOGAMON-TALK teaching media resulted in a significant enhancement of students' speaking skills, as evidenced by the substantial increase in pretest and posttest scores. The media under consideration has been developed as an educational instrument to motivate students to engage in verbal interaction in English. Based on Suyono (2021), speaking skills are only presented in the explanation of the functions of language expressions, without providing opportunities to practice the expressions. Therefore, Agustina et al., (2022) revealed that the use of media as a learning tool is needed. The utilization of this media can facilitate an opportunity for students to engage in the practice of student English speaking skills. The implementation of BOGAMON-TALK is designed to encourage students to adopt an active role as participants in the learning process. This approach involves expressing opinions, asking questions, and responding in English according to the game instructions. This approach motivates students to speak English because it creates a relaxed and non-stressful learning environment. This effectively reduces students' anxiety level when speaking a foreign language, especially English, which has been a major obstacle in developing foreign language speaking skills.

In addition, the integration of these media facilitates student autonomy and collaborative learning. As stated by Lisnawati (2021), the role of teaching media is not only as a tool to make it easier for students to understand the material, but also to facilitate students to become a generation that can think critically, creatively, innovatively, work together, and collaborate. This role is of crucial importance for the acquisition of language skills, as the development of speaking skills is optimized when students engage in communicative tasks. BOGAMON-TALK media facilitates a learning environment in which students feel comfortable experimenting with language and learning from other students. In this way, the use of this media supports the cognitive and affective domains of learning.

The implementation of BOGAMON-TALK aligns with the principles of communicative language teaching (CLT), which emphasizes interaction as both the means and the objective of language learning. The media-structured instructions and interactive instructions incorporated into the game encourage students to use English in a meaningful way, improving not only students' fluency but also students' confidence, as stated (Rifa'i, 2021). The interactive nature of the game has been demonstrated to facilitate the maintenance of students' interest, rendering the learning process more dynamic and enjoyable.

In conclusion, the utilization of BOGAMON-TALK as an educational game media and speaking skill training instrument is effective when incorporated into English learning activities. The

findings indicate that BOGAMON-TALK, a game-based learning media, can serve as an effective alternative to enhance students' English speaking skills, boost learning motivation, and improve academic outcomes.

CONCLUSION

A BOGAMON-TALK (Board Game of Monopoly Talking) functions as instructional material for enhancing students' speaking competence. The development of the model utilized the five sequential stages known as Analysis, Design, Development, Implementation, and Evaluation, which stem from the ADDIE Model. The effectiveness of BOGAMON-TALK in teaching English to students was documented by materials and media experts. An evaluation of BOGAMON-TALK through a t-test showed that students experienced substantive improvements in their speaking abilities when they used the program. This research encounters material restrictions despite its findings. It is recommended that subsequent researchers consider the adaptation of this board-based educational game into non-print or electronic media to enhance its accessibility and facilitate the enhancement of English speaking skills.

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Strategic decision-making in TVET higher education: Applying the fuzzy delphi technique to foster inclusive digital pedagogy in Indonesia-Malaysia

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ABSTRACT

The rapid digitalization of education demands inclusive pedagogical strategies, especially within Technical and Vocational Education and Training (TVET), to ensure equitable learning opportunities. This study focuses on post-secondary students and aims to identify the competencies required by educators in implementing inclusive digital pedagogy. It also serves as a foundational reference for future in-depth research. The study examines the strength of consensus among expert groups from Indonesia and Malaysia regarding inclusive digital pedagogy using the Fuzzy Delphi Technique (FDT). A purposive sampling technique was employed to select 30 experts from Indonesia and Malaysia. The selection criteria included academic qualifications, professional experience in TVET and digital pedagogy, and prior involvement in educational research or policy-making, in identifying and prioritizing key components, including infrastructure and training, digital skills development, accessibility, student-centered approaches, employer engagement, and personalized learning. Data analysis utilizing triangular fuzzy numbers revealed a strong consensus, highlighting the foundational role of infrastructure and innovative pedagogical practices aligned with industry needs. The findings contribute a comprehensive framework for enhancing digital inclusivity in Southeast Asian TVET contexts and demonstrate the effectiveness of FDT in consensus-based educational research. Future research is recommended to empirically validate the proposed framework in real classroom settings and to investigate its adaptability across different cultural environments in the ASEAN region.

