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Research Article

Structural Equation Modeling of Educaplay-Based Interactive Learning to Promote Learning Outcomes among Vocational School Students

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Abstract
Education in the digital era requires the integration of innovative technologies to enhance student learning outcomes. This study examines the mediating role of student engagement in the relationship between interactive learning using Educaplay and learning outcomes. A quantitative research design was employed, involving 125 students majoring in Business and Online Marketing, Accounting, and Banking Services at vocational schools. Data were collected through a structured questionnaire administered via Google Forms using a five-point Likert scale. The proposed model was analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The results indicate that Educaplay-based interactive learning has a significant positive effect on student learning outcomes, both directly and indirectly through student engagement. Furthermore, student engagement was found to partially mediate the relationship between interactive learning and learning outcomes. These findings suggest that integrating interactive digital learning platforms such as Educaplay-based interactive learning can increase student engagement and improve academic performance in vocational education, providing practical implications for technology-enhanced teaching and learning.

Keywords: educaplay, interactive learning, learning outcomes, student engagement

INTRODUCTION

Education is considered a strategic instrument for developing competent and skilled future generations who are capable of contributing to national development across various sectors (Ramstrand et al., 2026). In the digital era, education increasingly emphasizes the integration of technology into the learning process to improve accessibility, effectiveness, and efficiency (Sulistyowati et al., 2024). Technology-enhanced learning environments enable students to access instructional materials more flexibly, receive immediate feedback, and participate more actively in knowledge construction (Duterte, 2024). Meta-analytic evidence has consistently shown that technology integration has a positive effect on student achievement and instructional effectiveness (Schmid et al., 2014). In vocational education, digital technology is particularly important because it supports the development of practical competencies and higher-order thinking skills required in workplace and entrepreneurial settings (Bond et al., 2020; Zawacki-Richter et al., 2019).

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Among the various technology-enhanced instructional approaches, interactive learning has emerged as one of the most promising strategies for promoting meaningful student engagement and improving learning outcomes (Chen et al., 2025). Information technology plays a central role in facilitating interactive learning by expanding access to educational resources and enabling dynamic, learner-centered experiences (Das & Chakraborty, 2025). Interactive learning encourages students to actively participate in activities that foster critical thinking, problem solving, and collaboration (Blyznyuk & Kachak, 2024). Compared with conventional teacher-centered approaches, it provides greater opportunities for students to construct knowledge through direct engagement with instructional materials and timely feedback. According to the ICAP framework, deeper learning occurs when students engage actively and constructively with instructional content (Chi & Wylie, 2014). This perspective complements the multidimensional concept of student engagement proposed by Fredricks et al. (2004), which emphasizes behavioral, emotional, and cognitive engagement as key drivers of successful learning.

Educaplay is a web-based platform designed by authors to support teaching and learning through a variety of gamified activities, including quizzes, crossword puzzles, matching exercises, memory games, video quizzes, and word games. These features enable teachers to create engaging instructional content while allowing students to learn in a more enjoyable and participatory manner. Gamified digital environments have been shown to increase motivation, attention, and knowledge retention by combining formative assessment with immediate feedback and interactive challenges (Bai et al., 2020). Prior investigations confirm that gamification can enhance learning experiences when instructional design is aligned with learner characteristics and educational objectives (Oliveira et al., 2022; Toda et al., 2022). Although some scholars (e.g., Dichev & Dicheva, 2017; Wahyuningsih et al., 2024) note that the effectiveness of gamification depends on context and implementation quality, the overall evidence indicates substantial potential for improving educational outcomes.

Learning outcomes represent the extent to which students achieve cognitive understanding, motivation, and practical competence as a result of the learning process. In technology-enhanced learning environments, improved learning outcomes are associated with higher levels of student engagement (Duterte, 2024). Highly engaged students process, evaluate, and integrate new information more effectively, leading to stronger academic achievement (Fredricks et al., 2004; Kahu, 2013). In addition, students' perceived learning outcomes are widely used in educational technology research as a valid indicator of instructional effectiveness and learner satisfaction (Eom & Ashill, 2016). A scholar also suggests that well-designed online learning environments can significantly improve both engagement and learning performance (Martin et al., 2020).

