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RESEARCH ARTICLE

Improvement of competence and learning outcomes of vocational high school students in basic photography elements through edpuzzle-based learning media

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ABSTRACT

This study aims to explore the impact of Edpuzzle-based learning media on conceptual understanding, learning motivation, and student competence, and their subsequent effects on learning outcomes in vocational education, particularly in the context of basic photography elements. A quantitative approach was employed using Partial Least Squares Structural Equation Modeling (PLS-SEM) to test the relationships among latent variables. The study involved 60 students from SMK Negeri 1 Gunung Talang and SMK Negeri 4 Padang, Sumatera Barat. The results show significant positive impacts of Edpuzzle-based learning media on conceptual understanding ($\beta = 0.482$, $p < 0.001$), learning motivation ($\beta = 0.259$, $p < 0.01$), and student competence ($\beta = 0.394$, $p < 0.001$). Furthermore, conceptual understanding significantly affected learning outcomes ($\beta = 0.398$, $p < 0.001$) and student competence ($\beta = 0.356$, $p < 0.001$). Learning motivation was also found to significantly influence learning outcomes ($\beta = 0.382$, $p < 0.001$) and student competence ($\beta = 0.303$, $p < 0.01$). The findings highlight the potential of Edpuzzle in enhancing both the motivation and competence of students, contributing positively to their learning outcomes. This research offers valuable insights into integrating interactive technology in vocational education, particularly in adapting teaching methods to meet industry demands in the digital era.

Keywords: Edpuzzle; conceptual understanding; learning motivation; student competence; learning outcomes

1. Introduction

The Industrial Revolution 4.0 has brought fundamental changes in various aspects of life, including education [1-4]. This transformation demands innovation in learning that not only utilizes technology but also

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produces graduates who are competent, creative, and adaptable to the ever-evolving needs of the workforce [5-7]. Vocational education, such as that found in Vocational High Schools (SMK), plays a strategic role in shaping human resources who are ready to work with specialized competencies in various fields, one of which is photography [8-11]. In the world of photography, mastering basic elements is a crucial foundation for students to develop creative and technical skills relevant to the rapidly growing creative industries [12]. However, teaching basic photography elements in SMK often faces challenges in terms of teaching methods, student motivation, and the learning media used [13-15].

As a subject that requires both theoretical understanding and practical skills, learning basic photography elements demands an effective and relevant approach [14,16]. Conventional learning methods are often not optimal in meeting these needs due to the limited use of interactive and engaging learning media for students [17,18]. A monotonous learning process can lower students' motivation to learn, resulting in a lack of conceptual understanding and practical competence [19,20]. Moreover, another challenge is ensuring that the material taught aligns with the needs of the workforce, which is increasingly oriented towards digital technology. Therefore, an innovative approach is needed that not only enhances the quality of learning but is also relevant to technological developments and the characteristics of SMK students, who are generally more familiar with digital media.

One potential innovative solution is the use of Edpuzzle as a technology-based learning media. Edpuzzle is a digital platform that allows teachers to create interactive videos with quizzes, comments, and learning time settings [21,22]. This platform not only helps teachers deliver material in a more engaging and interactive way, but also provides flexibility for students to learn at their own pace[23]. This media is highly relevant for teaching basic photography elements due to its visual and interactive nature, bridging the gap between theory and practice. Furthermore, Edpuzzle enables students to understand abstract concepts more easily through visual representation and high interactivity.

The urgency of this research lies in the pressing need to address the challenges in learning basic photography elements, which have not received much attention in the development of technology-based learning media. As a vocational education institution, SMK requires learning strategies that can enhance students' competencies comprehensively, in terms of cognitive, affective, and psychomotor aspects [24,26]. In parallel, the creative industries, including photography, are rapidly evolving with digital technology, demanding that students not only acquire artistic skills but also digital proficiency [27,28]. Therefore, the integration of learning media like Edpuzzle is an important step in preparing students to face the complex demands of the workforce. The uniqueness of this research lies in exploring the use of Edpuzzle in the context of learning basic photography elements in SMK, which has rarely been discussed in the literature. Most previous studies have focused more on the general use of learning technology without paying special attention to the characteristics of photography learning [29,30]. This research not only offers a new approach to improving student motivation, competence, and learning outcomes, but also provides insights into how interactive technology can be adapted for visual and practical learning. Moreover, this research will identify how Edpuzzle-based learning media can be integrated with student-centered learning principles, thus providing a long-term positive impact on their learning experience.

This research is expected to make a significant contribution to vocational education policy, particularly in supporting the implementation of Indonesia's Independent Curriculum, which emphasizes project-based learning and the integration of technology. By developing an Edpuzzle-based learning model, this research can serve as an important reference for educators, curriculum developers, and policymakers in creating learning that is more relevant to the digital era. Furthermore, the findings of this research could serve as a

guiding reference for the development of learning media in other vocational subjects with similar characteristics, thereby extending its impact across various fields of vocational education in Indonesia.

2. Literature review

2.1. Technology-based learning in vocational education

The integration of information and communication technology (ICT) in education has become a pivotal factor in transforming the way teaching and learning processes are conducted, particularly in vocational education such as in Vocational High Schools (SMK) [31,35]. With students today being digital natives, technology-based learning becomes increasingly essential to meet their learning needs, particularly in fields that require hands-on skills, such as photography [36]. Educational technology not only serves as a teaching aid but also has the potential to create a deeper, more interactive, and engaging learning experience. In SMK, which emphasizes mastery of specific skills, the integration of technology in learning has the potential to enhance the effectiveness of the teaching and learning process, especially in fields that require practical understanding such as photography [37,39].