INTRODUCTION

Inclusive digital pedagogy has emerged as a critical global priority, especially in the rapidly evolving field of education. The increasing reliance on digital technologies in educational systems necessitates addressing diverse learners' needs, ensuring equity, and fostering active participation (UNESCO, 2020). This is particularly significant for Technical and Vocational Education and

Training (TVET), where learners often come from varied socio-economic and educational backgrounds (Cheng & Lin, 2002). A well-rounded approach to digital pedagogy can help bridge gaps in accessibility and ensure that all learners benefit from technological advancements. As TVET becomes central to workforce development, addressing inclusivity in digital learning is more pressing than ever.

Technical and Vocational Education and Training (TVET) plays a critical role in preparing individuals with the practical and technical competencies required by the contemporary workforce, especially as the education sector transitions toward the paradigm of the Industrial Revolution 5.0. The elements of knowledge and the latest learning strategies in TVET pedagogy can produce graduates to meet the needs of the industry (Lubis, 2010).

The rise of AI in education is propelled by its capacity to process vast amounts of data and generate insights that inform personalized learning pathways (Rane et al., 2025). While the integration of digital tools has become more widespread to enhance learning outcomes, significant challenges related to inclusivity persist. Technology tailored to meet the unique needs of diverse students is essential for promoting inclusion. When supported by inclusive policies, teacher training, and pedagogy, digital tools can help reduce barriers to inclusive education (Gottschalk & Weise, 2023).

Despite efforts to digitalize education, significant gaps remain in access and inclusivity. Learners from marginalized communities often face barriers such as inadequate internet access, limited digital literacy, and a lack of supportive infrastructure (OECD, 2021). In Indonesia and Malaysia, these challenges are pronounced, with TVET institutions catering to a diverse population with varying levels of preparedness for digital learning (Hani et al, 2024). Bridging this digital divide is crucial for ensuring equitable opportunities in education and workforce readiness, especially in a region with complex socio-economic dynamics.

The Southeast Asian context presents unique challenges and opportunities for inclusive digital pedagogy, driven by the region's socio-economic diversity and rapid digital transformation. Factors such as rapid urbanization, economic disparities, and culturally diverse populations necessitate context-sensitive and adaptive approaches to digital education. Urban centers in Southeast Asia are experiencing accelerated technological integration, but rural and underserved areas often lag due to limited infrastructure and access to digital resources (OECD, 2021). This digital divide creates significant barriers to inclusive education, particularly in Technical and Vocational Education and Training (TVET), which often caters to learners from varied socio-economic backgrounds.

Indonesia and Malaysia, as prominent players in the region's TVET landscape, have recognized the need to integrate inclusive digital pedagogical practices to enhance educational equity and quality. Both nations have made commendable progress in digitalizing their education systems, with initiatives such as Malaysia's Digital Economy Blueprint and Indonesia's focus on increasing digital literacy (Hani et al, 2024). However, these advancements are unevenly distributed, leaving gaps in access and inclusivity that hinder equitable participation. Comprehensive frameworks that prioritize inclusivity and address these disparities are essential for leveraging the full potential of digital transformation in education. Such frameworks must account for regional disparities, cultural nuances, and the specific needs of TVET learners, enabling both nations to build resilient and inclusive education systems that prepare students for the demands of a globalized workforce (UNESCO, 2020).

The implementation of inclusive digital pedagogy requires a strategic approach that takes into account the diverse backgrounds and experiences of students so that equal learning processes and outcomes will be created. One key strategy is to design learning development that can combine various pedagogical perspectives, fair assessments, and collaboration-based learning. Designing learning development ensures that every student gets equal access to education and equips them to be able to face changes in the world and contribute as agents of social transformation. In addition, another important strategy is the implementation of inclusive and differentiated assessments, which provide equal opportunities for all students to actively participate and achieve their learning goals (Hashim et al., 2019).

Inclusive pedagogy is based on the principle of meeting diverse learning needs, ensuring equitable access to education, and creating a participatory learning environment. Digitalisation, both

in the educational and industrial context, creates massive opportunities to make learning in TVET institutions more demand-driven and adequate to serve the purpose of producing highly skilled graduates (Kuntadi et al., 2022). Digital pedagogy, when combined with inclusivity principles, has the potential to transform TVET education by addressing individual learner needs while leveraging technology to enhance engagement and outcomes.