Previous studies have consistently demonstrated that digital learning tools (e.g., Quizizz, Kahoot, Canva) improve student motivation, engagement, and academic performance (Zainuddin et al., 2020; Sailer & Homner, 2020). However, empirical studies focusing specifically on Educaplay is limited, particularly in vocational secondary education. Moreover, most prior research (e.g., Fajriah et al., 2025; Widiastuti, 2024) have examined the direct effects of digital learning media on engagement or learning outcomes, while few studies have investigated the mediating role of student engagement in explaining how interactive learning influences academic outcomes. Accordingly, this study addresses an important theoretical and empirical gap in the educational technology literature. This study focuses on Educaplay as a comprehensive interactive learning

platform and further examining vocational high school students in Indonesia, and testing student engagement as a mediating mechanism between interactive learning and perceived learning outcomes.

In detail, this study addresses four research questions concerning the use of Educaplay in vocational education. First, it examines whether Educaplay-based interactive learning significantly influences students' perceived learning outcomes. Second, it investigates whether Educaplay-based interactive learning enhances student engagement. Third, it examines whether student engagement significantly affects perceived learning outcomes. Finally, it tests whether student engagement mediates the relationship between Educaplay-based interactive learning and perceived learning outcomes. By addressing these research questions, this study aims to contribute both theoretically and practically to the development of effective technology-enhanced learning strategies in vocational education.

METHOD

Research Design

This study employed a quantitative explanatory research design to examine the direct and indirect relationships among Educaplay-based interactive learning, student engagement, and perceived learning outcomes. Quantitative explanatory research is appropriate when the objective is to test hypotheses and determine causal relationships among variables using statistical analysis. Data were collected through a structured questionnaire and analyzed using Partial Least Squares-Structural Equation Modeling (PLS-SEM), which is suitable for testing complex models involving mediating variables and latent constructs (Hair et al., 2022).

Population and Sample

The study was conducted at vocational school (SMKN) 2 Buduran, Sidoarjo, East Java, Indonesia. The school was selected because it is a leading vocational high school offering business-related programs, including online business and marketing, accounting, and banking services, which are relevant to the creative products and entrepreneurship course. In addition, this school has implemented various digital learning technologies, including Quizizz, Kahoot, and Educaplay, making it an appropriate setting for examining the effectiveness of Educaplay. The population amounted to 181 grade XI students at SMKN 2 Buduran from the Online Business and Marketing (BD), Accounting (Ak), and Banking Services (LPb) majors. The sampling technique used a one-stage sampling procedure. One-stage sampling is where the researcher has access to the names of the population and can conduct single or continuous sampling (Creswell, 2021). The sampling criteria in this study were grade XI students at SMKN 2 Buduran from the BD, Ak, and LPb majors who had taken creative products and entrepreneurship subjects with business resource planning material. Following the determination of the sample size using the Slovin technique with a 5% margin of error, the research sample consisted of 125 respondents in total.

Data Collection

Data were collected using a structured questionnaire administered online through Google Forms. The questionnaire was developed to measure three latent variables: Educaplay interactive learning, student engagement, and perceived learning outcomes.

All items were assessed using a five-point Likert scale, where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree. The questionnaire consisted of 25 items. Educaplay interactive learning was measured using 14 items that assessed students' perceptions of the platform's ease of use, navigation, content clarity, relevance, visual attractiveness, learning experience, active participation, and teacher support. Perceived learning outcomes were measured using 6 items that evaluated students' self-reported improvements in subject mastery, conceptual understanding, learning motivation, interest in the subject, practical skills, and perceived skill development after using Educaplay. Student engagement was measured using 5 items, representing cognitive, emotional, and behavioral engagement, including concentration, active information processing, enthusiasm, satisfaction, and participation in learning activities. The questionnaire items were adapted from established theoretical frameworks and previous studies on educational technology, student engagement, and learning outcomes, and were modified to fit the context of vocational education and the use of Educaplay (Zainuddin et al., 2020). A detailed list of the questionnaire items is presented in Table 1.