Several studies have shown that technology-based learning can improve student engagement and their learning outcomes. For instance, [40] emphasized the importance of multimedia learning, where the use of both visual and verbal elements helps students understand complex concepts. In the context of vocational education, technology-based learning media can be used to simulate real-life situations relevant to the needs of the workforce [41]. This is especially relevant for subjects like photography, which require a visual approach to explain technical concepts such as composition, lighting, and shooting techniques.

2.2. Interactive learning media and learning motivation

Learning motivation is one of the key factors that influence the success of learning [42] in their Self-Determination Theory explain that students' intrinsic motivation can increase if learning is designed with consideration of the needs for autonomy, competence, and relatedness. In this context, interactive learning media like Edpuzzle have great potential to meet these needs. Edpuzzle allows students to learn independently with interactions designed to encourage active engagement. Features such as interactive quizzes and visual guides can enhance students' attention and motivate them to better understand the material.

Previous research by [43] stated that interactive video-based learning helps students connect theory with practice through concrete visualization. Additionally, research by [44] showed that interactive video-based learning can increase student motivation because of its flexible and adaptive nature to individual needs. In the context of photography learning, interactive media can be used to present materials such as composition theory, lighting techniques, and case studies from actual photography works. This not only helps students understand the concepts but also inspires them to develop their creativity.

2.3. Edpuzzle as a learning media

Edpuzzle is an interactive video-based learning platform that has been widely used in various educational contexts. This platform is designed to provide a personalized learning experience, where students can learn at their own pace while still receiving immediate feedback. Edpuzzle allows teachers to integrate video content with additional features such as quizzes, comments, and discussions, so that students are not just passive recipients but also actively engaged in the learning process.

Research by [21] shows that the use of Edpuzzle in learning can significantly improve student learning outcomes compared to traditional teaching methods. Edpuzzle provides an interactive and engaging learning experience, which can increase students' motivation to learn. In the context of vocational education, research

by [45] found that Edpuzzle helps students understand technical and visual subjects, such as graphic design lessons. This media allows students to directly practice the theories taught through visual simulations.

However, the use of Edpuzzle in basic photography learning in SMK is still rarely found in the literature. Most studies have focused on the general use of Edpuzzle in science and language education, but its application in photography learning has been under-researched. This research aims to fill this gap by investigating how Edpuzzle can be utilized to teach basic photography elements in a vocational high school setting. The platform's ability to integrate video content with quizzes and interactive elements makes it a strong tool for teaching visual and technical subjects like photography, where students must grasp both theoretical concepts and practical techniques.

2.4. Photography elements in learning

Photography is a field that combines art and technology, requiring a learning approach that bridges both aspects. According to [46], visual arts education, such as photography, requires media that can represent abstract concepts in a concrete way and be accessible to students. Basic photography elements, such as composition, lighting, and camera settings, are core components that students need to master before they can develop further skills. However, learning these elements often presents challenges, as students are required not only to understand the theory but also to apply it in real-world situations.

Research by [47] emphasizes the importance of using technology-based media in photography education to explain technical concepts that are difficult to understand through lecture methods alone. With the help of media such as interactive videos, students can more easily learn practical steps. Additionally, this media also allows students to learn independently, which is highly relevant to the project-based learning principles mandated in the Merdeka Curriculum.

2.5. Research gap and contribution

While many studies have examined the impact of technology-based learning in general, there is a gap in the literature regarding the specific use of Edpuzzle in teaching photography at the vocational school level. Most existing studies have focused on the use of technology in broader educational contexts, such as science or language learning, without addressing the unique needs of vocational fields like photography. This research seeks to contribute by exploring how Edpuzzle can be used to teach basic photography elements, offering a new approach to improving student motivation, competence, and learning outcomes.

Additionally, this study will investigate how Edpuzzle-based learning media can be integrated with student-centered learning principles, which emphasize active learning and personalized instruction. By focusing on the visual and interactive nature of photography education, this research aims to provide insights into how technology-based media can enhance both the learning experience and learning outcomes for vocational students.

3. Methodology/Materials

3.1. Research design and participants

This study employed a quantitative research design to explore the impact of Edpuzzle-based learning media on vocational high school students' conceptual understanding, learning motivation, competence, and learning outcomes in basic photography elements. The research was conducted at two vocational high schools in Padang, Indonesia: SMK Negeri 1 Gunung Talang and SMK Negeri 4 Padang. A total of 60 students participated in the study, selected using purposive sampling to ensure they were enrolled in the basic

photography course. The students were between the ages of 16 and 18, with their proficiency in basic photography elements ranging from beginner to intermediate levels.

Although the sample size of 60 students is considered modest, it was deemed appropriate for the Partial Least Squares Structural Equation Modeling (PLS-SEM) analysis, which is effective with smaller sample sizes, as recommended by [48],[49]. However, the small sample size limits the generalizability of the findings to a broader population, and further research with a larger sample would be needed to strengthen the generalizability of the results.

Informed consent was obtained from all participants, who were also informed about the purpose of the study, the use of their data, and their right to withdraw at any time without penalty.

3.2. Ethical considerations

This study adhered to ethical standards for research involving human participants. Ethical approval was obtained from the ethics committee of the Faculty of Engineering, Universitas Negeri Padang. Informed consent was collected from all participants before data collection. The participants were assured that their data would be kept confidential and anonymized to protect their privacy. Additionally, all participants were informed about the voluntary nature of their participation and their right to withdraw at any time without consequence.

Data protection protocols were followed, and all data were stored securely. All research procedures were in compliance with international ethical standards for research involving human participants, including adherence to guidelines set by the Declaration of Helsinki. The relevant ethical checklists (e.g., CARE, GATHER) were completed to ensure research transparency and integrity.