The Fuzzy Delphi Technique offers a robust methodological approach to achieve consensus on critical elements of inclusive digital pedagogy. This method integrates expert opinions to identify key factors and prioritize their implementation based on collective agreement (Hsu & Sandford, 2007). By applying this technique in the Indonesian-Malaysian context, this study ensures that the identified elements are both culturally relevant and practically applicable. Its adaptability makes it particularly suitable for addressing the complexities of TVET education in Southeast Asia.

Indonesia and Malaysia share similarities in their TVET landscapes, including diverse populations and rapidly expanding digital economies. However, differences in governance, infrastructure, and cultural contexts influence the adoption of inclusive digital pedagogy. While Malaysia has made significant progress in integrating digital tools within TVET curricula, Indonesia faces challenges such as limited infrastructure in rural areas. Understanding these differences is critical for developing tailored strategies that address the unique needs of both nations. Policymakers in both countries play a central role in fostering inclusive digital pedagogy in TVET. Strategic investments in infrastructure, teacher training, and digital resources are vital for creating an equitable learning environment. Policies that promote public-private partnerships can further enhance resource availability and ensure alignment with industry needs. Both nations have introduced initiatives to digitalize education, but gaps in implementation highlight the need for continuous evaluation and adaptation.

A related study, "Transforming Inclusive Digital Pedagogy in Malaysian Tertiary TVET: Adapting to a New Educational Landscape", provides a valuable contextual reference by examining how Malaysian institutions have responded to the demand for digital inclusivity in TVET (Jamil et al., 2024). However, while that study focused on a single country perspective and emphasized institutional adaptation, the current study broadens the scope by incorporating a cross-country comparison between Indonesia and Malaysia. Furthermore, the study uses the Fuzzy Delphi Technique (FDT) to systematically gather and analyze expert consensus, allowing for the formulation of a robust and participatory framework for inclusive digital pedagogy.

This study aims to develop a consensus-driven framework for inclusive digital pedagogy in Indonesian-Malaysian TVET. It identifies key elements through expert input and prioritizes them using the Fuzzy Delphi Technique. The subsequent sections outline the study's methodology, findings, and implications, offering a comprehensive analysis of inclusive digital pedagogy tailored to the needs of both nations.

This study seeks to build a consensus-driven framework for inclusive digital pedagogy in the context of Indonesian and Malaysian TVET systems. By utilizing the Fuzzy Delphi Technique (FDT), this study systematically identifies and prioritizes important pedagogical elements based on expert insights. In addition to offering a practical and contextually responsive model for advancing equitable digital education, this study also contributes a participatory methodological approach that encourages cross-national collaboration in shaping inclusive teaching practices.

METHOD

This study uses the Fuzzy Delphi Technique to identify and rank the main components of inclusive digital pedagogy in TVET higher education in Indonesia and Malaysia. The Fuzzy Delphi Technique is widely recognized for its capacity to achieve expert consensus on complex issues through systematic data collection and analysis (Hsu & Sandford, 2007). Figure 1 is the research design and steps using the fuzzy technique.
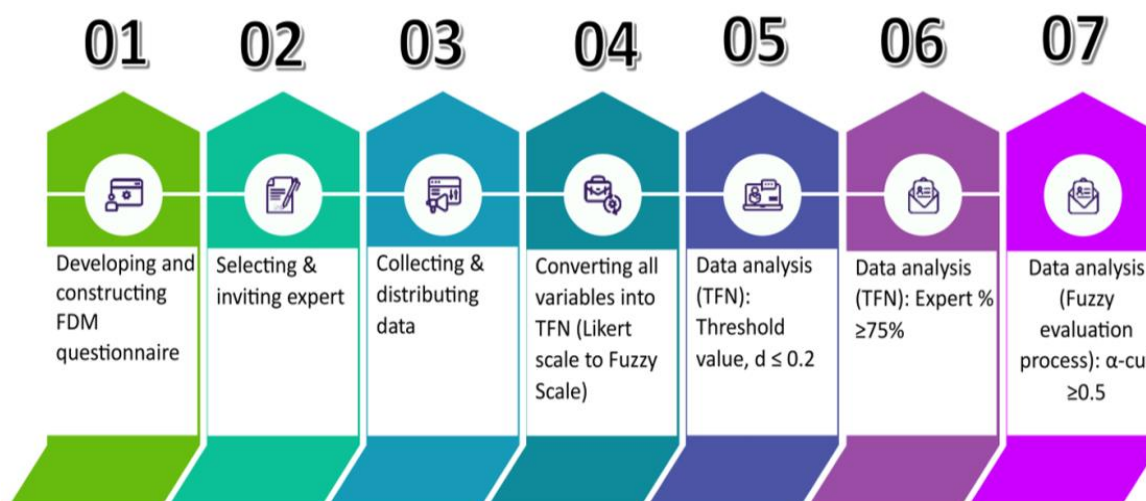
Figure 1. Fuzzy Delphi Data Collection and Data Analysis