Table 1
Questionnaire items and measurement scale

Variable	Code	Questionnaire Item
Educaplay Interactive Learning (X)	X1	The features on the Educaplay platform are easy to understand and use
	X2	The navigation features in Educaplay help me learn more efficiently
	X3	Educaplay improves my understanding of the subject matter
	X4	Using Educaplay helps me remember information better
	X5	The material presented through Educaplay is easy to understand
	X6	The information provided in Educaplay is highly relevant to my learning
	X7	Educaplay's interface is attractive and enjoyable to use
	X8	The visual design of Educaplay supports my learning process
	X9	Educaplay provides a positive learning experience
	X10	I am satisfied with the use of Educaplay in my learning process
	X11	The activities in Educaplay make me more active in learning
	X12	I feel more involved in the learning process when using Educaplay
	X13	The teacher provides clear feedback on assignments completed through Educaplay
	X14	The teacher supports the use of Educaplay in classroom learning
Perceived Learning Outcomes (Y)	Y1	Learning through Educaplay helps me master the subject matter better
	Y2	I find it easier to understand difficult concepts after learning through Educaplay
	Y3	I feel more motivated to learn after using Educaplay
	Y4	Using Educaplay makes me more interested in the subject being taught
	Y5	Activities in Educaplay help me develop practical skills relevant to the subject
	Y6	I feel that my motor skills improve through the use of Educaplay
Student Engagement (Z)	Z1	I feel more focused and think more deeply when learning with Educaplay
	Z2	Using Educaplay makes me more active in processing information
	Z3	I feel happy and enthusiastic when using Educaplay for learning
	Z4	I am satisfied with my learning experience through Educaplay
	Z5	I participate more in learning activities after using Educaplay

Research Instrument and Validity Test

Each indicator in the questionnaire has been tested for validity and reliability. Validity test was conducted using outer loading and AVE (Average Variance Extracted) values, while reliability was tested through Cronbach's Alpha and Composite Reliability. The test results show that all indicators meet the valid and reliable requirements.

Data Analysis

The collected data was analyzed using PLS-SEM approach with the help of the SmartPLS software. In order to investigate both direct and indirect correlations between variables and determine the mediating function of student engagement, the PLS-SEM approach was utilized. The analysis process includes outer model, inner model, and hypothesis testing.

RESULT

Data Description

Data collection for the study was carried out from February to March 2025. Students in grade XI specializing in Online Business and Marketing (BD), Accounting (Ak), and Banking Services (LPb) participated in this survey as respondents. A Google Form was utilized to give a study questionnaire to students in-person at the school in order to collect data. A total of 131 respondents had been gathered by the study's conclusion. Nevertheless, the sample was derived using the Slovin formula with a 5% degree of error, meaning that 125 student samples were drawn from a population of 181 students. According to the data (Table 2), the percentage of female respondents of 85.6% is the largest number of respondents than male respondents who totaled 14.4%. From the table, it is known that the respondents were taken from 25 students in each class in three majors, namely XI BD, XI Ak 1, XI Ak 2, XI Ak 3, and XI LPb.

Table 2
Respondent characteristics

Category	Total	Percentage
Gender		
Female	107	85.6%
Male	18	14.4%
Class		
XI BD	25	20%
XI AK 1	25	20%
XI AK 2	25	20%
XI AK 3	25	20%
XI LPb	25	20%

Convergent Validity

The convergent validity test used the outer loadings score as the main indicator. The value criteria for outer loadings that are considered significant and meet the standards are greater than 0.7 (Hair et al., 2022). Convergent validity analysis results from data processing with the SEM-PLS application are shown in Table 3.

Table 3
Outer loading

Variable	Code	Outer Loading
Interactive Learning (X)	X1	0.755
	X2	0.831
	X3	0.794
	X4	0.804
	X5	0.740
	X6	0.816
	X7	0.762
	X8	0.779
	X9	0.856
	X10	0.865
	X11	0.808
	X12	0.775
	X13	0.746
	X14	0.710
Learning Outcomes (Y)	Y1	0.799
	Y2	0.811
	Y3	0.839
	Y4	0.866
	Y5	0.787
	Y6	0.796
Student Engagement (Z)	Z1	0.796
	Z2	0.845
	Z3	0.758
	Z4	0.849
	Z5	0.832

Source: SmartPLS Output, 2025

Based on the aforementioned data, every item has a score greater than 0.7 when the factor loading score is tested with interactive learning factors, learning outcomes, and student engagement. As a result, everything is deemed legitimate and maintainable.