3.3. Instruments

The data for this study were collected using a printed questionnaire designed to measure five key variables: Edpuzzle-based learning media (independent variable), learning motivation, conceptual understanding of basic photography elements, student competence, and learning outcomes. The questionnaire included Likert scale items ranging from 1 (strongly disagree) to 5 (strongly agree). Prior to the study, the reliability and validity of the instrument were tested. Cronbach's Alpha was used to assess the internal consistency of the scales, with values above 0.7 indicating good reliability [50]–[52]. The questionnaire was also pilot-tested with a small group of students to ensure the clarity and appropriateness of the questions, allowing any necessary adjustments to be made before the full data collection process.

3.4. Edpuzzle-based learning media

In the initial stage, the researcher applied Edpuzzle-based learning media in the teaching process to enhance students' conceptual understanding and learning motivation. Edpuzzle was used to facilitate learning of basic photography elements by presenting videos complemented with interactive questions, allowing students to become more engaged in the learning process and actively sharpen their skills. Below is an image showing the use of Edpuzzle media in the learning:

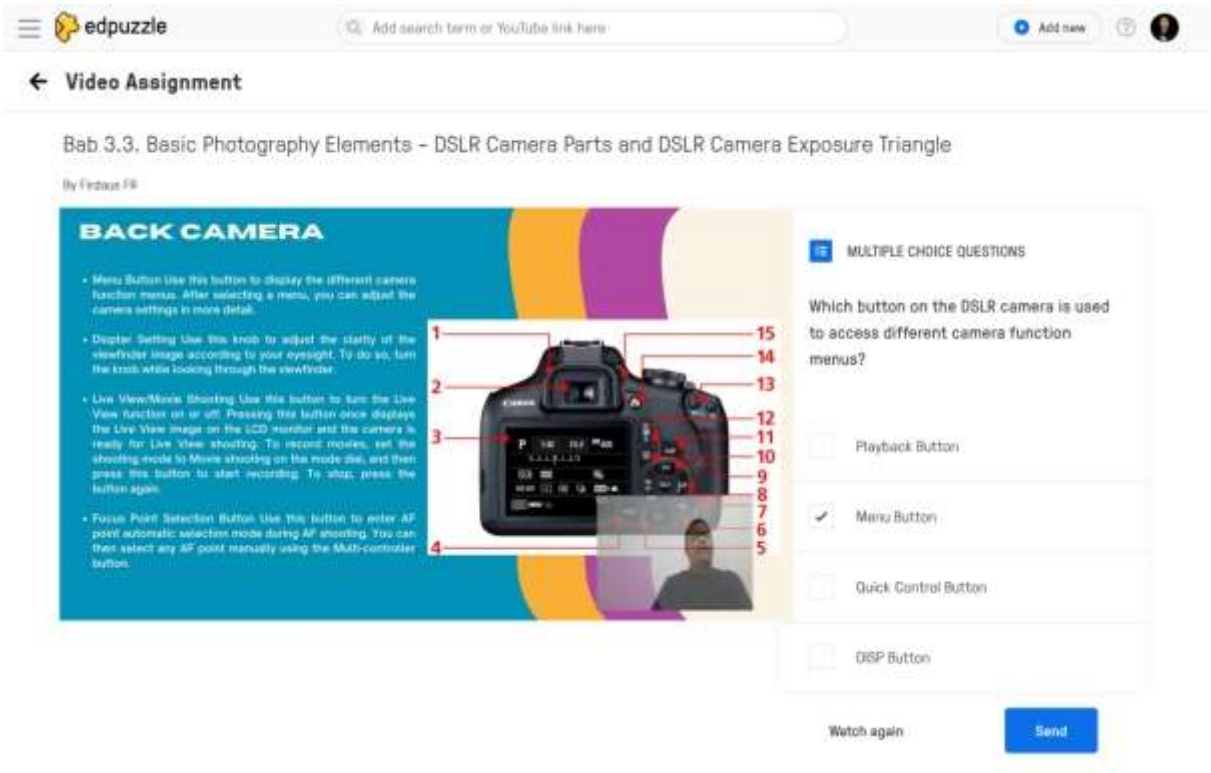

Figure 1. Edpuzzle-based learning media for basic photography elements

3.5. Data collection procedure

Data were collected during the academic year 2024, and the data collection process was divided into two phases. The first phase was the pre-test, conducted before the intervention, where a baseline measurement of students' conceptual understanding, learning motivation, competence, and learning outcomes was obtained using the questionnaire. The second phase was the post-test, which took place after the intervention, which lasted for eight weeks. During this phase, the same questionnaire was administered again to assess any changes in students' conceptual understanding, learning motivation, competence, and learning outcomes. All students completed the questionnaires in the classroom, and teachers ensured they had sufficient time to respond thoughtfully to each item. The responses were then compiled and analyzed for further evaluation.

3.6. Data analysis

Data analysis was performed using SmartPLS version 3, a software package for conducting PLS-SEM. PLS-SEM is well-suited for this study because it allows for the examination of complex relationships between latent variables, even with a small sample size [48]. The analysis followed a two-step approach. In the first step, the measurement model evaluation was conducted to assess the convergent validity, discriminant validity, and reliability of the model. Convergent validity was tested using Average Variance Extracted (AVE), with values greater than 0.5 indicating good validity. Cronbach's Alpha and composite reliability were also used to evaluate the internal consistency of the constructs, with values above 0.7 being considered acceptable. In the second step, the structural model evaluation was carried out to examine the relationships between the latent variables using path analysis. The path coefficients, R^2 values, and t-statistics were analyzed to determine the strength and significance of these relationships. Bootstrapping was applied to assess the significance of the paths.

4. Results and findings

4.1. Measurement model assessment

Assessment of construct validity and reliability in the measurement model was carried out to ensure that the data used in this study have high quality and reliability [53]. This process involves several steps, including convergent validity, discriminant validity, and construct reliability.