Its integration of fuzzy logic ensures precision and minimizes ambiguity in decision-making processes (Habibi et al., 2014). By leveraging this approach, the study ensured that the framework developed was both rigorous and relevant to the context of TVET education.

This study involved 30 experts from both Indonesia and Malaysia, selected through purposive sampling to ensure that participants possessed relevant expertise and experience in the fields of TVET and digital pedagogy (Creswell & Poth, 2018). The inclusion criteria required a minimum of five years of academic or professional experience in areas such as technical education, digitalization, or TVET instruction. This diverse and knowledgeable expert panel formed the foundation for applying the Fuzzy Delphi Technique (FDT), which was used to systematically process and synthesize expert opinions to reach consensus on key elements of inclusive digital pedagogy. This selection process ensured a diverse and knowledgeable panel capable of providing informed insights.

Table 1 provides a detailed demographic profile of the experts participating in the study, showcasing their diverse backgrounds and extensive experience. Among the Indonesian experts, the majority were male (60%), while 40% were female, highlighting a significant representation of women in technical and vocational fields. This balance is crucial in promoting gender inclusivity within TVET, as it ensures that diverse perspectives are incorporated into the analysis. In Malaysia, male experts constituted 70% of the participants, with females accounting for 30%, reflecting a slightly higher male dominance in the Malaysian TVET sector. These gender distributions align with broader trends in STEM and vocational education, where male representation often exceeds female representation (OECD, 2021). The inclusion of female experts in both countries underscores the study's commitment to diversity and inclusivity.

Table 1. Experts' Demographic Information

No.	Demographic	Statement	N	Percentage
Indonesia Expert				
1	Gender	Male	6	60%
		Female	4	40%
2	Experience (Academic)	5-9 Years	1	10%
		10-14 Years	-	-
		15 Years and above	9	90%
3	Expertise	Business Administration	5	50%
		Mechanical Engineering	1	10%
		Accounting	1	10%
		Electrical Engineering	2	20%
		Computer and Informatics	1	10%
Malaysian Expert				
4	Gender	Male	7	70%
		Female	3	30%

No.	Demographic	Statement	N	Percentage
5	Experience (Academic)	5-9 Years	3	30%
		10-14 Years	5	50%
		15 Years and above	2	20%
6	Expertise	Engineering Education (Lecturer)	4	40%
		TVET Educator with Certified SKM Level 3	4	40%
		Digitalization Education (Lecturer)	2	20%

In terms of experience, most participants from both countries had over 15 years of academic or professional expertise, indicating their in-depth understanding of TVET and digital pedagogy. Notably, 90% of Indonesian experts fell into this category, while Malaysian experts displayed a more varied distribution, with 50% having 10-14 years of experience and 20% with over 15 years. This diversity in experience levels enriched the data by incorporating both seasoned perspectives and insights from mid-career professionals. The fields of expertise were equally diverse; Indonesian experts were predominantly from business administration (50%), mechanical engineering (10%), electrical engineering (20%), accounting (10%), and computer and informatics (10%). In contrast, Malaysian experts were primarily TVET educators (40%) and specialists in engineering education (40%), with a smaller proportion focusing on digitalization in education (20%). This blend of technical and pedagogical expertise ensured a holistic understanding of inclusive digital pedagogy within TVET contexts.