Discriminant Validity

A latent construct score needs to be higher than the latent construct scores of other variables in order to pass discriminant validity testing, which examines the Cross Loading table and the Fornell-Larcker Criterion (Hair et al., 2022). The results of the discriminant validity test are shown in Table 4 and Table 5.

Table 4
Fornell-Larcker criterion value

Variable	X	Y	Z
Learning Outcomes (Y)	0.817		
Interactive Learning (X)	0.741	0.790	
Student Engagement (Z)	0.718	0.619	0.817

As shown in Table 4, each latent construct has a score greater than the score of other latent constructs. This shows that it has met the Fornell-Larcker Criterion. On the other hand, another discriminant validity testing criterion is to review the cross loadings score. The score is said to meet the requirements when each latent construct score has a

score greater than the score of other latent constructs (Hair et al., 2022). Table 5 demonstrates the results of testing cross loadings.

Table 5
Cross loadings

Variable	Interactive Learning (X)	Learning Outcomes (Y)	Student Engagement (Z)
X1	0.513	0.755	0.401
X2	0.541	0.831	0.449
X3	0.631	0.794	0.478
X4	0.598	0.804	0.467
X5	0.559	0.740	0.421
X6	0.617	0.816	0.554
X7	0.496	0.762	0.420
X8	0.590	0.779	0.438
X9	0.599	0.856	0.570
X10	0.628	0.865	0.585
X11	0.684	0.808	0.571
X12	0.666	0.775	0.550
X13	0.515	0.746	0.400
X14	0.493	0.710	0.470
Y1	0.799	0.623	0.565
Y2	0.811	0.644	0.539
Y3	0.839	0.594	0.543
Y4	0.866	0.654	0.700
Y5	0.787	0.565	0.585
Y6	0.796	0.547	0.575
Z1	0.606	0.549	0.796
Z2	0.563	0.470	0.845
Z3	0.435	0.385	0.758
Z4	0.652	0.560	0.849
Z5	0.635	0.531	0.832

The data demonstrated each construct has a cross loadings score larger than the score of other latent constructs, so the cross loadings score criteria have been met. Based on the findings displayed in Table 4, it can be said that the constructs are deemed valid since the criteria for discriminant validity have been met.

Composite Reliability

Composite reliability is a measurement of the construct value which can be said to be reliable and reliable if it is at a value> 0.7. Meanwhile, Cronbach Alpha is a calculation used to measure composite reliability results with a value of> 0.07 (Hair et al., 2022). The reliability test results are demonstrated in Table 6.

Table 6
Validity and reliability

Variable	Cronbach Alpha	rho_a	Composite Reliability	AVE
Interactive Learning (X)	0.900	0.903	0.923	0.668
Learning Outcomes (Y)	0.953	0.956	0.959	0.624
Student Engagement (Z)	0.876	0.884	0.909	0.667

According to Table 6, the discriminate validity results for interactive learning variables, learning outcomes, and student engagement all items have a score > 0.7. Thus, the item as a whole is able to strengthen reliability. Additionally, the Average Variance Extracted (AVE) results for learning outcomes, student engagement, and interactive learning variables all had scores greater than 0.5. Thus, the item as a whole is able to strengthen reliability.

R-Square

The first step in assessing the structural model is to look at each dependent variable's R-Square (R^2) value, which shows how well the model predicts outcomes. The percentage of the dependent variable's variance that the independent (exogenous) latent variables were able to detect was indicated by the R^2 value. According to Al-Emran et al. (2019), the model's predictive accuracy increases with the R^2 score, which ranges from 0 to 1. A high R^2 therefore signifies that the model supports the dependability of the research model structure and has good forecasting skills. The following is a general classification of the requirements for evaluating the R^2 value, per Hair et al. (2022): (1) 0.75 indicates a substantial (strong) predictive level, (2) 0.50 indicates a moderate predictive level (medium), and (3) 0.25 indicates a weak predictive level.