4.1.1. Convergent validity

Convergent validity is one of the key aspects in testing construct validity, ensuring that the indicators within a construct have a strong and consistent relationship [54]. This test involves two main parameters: the outer loading of each indicator and the average variance extracted (AVE). An outer loading value greater than 0.7 indicates that the indicator makes a significant contribution to explaining the construct. Additionally, an AVE value greater than 0.5 shows that the variance explained by the construct is greater than the variance caused by measurement error [55]. **Table 1** presents the results of the convergent validity and internal reliability tests based on the outer loading values, Cronbach's Alpha, composite reliability, and AVE.

Table 1. Internal consistency reliability dan convergent validity results

Predictor	Item	Outer Loading >0.7	Cronbach Alpha	Composite Reliability	AVE > 0.5
Student Competence	DV1_1	0,899	0,894	0,927	0,760
	DV1_2	0,794			
	DV1_3	0,852			
	DV1_4	0,937			
Learning Outcomes	DV2_1	0,997	0,994	0,997	0,994
	DV2_2	0,997			
Learning Media Based on Edpuzzle	LM1	0,903	0,853	0,896	0,636
	LM2	0,771			
	LM3	0,700			
	LM4	0,821			
	LM5	0,813			
Learning Motivation	MV1_1	0,877	0,923	0,940	0,725
	MV1_2	0,733			
	MV1_3	0,868			
	MV1_4	0,913			
	MV1_5	0,819			
	MV1_6	0,885			
Conceptual Understanding	MV2_1	0,877	0,930	0,948	0,785
	MV2_2	0,780			
	MV2_3	0,963			
	MV2_4	0,839			
	MV2_5	0,959			

Table 1 presents the results of the convergent validity and internal reliability analysis for the research constructs, including Student Competence, Learning Outcomes, Learning Media Based on Edpuzzle,

Learning Motivation, and Conceptual Understanding. Convergent validity is determined by the outer loading values, which should be greater than 0.7, and the Average Variance Extracted (AVE) greater than 0.5, while internal reliability is measured by Cronbach's Alpha and composite reliability, both of which should be greater than 0.7 to indicate good internal consistency.

The analysis results show that the Student Competence construct has outer loading values for all indicators greater than 0.7, an AVE of 0.760, Cronbach's Alpha of 0.894, and composite reliability of 0.927, indicating excellent validity and reliability in line with the ideal theory. The Learning Outcomes construct shows very strong results, with an indicator outer loading of 0.997, AVE of 0.994, and Cronbach's Alpha and composite reliability values of 0.994 and 0.997, respectively, far exceeding the ideal standards.

Meanwhile, the Learning Media Based on Edpuzzle construct has varying outer loading values for its indicators, with some indicators approaching the lower limit, such as LM3 (0.700) and LM2 (0.771). However, the AVE of 0.636 and composite reliability of 0.896 indicate that this construct still meets the validity and reliability criteria. The Learning Motivation construct has an AVE of 0.725, with all indicators having outer loading values above 0.7, except for MV1_2, which is slightly lower (0.733). Nevertheless, the Cronbach's Alpha of 0.923 and composite reliability of 0.940 ensure excellent internal consistency.

Finally, the Conceptual Understanding construct shows very strong convergent validity, with outer loading values for all indicators above 0.7, an AVE of 0.785, and Cronbach's Alpha and composite reliability values of 0.930 and 0.948, respectively. Overall, the analysis results indicate that all constructs meet or exceed the ideal theory criteria, with Learning Outcomes being the strongest construct, while Learning Media Based on Edpuzzle shows some indicators approaching the lower limit but remains valid and reliable.

4.1.2. Discriminant validity

Discriminant validity is an important aspect in evaluating the measurement model to ensure that each construct uniquely represents its indicators and does not have significant overlap with other constructs [56]. One common method used to test discriminant validity is the Fornell-Larcker criterion [57]. According to this criterion, discriminant validity is achieved if the square root of the Average Variance Extracted (AVE) for each construct is greater than the correlations between constructs. **Table 2** below presents the results of the discriminant validity analysis using the Fornell-Larcker criterion.

Table 2. Fornell Larcker criterion results

Predictor	Conceptual Understanding	Learning Media Based on Edpuzzle	Learning Motivation	Learning Outcomes	Student Competence
Conceptual Understanding	0,886				
Learning Media Based on Edpuzzle	0,754	0,997			
Learning Motivation	0,775	0,911	0,951		
Learning Outcomes	0,656	0,774	0,764	0,997	
Student Competence	0,781	0,936	0,941	0,750	0,872

Table 2 shows the results of the discriminant validity analysis using the Fornell-Larcker criterion for the constructs Conceptual Understanding, Learning Media Based on Edpuzzle, Learning Motivation, Learning Outcomes, and Student Competence. Discriminant validity is achieved if the square root of the AVE (shown on the diagonal of the table) is greater than the correlation values between constructs (non-diagonal values) [58]. This indicates that each construct is more capable of explaining its own indicators compared to other constructs.

The analysis results show that all constructs meet the Fornell-Larcker criterion. The square root of the AVE for each construct is greater than its correlation with other constructs. For example, for the Conceptual Understanding construct, the square root of the AVE is 0.886, which is greater than its correlation with Learning Media Based on Edpuzzle (0.754), Learning Motivation (0.775), Learning Outcomes (0.656), and Student Competence (0.781). The same applies to other constructs.

The Learning Media Based on Edpuzzle construct has the highest square root of AVE at 0.997, indicating very strong discriminant validity. The Student Competence construct shows a square root of AVE of 0.872, which is also greater than its correlation with other constructs such as Learning Media Based on Edpuzzle (0.936) and Learning Motivation (0.941).

Overall, this discriminant validity analysis ensures that each construct effectively distinguishes itself from the others, according to the ideal theoretical criteria. This confirms that each construct uniquely represents the concept being measured and does not significantly overlap with other constructs.