The study utilized a structured questionnaire to gather data from the experts. The instrument employed in this study was adapted from a validated framework, questionnaire with a Likert scale level divided into 7 levels of statements including the following: strongly disagree (1), strongly disagree (2), disagree (3), moderately agree (4), agree (5), strongly agree (6), strongly agree (7). For the statement elements regarding digital pedagogy in TVET, experts were asked to express their opinions on each item.

Table 2. Questionnaire Instrument

No.	Elements of Digital Pedagogy in Higher Education TVET	Agreement Scale						
		1	2	3	4	5	6	7
1	Accessibility and Accommodation							
2	Personalized Learning							
3	Digital Pedagogy Skills							
4	Employer Engagement							
5	Infrastructure and Training							
6	Student-Centered Approach							
7	Digital Skills Development							

This prior research served as a foundational reference in developing the instrument (Jamil et al., 2024). Experts rated the elements on a Likert-type scale, with their responses analyzed to compute threshold values, fuzzy scores, and consensus percentages. This approach facilitated a nuanced understanding of expert opinions.

The Fuzzy Delphi Technique employs a three-step evaluation process: data fuzzification, calculation of fuzzy scores, and defuzzification (Hsu & Sandford, 2007). In this study, the fuzzification step converted expert ratings into triangular fuzzy numbers to account for variability in their responses. The second step calculated fuzzy scores for each element, followed by defuzzification to derive crisp values for interpretation. This rigorous process ensured consistency and reliability in the analysis.

The fuzzy scales allow the researcher to identify the range of possible scores that reflect the experts' opinion instead of the single score provided by the traditional scale (Li, 2013). The study established clear criteria for consensus based on threshold values, fuzzy scores, and expert agreement percentages. A threshold value (d) ≤ 0.2 indicated a strong level of consensus, while a minimum agreement of 75% was required for an element to be accepted (Habibi et al., 2014). Additionally, fuzzy scores exceeding 0.5 were deemed significant, ensuring that only highly relevant elements were included in the framework.

To ensure the validity and reliability of the questionnaire, a pilot test was conducted with a separate group of TVET experts. Feedback from the pilot group led to minor revisions in the questionnaire, enhancing its clarity and comprehensiveness. This step aligned with best practices in survey design, which emphasize the importance of instrument validation to enhance data quality (Creswell & Poth, 2018). Jamil et al., (2024) stated that expertise was acknowledged when someone had gained over five years of experience in their field. This time-based criterion recognizes the level of expertise and real-world understanding that accompany long-term involvement in a specific field. Most participants from both countries had more than 5 years of academic or professional experience in TVET higher education, demonstrating their deep understanding of digital pedagogy. In the Fuzzy Delphi Method, the focus is on a purposive sample of experts who possess substantial knowledge, practical experience, and expertise in the relevant domain. The selection of these experts is guided by defined criteria, including academic qualifications, professional involvement, fieldwork, and scholarly contributions. As such, the number of participants in an FDM study does not follow traditional sample size conventions. Adler & Ziglio (1996) suggest that a panel of 10 to 15 experts is adequate, provided that the selection process is rigorous and well-justified. Unlike traditional quantitative methods that rely on inferential statistics and internal consistency measures such as Cronbach's Alpha, the FDM assesses validity and reliability through the level of expert agreement using a Likert scale adapted with fuzzy logic principles. Each item is analyzed using fuzzy number techniques to determine thresholds, consensus percentages, and ranking priorities. As Saedah et al., (2020) emphasize, reliability in such methods is embedded within the consensus patterns among expert responses.

Given the diverse socio-economic and educational contexts of Indonesia and Malaysia, the study considered regional disparities in digital access and infrastructure. Experts provided insights into these contextual factors, ensuring that the identified elements were both practical and culturally relevant. This contextualization strengthened the applicability of the findings to the Indonesian-Malaysian TVET landscape.

The study adhered to ethical guidelines for research involving human participants. Experts provided informed consent, and their anonymity was maintained throughout the study. Ethical approval was obtained from institutional review boards in both countries, ensuring compliance with international research standards (Flick, 2018). This ethical framework underscored the study's commitment to integrity and transparency.

RESULTS AND DISCUSSION

Results

The study identified seven key elements of inclusive digital pedagogy in Indonesian-Malaysian TVET higher education. These elements achieved a high level of expert consensus and were ranked based on their fuzzy scores and expert agreement percentages. The identified elements of Table 2 outline the results, providing detailed insights into the rankings and consensus levels.