Table 7
R-Square

	R Square	Criteria
Learning Outcomes (Y)	0.658	Medium
Student Engagement (Z)	0.384	Weak

As shown in Table 7, the value of the learning outcomes variable (Y) is 0.658 or 65.8% which is classified as moderate and means that 65.8% of learning outcomes are influenced by exogenous variables. The value of the student engagement variable (Z) is 0.384 or 38.4% with a moderate classification which means that 38.4% of student engagement is influenced by exogenous variables.

F-Square

The impact or contribution of external latent variables on endogenous latent variables in the structural model is assessed using the f-square (f^2) measure. The f^2 value gives an idea of the strength of the influence of a construct on other constructs. According to framework put forward by Hair et al. (2022), the interpretation of the f^2 value is classified as follows: (1) $f^2 = 0.02$ indicates a small (weak) influence, (2) $f^2 = 0.15$ indicates a moderate influence, and (3) $f^2 = 0.35$ indicates a large influence (strong).

Table 8
F-square

Variable	X	Y	Z
Interactive Learning (X)		0.418	0.623
Learning Outcomes (Y)			
Student Engagement (Z)		0.318	

The f^2 effect size analysis (Table 8) indicates that interactive learning has a substantial influence on both learning outcomes and student engagement. Specifically, the effect of interactive learning on learning outcomes is 0.418, which is classified as a

large effect size, suggesting that interactive learning makes a strong contribution to improving students' perceived learning outcomes. Likewise, the effect of interactive learning on student engagement is 0.623, representing a large effect size and indicating that the implementation of Educaplay-based interactive learning strongly enhances students' engagement in the learning process. Furthermore, student engagement has an effect size of 0.318 on learning outcomes, which is classified as a medium effect. This finding suggests that although student engagement exerts a moderate influence on learning outcomes, it remains an important factor in explaining students' academic achievement.

Predictive Relevance (Q^2)

The blindfolding procedure, which evaluates the model's prediction power to the resulting observation value, yields the Q-Square (Q^2) value. The predictive significance of external (independent) constructions to endogenous (dependent) components is indicated by Q^2. If the Q^2score is greater than 0, the model has good predictive relevance; conversely, when the Q-Square score is less than 0, the predictive capability of the structural model is low (Hair et al., 2022). The interpretation of the Q^2value according to Latan and Ramli (2013) is as follows: (1) $Q^2 = 0.02$ indicates weak predictivity, (2) $Q^2 = 0.15$ indicates moderate predictivity, and (3) $Q^2 = 0.35$ indicates strong predictivity.

Table 9
Q-Square

	Q^2predict	RMSE	MAE
Learning Outcomes (Y)	0.452	0.759	0.480
Student Engagement (Z)	0.299	0.860	0.574

Table 9 shows that the learning outcomes variable has a significant predictive relevance of the structural model with a Q-square score of 0.452. The structural model's predictive relevance for the student engagement variable is 0.299, which indicates that it is categorized as moderate. In this sense, the model in this study has satisfied the goodness (model fit) criterion.

Quality Index

The overall adequacy of the structural model is assessed using the Goodness of Fit (GoF) index. By representing the combined performance of the measurement model and structural model, this index functions as an integrated statistic. The SRMR value can be used to determine the Goodness of Fit. If the SRMR value is less than 0.10, the PLS model is deemed to meet the Goodness of Match criteria; if it is less than 0.08, the model is deemed to be a perfect match. The following table displays the results of the Goodness of Fit test.

Table 10
Model fit value

	Saturated Model	**Estimated Model**
SRMR	0.063	0.063
d_ULS	1.305	1.305
D-G	0.789	0.789
Chi Square	506.935	506.935
NFI	0.803	0.803