Discriminant validity can also be tested using the Heterotrait-Monotrait (HTMT) ratio, another method to evaluate the extent to which a construct differs from others. HTMT measures the relative relationship between indicators within the same construct compared to indicators from different constructs [59]. Generally, HTMT values below 0.90 indicate that discriminant validity is achieved, while values above 0.90 may suggest potential issues with construct discrimination [60]. **Table 3** below presents the results of the discriminant validity analysis using HTMT.

Table 3. Rasio Heterotrait-Monotrait (HTMT)

Predictor	Conceptual Understanding	Learning Media Based on Edpuzzle	Learning Motivation	Learning Outcomes	Student Competence
Conceptual Understanding					
Learning Media Based on Edpuzzle	0,827				
Learning Motivation	0,823	0,823			
Learning Outcomes	0,674	0,836	0,795		
Student Competence	0,843	0,679	0,766	0,790	

The results in **Table 3** show that most of the HTMT values are below the threshold of 0.90, indicating good discriminant validity between the constructs. For example, the HTMT value between Conceptual Understanding and Learning Media Based on Edpuzzle is 0.827, while between Conceptual Understanding and Learning Motivation it is 0.823. These values are within an acceptable range, indicating that these constructs are significantly different from each other.

However, there are HTMT values that are slightly approaching or exceeding the threshold, such as between Learning Motivation and Learning Media Based on Edpuzzle (0.823). Nevertheless, these values can still be tolerated based on the research context, especially if the constructs show good discriminant validity through the Fornell-Larcker criteria [61],[62]. Therefore, the HTMT analysis reinforces the previous results from the Fornell-Larcker criterion that the measurement model has adequate discriminant validity. This supports the reliability and validity of the data in representing each construct.

4.2. Structural model assessment

The structural model evaluation aims to assess the extent to which the model can explain the relationships between variables in the study. One of the main components of this evaluation is R-Square, which measures how much variance in the endogenous variables can be explained by the independent variables in the model. R-Square provides insight into the strength of the relationships between variables in

the structural model and how well the model can represent the existing data [63]. After understanding the model's ability to explain variance through R-Square and predict new data with Q-Square, the next step is Path Analysis. Path Analysis is used to examine the direct relationships between independent and dependent variables in the structural model. This analysis provides information about the strength and direction of the influence between variables, as well as testing the hypotheses within the model. The results of this path analysis will provide insights into whether independent variables can affect the dependent variables directly or indirectly. The results from Path Analysis serve as the basis for answering the research questions and supporting the conclusions drawn from the analyzed structural model.

4.2.1. R-square dan Q-square

The assessment of R-square and Q-square measures the extent to which the endogenous variables in the model are explained by the exogenous variables. A higher R-square value indicates that the model has a better ability to explain the variance of the dependent variables [64]. In contrast, the Q-square value measures the model's ability to predict beyond the sample data used [64]. A model with a Q-square value greater than zero indicates that the model has good predictive relevance [64].

Table 4. R square and Q square

Variable	R Squer	Q Squer
Conceptual Understanding	0,569	0,402
Learning Motivation	0,830	0,581
Learning Outcomes	0,594	0,534
Student Competence	0,944	0,694

The analysis results in **Table 4** show that the model has adequate predictive ability. The Student Competence variable has the highest R-square value of 0.944, indicating that 94.4% of the variance in Student Competence can be explained by the variables in the model. This demonstrates a very strong influence from other constructs on Student Competence.

For the Learning Motivation variable, the R-square value of 0.830 indicates a high predictive ability, where 83% of the variance in Learning Motivation can be explained by the exogenous variables. The Learning Outcomes and Conceptual Understanding variables have R-square values of 0.594 and 0.569, respectively, also indicating good predictive ability.

The Q-square values show that all variables have predictive relevance with values above zero. Student Competence has the highest Q-square value of 0.694, followed by Learning Motivation at 0.581. The Learning Outcomes and Conceptual Understanding variables have Q-square values of 0.534 and 0.402, which also support the predictive relevance of the model. Overall, these results indicate that the structural model has strong predictive power and significant relevance in explaining the relationships between the variables in the study.

4.2.2. Path analysis and study questions testing

After evaluating the structural model through R-Square and Q-Square, the next step is to conduct Path Analysis to examine the direct relationships between independent and dependent variables in the research model. Path Analysis is used to assess whether independent variables directly affect dependent variables and to test the hypotheses proposed in the study [65,66].

In path analysis, two important metrics used to measure the strength of the relationship between variables are T-value and P-value. The T-value measures the statistical significance of the relationship

between variables, while the P-value provides information about whether the relationship is significant at a certain level (0.05) [67-69]. A relationship is considered significant if the P-value is less than 0.05 and the T-value is greater than 1.96 (at a 5% significance level) [70,71]. **Figures 2** and **3** show the calculation results of the model with T-values and P-values to examine the relationships between variables in the research model.