All elements surpassed the threshold value for acceptance ($d \leq 0.2$), demonstrated a fuzzy score greater than 0.5, and achieved at least 75% expert agreement, indicating robust consensus. Table 3 summarizes the ranking, fuzzy scores, threshold values, and consensus levels.

Table 3. Findings for Elements of Inclusive Digital Pedagogy for Indonesian and Malaysian TVET

No.	Elements of Inclusive Digital Pedagogy for Indonesian-Malaysian TVET	Triangular Fuzzy Numbers Condition		Fuzzy Evaluation Process Condition				Expert Consensus	Ranking
		Threshold Value, d	Percentage of Experts' Consensus, %	m1	m2	m3	Fuzzy Score (A)		
1	Accessibility and Accommodation	0.095	80.0%	0.730	0.880	0.960	0.857	Accepted	3
2	Personalized Learning	0.118	80.0%	0.680	0.855	0.960	0.832	Accepted	7

| No. | Elements of Inclusive Digital Pedagogy for Indonesian-Malaysian TVET | Triangular Fuzzy Numbers Condition | | Fuzzy Evaluation Process Condition | | | | Expert Consensus | Ranking |
		Threshold Value, d	Percentage of Experts' Consensus, %	m1	m2	m3	Fuzzy Score (A)		
3	Digital Pedagogy Skills	0.137	100.0%	0.690	0.860	0.965	0.838	Accepted	6
4	Employer Engagement	0.143	90.00%	0.700	0.870	0.965	0.845	Accepted	4
5	Infrastructure and Training	0.061	100.00%	0.760	0.910	0.980	0.884	Accepted	1
6	Student-Centered Approach	0.107	100.00%	0.680	0.865	0.975	0.840	Accepted	5
7	Digital Skills Development	0.129	100.00%	0.730	0.890	0.975	0.865	Accepted	2

Infrastructure and training emerged as the most critical components, receiving the highest fuzzy score and full consensus, indicating their fundamental importance in supporting other elements of digital pedagogy. Digital skills development followed closely, highlighting the importance of equipping learners with the competencies needed to navigate digital learning environments. Accessibility and accommodation were emphasized as critical to ensuring equitable participation, especially for underserved learners. Employer engagement and student-centered approaches were prioritized for their role in aligning educational practices with workforce needs and learner preferences. The last two elements, ranked digital pedagogy skills and personalized learning, were also identified as critical to supporting differentiated instruction and enhancing the adaptability of learning environments. These seven elements form the basis for a comprehensive and inclusive digital pedagogy framework tailored to the diverse contexts of Indonesian and Malaysian TVET higher education.

As explained in the table above, Infrastructure and training emerged as the top-ranked elements, with a fuzzy score of 0.884 and unanimous consensus among experts (100%). The infrastructure and training priorities reflect their fundamental impact in enabling other elements of inclusive digital pedagogy. Experts emphasized the need for equitable access to digital tools and comprehensive professional development for educators (Hani et al, 2024).

Digital skills development ranked second, achieving a fuzzy score of 0.865 with 100% consensus. Technology has revolutionized teaching methodologies, offering personalized and interactive learning experiences that cater to diverse learning styles (Subroto et al., 2023).

Accessibility and accommodation, ranked third (fuzzy score = 0.857), was also highlighted as important. Experts pointed out that without accessible resources and accommodation, inclusive practices cannot be fully realized, especially for higher education learners from underserved communities. Employer engagement (ranked fourth, fuzzy score = 0.845) and a student-centered approach (ranked fifth, fuzzy score = 0.840) were identified as critical elements in aligning TVET curricula. Employer engagement ensures that digital pedagogy aligns with industry needs, bridging the gap between education and employment (Jamil et al., 2024). Meanwhile, a student-centered approach emphasizes the importance of tailoring educational experiences to individual learner needs, fostering greater engagement and inclusivity.

Digital pedagogy skills and personalized learning, ranked sixth and seventh, respectively, are recognized as integral components of inclusive digital pedagogy. Digital pedagogy skills (fuzzy score = 0.838) equip educators with innovative teaching strategies and technological competencies necessary for effective instruction (Salmon, 2013). Personalized learning (fuzzy score = 0.832), on the other hand, addresses the diverse needs of learners by enabling flexible and adaptive teaching methods.