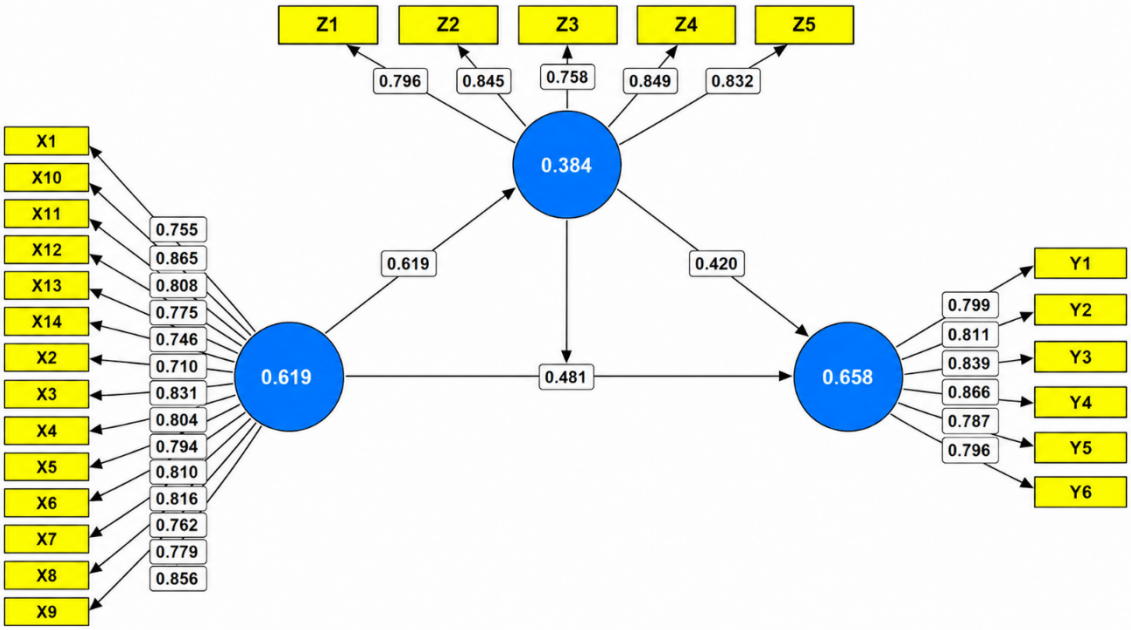
Hypothesis Testing

Hypothesis testing is pursued through observing the Original Sample (O) score to to determine the direction of the connection between variables. A positive direction is indicated by an Original Sample score close to +1, while a negative direction is reflected by a value close to -1. P-values and T-statistics are used to evaluate the relationship's significance. If the T-statistics surpass the crucial score of 1.96 or the P-Values fall below the significance level of 0.05, the association is deemed significant (Al-Emran et al., 2019). Based on these standards, the outcomes of hypothesis testing are compiled in Table 11.

Table 11
Hypothesis tests

Path	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
X → Y	0.481	0.527	0.191	2.519	0.012
X → Z	0.619	0.636	0.114	5.412	0.000
Z → Y	0.420	0.375	0.183	2.292	0.022
X → Z → Y	0.260	0.231	0,110	2.367	0.018

Figure 1
Structural model



The structural model results (Table 11 and Figure 1) indicate that all hypothesized relationships are positive and statistically significant. Interactive learning has a significant positive effect on learning outcomes ($\beta = 0.481$, $t = 2.519$, $p = 0.012$). In addition, interactive learning exerts a strong positive influence on student engagement ($\beta = 0.619$, $t = 5.412$, $p < 0.001$). Furthermore, student engagement significantly and positively affects learning outcomes ($\beta = 0.420$, $t = 2.292$, $p = 0.022$). Lastly, the interactive learning

indirectly affects learning outcomes through student engagement significantly by 0.26 with T statistic 2.367 > 1.96 or P values 0.018 < 0.05.

DISCUSSION

The first results indicate that Educaplay interactive learning has a positive and significant effect on perceived learning outcomes. Therefore, Hypothesis 1 is supported. This finding suggests that the use of Educaplay as an interactive learning medium can effectively enhance students' understanding, motivation, and perceived mastery of the subject matter. Students also perceived the platform as visually attractive and engaging, which contributed to a more enjoyable learning experience. These characteristics are important because the usability and design quality of digital learning tools influence learners' cognitive processing and knowledge retention. According to Mayer (2021), well-designed multimedia environments support meaningful learning by reducing extraneous cognitive load and facilitating active information processing. In addition, immediate feedback and repeated practice opportunities in gamified platforms have been shown to improve academic performance (Van der Kleij et al., 2015). The findings are consistent with prior international studies demonstrating that interactive and gamified learning environments positively influence academic outcomes. For instance, Zainuddin et al. (2020) that found that gamified e-quizzes significantly improved students' learning performance and participation. Likewise, Sailer and Homner (2020) reported that gamification has a positive effect on cognitive and behavioral learning outcomes.