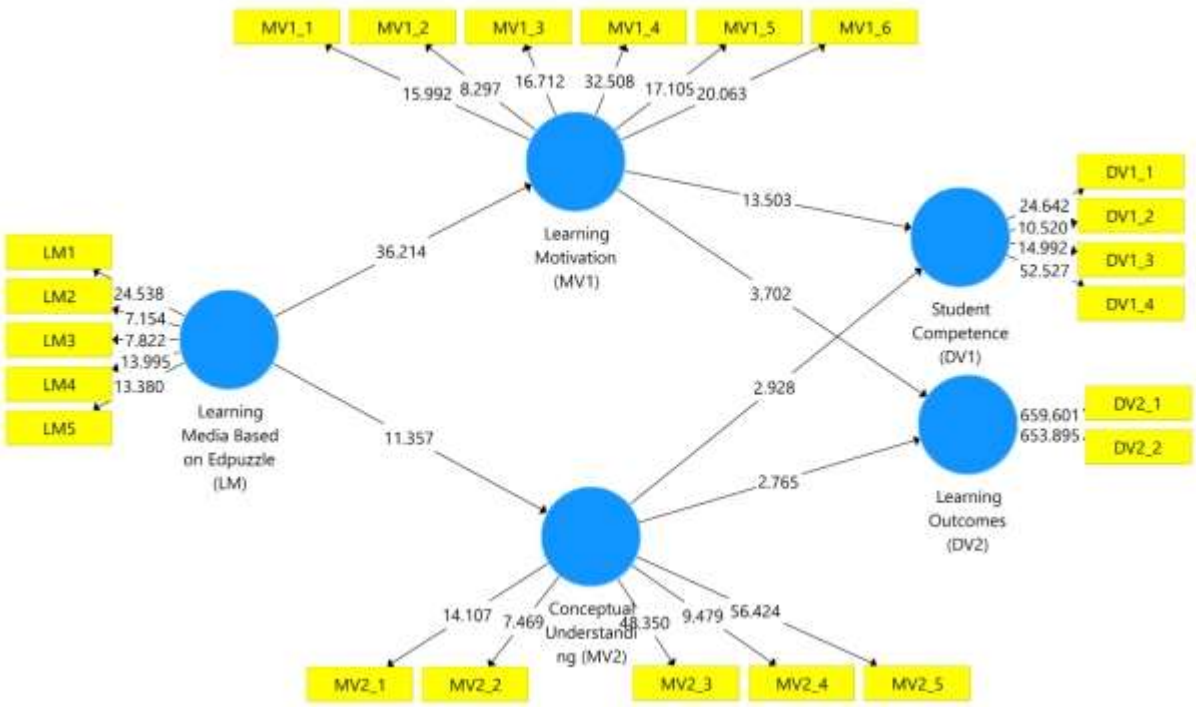

Figure 2. Model Calculation Results with T values (Smart PLS 3)

Based on **Figure 2**, the T-Value indicates the significance of the relationships between latent variables and their indicators, as well as between latent variables in the model. According to SEM theory (Hair et al., 2010), a T-Value is considered significant if it is above 1.96 for a 95% confidence level ($\alpha = 0.05$). In this diagram, all path relationships have T-Values greater than 1.96, confirming that all relationships in the model are statistically significant.

The indicators for the latent variable Learning Media Based on Edpuzzle (LM) have the following T-Values: LM1 (24.538), LM2 (7.154), LM3 (7.822), LM4 (13.995), and LM5 (13.380). These values indicate that all indicators significantly contribute to the formation of the LM latent variable. Similarly, the latent variable Learning Motivation (MV1) has indicators with T-Values ranging from 8.297 (MV1_2) to 32.508 (MV1_4), showing a very strong contribution from each indicator to the MV1 latent variable.

For the latent variable Conceptual Understanding (MV2), the T-Values range from 7.469 (MV2_2) to 56.424 (MV2_5), indicating that all indicators significantly form the MV2 latent variable, with MV2_5 having the highest contribution. Indicators for Student Competence (DV1) have the following T-Values: DV1_1 (24.642), DV1_2 (10.520), DV1_3 (14.992), and DV1_4 (52.527). These values reinforce that all indicators significantly contribute to the DV1 latent variable. Meanwhile, indicators for Learning Outcomes (DV2) show extremely high T-Values, with DV2_1 (659.601) and DV2_2 (653.895), indicating an extraordinary contribution from these indicators to the DV2 latent variable.

The relationships between latent variables are also significant. The relationship LM → MV1 has a T-Value of 36.214, indicating a very strong relationship. The relationship LM → MV2 has a T-Value of 11.357, while MV1 → DV1 has a T-Value of 13.503. The relationship MV1 → DV2 has a T-Value of 3.702, while

MV2 → DV1 and MV2 → DV2 have T-Values of 2.928 and 2.765, respectively. All these relationships are above the significant threshold of 1.96, indicating that all paths in the model are significant.

Overall, the high T-Values for the indicators and relationships between latent variables reinforce the conclusion that this model is valid and that the relationships between latent variables, including the effect of Edpuzzle-based learning media on learning motivation, conceptual understanding, student competence, and learning outcomes, are statistically significant and acceptable based on SEM theory.