Infrastructure and training emerged as the most critical components, achieving the highest fuzzy score and unanimous expert consensus, underscoring their foundational role in enabling all other elements of digital pedagogy. Accessibility and accommodation were also highlighted as

pivotal in ensuring inclusive participation, particularly for marginalized and underserved student populations. Additionally, employer engagement and learner-centered approaches were prioritized for their capacity to align educational practices with industry demands and individual learner needs.

Although ranked lower, digital pedagogy skills and personalized learning were still considered vital, contributing to differentiated instruction and enhancing the adaptability of learning environments. Collectively, these seven elements establish a robust and inclusive framework for digital pedagogy, responsive to the unique educational contexts of TVET higher education in Indonesia and Malaysia.

Discussion

Infrastructure and training emerged as the most critical elements, underlining their foundational importance in Indonesian-Malaysian TVET. Robust infrastructure, including access to digital tools and internet connectivity, is essential to ensure equitable learning opportunities (UNESCO, 2020). Many educators highlighted the importance of ongoing and comprehensive training to increase their confidence and skills in utilizing technology effectively for teaching purposes (Subroto et al., 2023). Educators and students encountered comparable issues with internet connectivity characterized by slow and unstable access, along with increased costs. Despite these challenges, their commitment to continuing online teaching and learning remained strong (Johari et al., 2024).

Digital skills development ranked as the second most significant element, reflecting its vital role in preparing TVET learners for the demands of the Fourth Industrial Revolution. Experts stressed the importance of equipping students with practical digital competencies, such as data literacy, programming, and problem-solving (Cheng & Lin, 2002). Vocational education possesses unique characteristics that require specialized approaches. It focuses on preparing students for specific careers, such as assistant technicians, technicians, or supervisors in various industries (Febriana et al., 2023). The findings reinforce the need for TVET institutions to integrate digital skills training into curricula, ensuring that students are prepared for both current and future workforce demands. To achieve this, educators must receive effective training on using digital tools to enhance learning outcomes and create inclusive learning environments (Bong & Chen, 2024).

Accessibility and accommodation were identified as key elements in fostering inclusivity, particularly for underserved populations in rural areas. Experts noted that physical and digital barriers, such as limited internet access and inadequate devices, significantly hinder equitable participation in digital learning (OECD, 2021). To address these challenges, TVET institutions must adopt strategies like subsidized technology programs and adaptive digital tools (Ahmad et al, 2020). Prioritizing accessibility is essential to bridging the digital divide and ensuring that all learners, regardless of socioeconomic status, can benefit from digital pedagogy.

Employer engagement ranked fourth, highlighting its crucial role in aligning TVET curricula with industry needs. Experts emphasized that active collaboration with employers ensures the relevance of digital pedagogy, helping students acquire job-ready skills. For instance, partnerships with industry leaders can provide insights into emerging technologies and practical applications, enhancing the employability of TVET graduates (Hani et al. 2024). This element underscores the need for sustained dialogue between education providers and industry stakeholders to create a workforce equipped for modern challenges. Good implementation of digital learning innovation will improve the quality of higher education and vice versa (Dewi & Kristanto, 2025).

Student-centered approaches were ranked fifth, reflecting their significance in promoting active engagement and personalized learning. Experts highlighted that learner-centered strategies, such as problem-based learning and flipped classrooms, foster critical thinking and adaptability (Salmon, 2013). These methods also accommodate diverse learning styles, making education more inclusive (Florian & Hawkins, 2011). Preparing students for workforce readiness is primarily the responsibility of universities. However, collaboration with industry is essential to establish benchmarks and standards that define the skill sets to be developed during their education (Kuntadi et al., 2022). However, the students experience a high level of stress and anxiety from online learning because of a lack of knowledge, skills, and unfamiliarity with the digital learning environment.

(Thomas, 2022). By empowering students to take ownership of their learning journeys, TVET institutions can create environments that are both supportive and responsive to individual needs.