The next results also reveal that Educaplay interactive learning has a positive and significant effect on student engagement, supporting H2. This finding provides empirical evidence that interactive digital learning environments can increase students' cognitive, emotional, and behavioral involvement in classroom activities. Educaplay offers a variety of activities, such as quizzes, puzzles, matching exercises, and video-based tasks, that encourage students to think critically, experiment, and learn from immediate feedback. This result aligns with previous international research. Bond et al. (2020) concluded that educational technology is positively associated with increased student engagement. Zainuddin et al. (2020) demonstrated that gamified assessment tools significantly enhance both engagement and motivation. Furthermore, Martin and Bolliger (2018) found that interactive instructional strategies play a critical role in fostering students' active participation.

The results indicate that student engagement has a positive and significant effect on perceived learning outcomes. Therefore, Hypothesis 3 is supported. This finding confirms that students who are more cognitively focused, emotionally enthusiastic, and behaviorally involved tend to achieve better academic outcomes. This study indicates that students who demonstrated higher engagement were more attentive during lessons, more active in answering questions, and more consistent in completing learning tasks. This active participation contributed to improved understanding and stronger perceptions of learning achievement. The finding is ssupported by established theory and empirical evidence. Fredricks et al. (2004) conceptualized engagement as a multidimensional construct closely linked to academic success. Kahu (2013) also emphasized that engagement serves as a key mechanism connecting educational experiences with academic achievement.

Lastly, the results further demonstrate that student engagement mediates the relationship between Educaplay interactive learning and perceived learning outcomes,

supporting H4. The mediating role of student engagement suggests that the effectiveness of interactive learning depends largely on the extent to which students become actively involved in the learning process. This mechanism is consistent with the mediation framework proposed by Baron and Kenny (1986) and with constructivist learning theory, which emphasizes that meaningful learning occurs when students actively construct knowledge. This finding is consistent with international studies demonstrating that engagement functions as a central mechanism linking instructional design and academic performance. Zainuddin et al. (2020) showed that gamified learning tools simultaneously enhance engagement and academic achievement. Ryan and Deci (2020) explained that engaging learning environments support intrinsic motivation, which strengthens both engagement and learning outcomes. Accordingly, student engagement serves as a crucial explanatory pathway through which Educaplay interactive learning enhances students' perceived learning outcomes.

CONCLUSION

This study examined the influence of Educaplay-based interactive learning on students' learning outcomes, with student engagement serving as a mediating variable. The findings demonstrate that interactive learning significantly enhances both student engagement and perceived learning outcomes. Furthermore, student engagement has a positive effect on learning outcomes and partially mediates the relationship between Educaplay-based interactive learning and learning outcomes. These results highlight that the effectiveness of technology-enhanced learning extends beyond the adoption of digital platforms alone; rather, it depends on the extent to which such platforms actively engage students cognitively, emotionally, and behaviorally throughout the learning process. The findings provide empirical support for the integration of interactive learning technologies in vocational education and suggest that fostering student engagement is a key mechanism for improving academic performance.

Despite these contributions, several limitations should be acknowledged. The study was conducted with Grade XI students from three vocational programs at a single vocational school, which may limit the generalizability of the findings to other educational contexts. In addition, the investigation focused exclusively on the Educaplay platform, whereas numerous digital learning applications may produce different educational outcomes. Future research should therefore include more diverse educational settings, larger and more heterogeneous samples, and comparisons across multiple interactive learning platforms. Moreover, incorporating additional explanatory variables, such as learning motivation, self-efficacy, learning satisfaction, digital literacy, or self-regulated learning, would provide a more comprehensive understanding of the mechanisms through which technology-enhanced learning influences student achievement.

Authors Contribution

D. M: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft, and Visualization. R. S: Supervision, Validation, Writing – review & editing, and Project administration

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Competing interests
The author has declared that there are no conflicts of interest

Data availability
The data were provided upon request to corresponding author (danismaulia25@gmail.com)

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