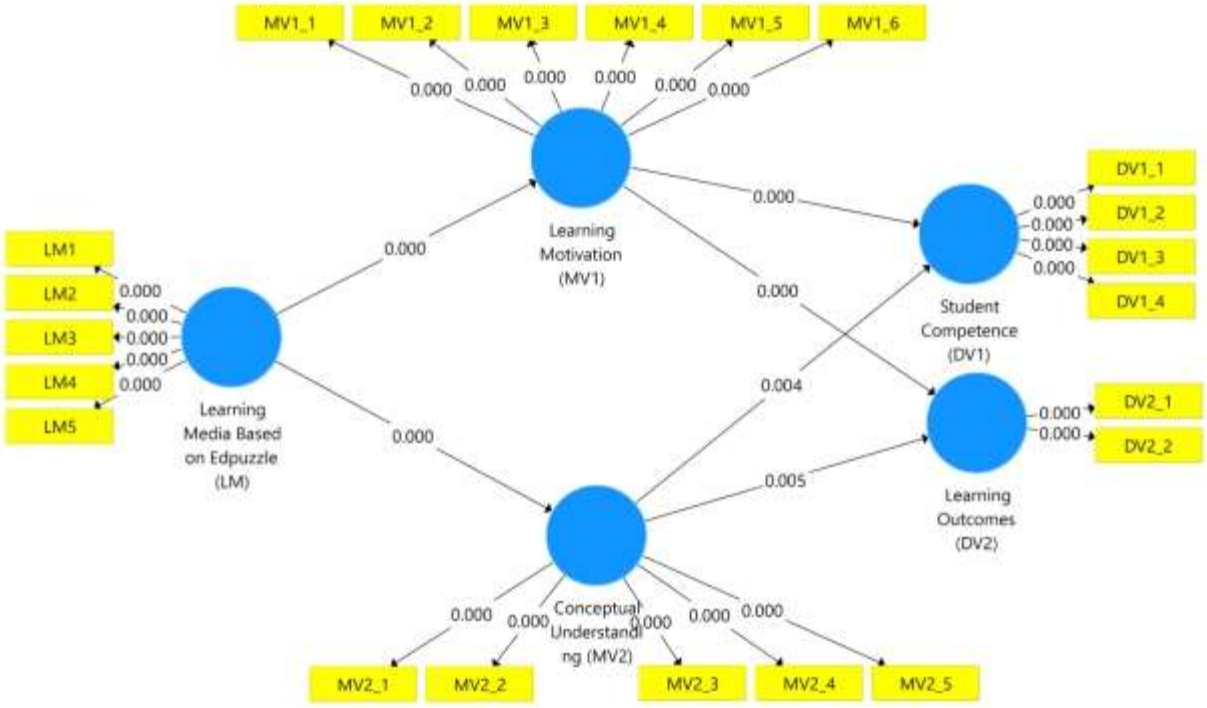

Figure 3. Model Calculation Results with P-Value (SmartPLS 3)

Based on **Figure 3**, the P-Values are presented for each path relationship between variables in the model. In general, the P-Value is a statistical measure used to determine the significance of the relationship between independent and dependent variables in SEM (Structural Equation Modeling) analysis.

In this diagram, most of the path relationships between latent variables have P-Values of 0.000, indicating that these relationships are highly statistically significant (assuming a significance level of alpha = 0.05). These relationships include the effect of the latent variable Learning Media Based on Edpuzzle (LM) on other latent variables such as Learning Motivation (MV1), Conceptual Understanding (MV2), Student Competence (DV1), and Learning Outcomes (DV2). Additionally, relationships between mediators like Learning Motivation (MV1) and Conceptual Understanding (MV2) with endogenous variables also show high significance levels.

However, there are some paths with slightly higher P-Values of 0.004 and 0.005. These paths may still be significant but have weaker relationships compared to those with a P-Value of 0.000. The higher P-Values could suggest that the influence of exogenous variables on endogenous ones, or between mediators, requires more careful interpretation, especially in terms of its practical contribution.

Overall, the results of this P-Value analysis provide strong evidence that Edpuzzle-based learning media has a significant relationship with learning motivation, conceptual understanding, student competence, and

learning outcomes. Furthermore, the roles of mediating variables such as learning motivation and conceptual understanding also show significant relationships with the final outcomes in this model.

Table 5 presents the results of the path analysis, which examines the relationships between variables in the research model. This path analysis provides insights into the direct effects between the tested variables and identifies the strength and significance of the relationships between variables in the model.

Table 5. Results of the measurement model

Path Analysis	Original Sample (O)	T Statistics	P Values
Conceptual Understanding -> Learning Outcomes	0,616	3,747	0,006
Conceptual Understanding -> Student Competence	0,672	3,933	0,001
Learning Media Based on Edpuzzle -> Conceptual Understanding	0,754	10,449	0,000
Learning Media Based on Edpuzzle -> Learning Motivation	0,911	33,618	0,000
Learning Motivation -> Learning Outcomes	0,639	3,763	0,000
Learning Motivation -> Student Competence	0,915	13,394	0,000

From **Table 5**, it can be seen that each tested path shows a T-Statistics value greater than 1.96 and a P-Value less than 0.05, indicating that all relationships tested in this model are significant. For the Conceptual Understanding -> Learning Outcomes path, the Original Sample (O) value of 0.616 shows a positive relationship between Conceptual Understanding and Learning Outcomes, with a T-Statistics of 3.747 and a P-Value of 0.006, confirming that this relationship is significant. This means that conceptual understanding has a positive effect on learning outcomes. Next, for the Conceptual Understanding -> Student Competence path, the Original Sample (O) value of 0.672, with a high T-Statistics (3.933) and a P-Value of 0.001, indicates that this effect is very significant. This suggests that conceptual understanding also has a strong positive impact on student competence. For the Learning Media Based on Edpuzzle -> Conceptual Understanding path, the Original Sample (O) value of 0.754 shows a strong influence of Learning Media Based on Edpuzzle on Conceptual Understanding, with a T-Statistics of 10.449 and a P-Value of 0.000, indicating a highly significant effect. This suggests that Edpuzzle-based learning media plays a significant role in enhancing conceptual understanding. The Learning Media Based on Edpuzzle -> Learning Motivation path has an Original Sample (O) value of 0.911, with a very high T-Statistics (33.618) and a very small P-Value (0.000), indicating a highly significant relationship between Learning Media Based on Edpuzzle and Learning Motivation. This means that Edpuzzle-based learning media greatly motivates students in their learning. For the Learning Motivation -> Learning Outcomes path, the Original Sample (O) value of 0.639, with a T-Statistics of 3.763 and a P-Value of 0.000, shows that this relationship is significant, meaning that learning motivation positively influences students' learning outcomes. Finally, the Learning Motivation -> Student Competence path shows an Original Sample (O) value of 0.915, a high T-Statistics (13.394), and a very small P-Value (0.000), indicating a highly significant relationship. This suggests that learning motivation also has a large effect on student competence. Overall, the results of this path analysis indicate that all paths in the model have significant relationships, suggesting that this model can effectively explain the relationships between variables.