Experts noted that educators must adopt innovative teaching strategies, such as gamification and interactive simulations, to enhance student engagement (Cheng & Lin, 2002). Nevertheless, the TVET Teacher Education programme needs to be revised so that the training provided for the future TVET educators may be able to help the country to achieve its mission and vision to be a developed country with high income by providing high-quality TVET educators (Hamdan et al., 2020). The teaching and learning competence of lecturers contributes to enhancing the performance of planning and deploying digital tools and resources in the teaching process, as well as managing and coordinating teaching strategies appropriately, thereby increasing student learning value (Dang et al., 2024).

Technology's rapid advancement has revolutionized our lives and work, creating a growing demand for a digitally skilled workforce (Hani et al, 2024). As human resources in education, educators play a critical role in supporting educational goal attainment. No matter how complex and perfect, the use of facilities, technology, and media does not guarantee the attainment of educational goals if not balanced with the abilities (Gunawan et al., 2024). Vocational education graduates must have various skills needed in work and industry because the nature of education prepares graduates to work (Febriana et al., 2023).

Personalized learning was identified as the seventh key element, emphasizing its role in catering to diverse learner needs. Education 4.0 and the emerging Education 5.0 lead a major shift in learning, where Artificial Intelligence (AI) helps create more personalized and flexible learning experiences (Rane et al., 2025). Implementing a learning management system in the education sector has become necessary at various levels of education, from primary school to higher education (Garad et al., 2021). Personalized learning also aligns with global trends in education, which advocate for flexible and learner-centered approaches to teaching.

The identified elements collectively form a comprehensive framework for inclusive digital pedagogy in Indonesian-Malaysian TVET, addressing a range of challenges such as infrastructure gaps, skill development, and personalized learning. Infrastructure and training are foundational, as they enable educators and students to access and utilize digital tools effectively. Although teachers have experience in teaching, a lack of skills in interactive technology tools can cause students to gain no benefit and struggle to keep up with their learning (Jaya et al. 2022).

By investing in robust digital infrastructure and professional development, policymakers can ensure that TVET institutions are equipped to support equitable digital education (Jamil et al., 2024). Digital skills development complements these efforts, preparing learners to navigate the complexities of the Fourth Industrial Revolution while fostering adaptability and lifelong learning (Cheng & Lin, 2002). This alignment of resources and skills underscores the interdependence of the framework's elements in promoting inclusivity.

The framework highlights a learner-centered approach by integrating accessibility, employer engagement, and personalized learning. Ensuring accessibility through adaptive technologies and subsidized digital tools helps bridge the digital divide in underserved regions (OECD, 2021). Overall, this study emphasizes the importance of strategic planning, targeted investments, and collaborative efforts between educators, policymakers, and stakeholders to address the challenges and maximize the opportunities presented by technology in education (Subroto et al., 2023).

AI-supported personalized learning further enhances inclusivity by addressing individual learner differences (Salmon, 2013). Furthermore, research on the role of technology in inclusive education in Indonesia advocated for equitable access and adaptive curricula, echoing the study's policy recommendations.

CONCLUSION

This study used the Fuzzy Delphi Technique (FDT) to systematically identify and prioritize critical elements of inclusive digital pedagogy in the Indonesian-Malaysian TVET higher education landscape. Through structured expert input and triangulated data analysis using fuzzy logic, the study

developed a consensus-driven framework that is based on statistical rigor and contextual relevance. The FDT methodology proved highly effective in capturing nuanced expert perspectives and minimizing ambiguity in complex and culturally diverse decision-making. The findings revealed seven key components, starting with infrastructure and training as the top priority, followed by digital skills development, accessibility, student-centered approaches, employer engagement, digital pedagogy skills, and personalized learning. These elements collectively address the digital divide, pedagogy gap, and industry demands prevalent in Southeast Asian TVET higher education.

Methodologically, this study contributes to the growing application of the fuzzy Delphi approach in educational research, demonstrating its suitability for cross-border studies, policy formulation, and curriculum planning. By leveraging this participatory and iterative technique, this study also encourages evidence-based practices in the strategic transformation of TVET higher education. Further research is recommended in several key areas. First, empirical studies should be conducted to implement and evaluate the proposed framework in actual classroom environments to assess its practical effectiveness and impact on learning outcomes. Second, longitudinal research could explore the sustainability and evolution of inclusive digital pedagogical practices over time. Third, comparative studies involving other ASEAN countries would be valuable in examining the framework's adaptability and cultural responsiveness across different regional settings.

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