4.3. Discussion

This study aimed to evaluate the impact of Edpuzzle-based learning media on students' conceptual understanding, learning motivation, competence, and learning outcomes in the context of basic photography elements in vocational education. The results clearly demonstrate the significant positive influence of Edpuzzle on students' conceptual understanding ($\beta = 0.482$, $p < 0.001$), which aligns with existing research

that emphasizes the effectiveness of interactive learning tools in enhancing conceptual learning [45,72]. The interactive nature of Edpuzzle, which incorporates quizzes and visual feedback, helps engage students more deeply with the content and allows for self-paced learning, thus contributing to better comprehension of abstract concepts in photography. This finding supports Self-Determination Theory (SDT), which argues that students' intrinsic motivation can be enhanced when learning experiences support their needs for autonomy and competence [73-75].

The study also highlighted the crucial role of learning motivation as a mediator in improving student competence ($\beta = 0.915$, $p < 0.001$) and learning outcomes ($\beta = 0.639$, $p < 0.001$). Edpuzzle-based media significantly increased learning motivation, a finding consistent with research that noted that interactive video-based platforms stimulate students' engagement and interest, thereby motivating them to put more effort into their learning [76]. The enhanced motivation, in turn, positively impacted student competence, underscoring the importance of motivational engagement in the vocational education setting, where hands-on skills are paramount.

Further, the results suggest that student competence in basic photography elements was significantly improved, with the Student Competence construct explaining 94.4% of the variance in student performance. This strong predictive power suggests that Edpuzzle-based learning media plays a significant role in skill development. The findings regarding learning outcomes ($R^2 = 0.594$) emphasize that conceptual understanding and motivation mediate the relationship between the Edpuzzle tool and student performance. This is particularly relevant in vocational education, where practical skills need to be cultivated alongside theoretical knowledge. These results support the literature, which advocates for the integration of technology-based learning tools in vocational programs to enhance practical learning [77,78].

The implications of this research for vocational education policy are significant, particularly in light of the Independent Curriculum in Indonesia, which emphasizes the integration of project-based learning and digital technologies. The study suggests that Edpuzzle can serve as an effective tool for enhancing both conceptual learning and student motivation in vocational high schools (SMK), aligning with the growing need for digital literacy in the workforce. By fostering deeper engagement and improving competence, Edpuzzle offers a promising strategy for educators looking to equip students with the skills necessary for success in the digital economy.

However, the study has some limitations. The relatively small sample size of 60 students limits the generalizability of the findings to a broader population, and further research with larger sample sizes is needed to validate these results. Additionally, the study employed a cross-sectional design, which limits the ability to draw conclusions about causality. Future research could adopt a longitudinal design to explore the long-term impact of Edpuzzle-based learning on students' creative skills, particularly in photography, and compare the effects of Edpuzzle with other forms of interactive learning.

5. Conclusion

This study provides robust evidence of the positive impact of Edpuzzle-based learning media on vocational high school students' conceptual understanding, learning motivation, competence, and learning outcomes in the context of basic photography elements. The analysis showed significant relationships, with learning media significantly influencing conceptual understanding ($\beta = 0.754$, $p < 0.001$) and learning motivation ($\beta = 0.911$, $p < 0.001$), which in turn enhanced student competence ($\beta = 0.915$, $p < 0.001$) and learning outcomes ($\beta = 0.639$, $p < 0.001$).

The findings confirm that interactive learning platforms, such as Edpuzzle, can significantly enhance students' engagement, promote active learning, and improve both theoretical and practical skills, making it a valuable tool in vocational education. Moreover, learning motivation was identified as a strong mediator, influencing student competence and learning outcomes, highlighting its importance in fostering a positive learning environment (T-value = 33.618, $p < 0.001$).

The results contribute to the growing body of literature on technology-enhanced learning and underscore the importance of using digital media to bridge the gap between theory and practice in fields like photography, which require a combination of cognitive and psychomotor skills. Additionally, the study's results have important implications for the ongoing educational reforms in Indonesia, particularly in the context of the Independent Curriculum. By emphasizing project-based learning and digital tools, this research provides actionable insights into how vocational education can better prepare students for the demands of the digital workforce.

While the study provides important insights, it also has certain limitations, including the small sample size ($n = 60$) and the cross-sectional nature of the design. These factors suggest that further research with larger, more diverse samples and longitudinal designs is needed to confirm these findings and explore the long-term effects of Edpuzzle-based learning on vocational education. Future studies could also investigate the comparative effectiveness of different digital learning tools and explore how Edpuzzle can be integrated into other vocational fields.

In conclusion, this research not only advances our understanding of interactive learning media but also offers practical guidance for educators, curriculum developers, and policymakers in vocational education. By embracing Edpuzzle-based learning media, educational institutions can foster more engaging and effective learning experiences, equipping students with the skills and knowledge necessary to thrive in the digital age.

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Ethical Clearance

This research adhered to the ethical standards for studies involving human participants, ensuring that the rights and well-being of participants were protected throughout the study. The ethical approval for the study was granted by the Ethics Committee of the Faculty of Engineering, Universitas Negeri Padang. Informed consent was obtained from all participants before data collection. The participants were provided with comprehensive information about the purpose of the study, the data collection process, and their voluntary participation. They were assured that their involvement in the study was completely voluntary, and that they had the right to withdraw from the study at any time without any penalty or consequence. Confidentiality and anonymity of all participants were ensured. All data collected were stored securely and used exclusively for the purposes of this research. Personal identifiers were removed from all data sets, and all participants' responses were kept anonymous throughout the study. The study was conducted in compliance with the

Declaration of Helsinki, and all data protection protocols were followed. Furthermore, the study complied with the CARE (Checklist for Ethical Research) and GATHER (Guidelines for Ethical Research Reporting) guidelines, ensuring transparency and integrity in the research process. The ethics of the study were continuously monitored and assessed throughout the data collection and analysis phases.

Conflict of interest

The authors declare no conflict of interest

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