Student e-learning effectiveness based on pedagogy, evaluation and technology dimensions (PET-D): Empirical studies in higher education in the COVID-19 epidemic

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Abstract The research examines the role of pedagogical, evaluative, and technological dimensions (PET-D) in the success of e-learning platforms in higher education. Specifically, it focuses on fashion design students at Yogyakarta State University during the COVID-19 pandemic. This study explores how these dimensions contribute to the effectiveness of e-learning by enhancing the quality of information, learner control, beneficial interactions, and appropriate strategies. The study involved 472 fashion design students from Universitas Negeri Yogyakarta who responded to a 28-item questionnaire distributed via Google Forms. The data collected was statistically analyzed, and both the validity and reliability of the instruments were assessed using Confirmatory Factor Analysis (CFA) followed by model fit tests. Findings indicate that all three dimensions pedagogy, evaluation, and technology positively impact the effectiveness of e-learning. Interesting further findings include the positive contributions of a learning community and student satisfaction with available facilities towards online learning success. Additionally, design aesthetics and technology mastery were identified as key to accessing information resources. The study highlights the importance of comprehensive evaluation of online learning implementations, digital content, and accessibility to ensure e-learning success. It underscores the need for digital competencies, tailored teaching methods, and innovative e-learning platforms to enhance educational outcomes during the pandemic. The research is limited to a specific group of students and a single discipline, suggesting the need for broader studies across various fields and institutions. Future research should investigate the long-term impacts of e-learning post-pandemic, the integration of new technologies, and the challenges of digital access to fully understand the potential of e-learning in transforming higher education comprehensively.

Keywords: e-learning effectiveness, pedagogies dimension, digital content, fashion design, COVID-19

1. Introduction

The recent surge in digital learning within higher education, notably accelerated by the COVID-19 pandemic, has prompted a critical reassessment of traditional teaching methods in favor of online platforms. This shift, catalyzed by the urgent need to respond to health crises and the broader trend towards digital integration, has emphasized the pivotal aspects of Pedagogy, Evaluation, and Technology (PET-D) in evaluating the effectiveness of e-learning, particularly in vocational education (Yeap et al., 2021). Research highlights the importance of comprehensively understanding various elements such as technological infrastructure, educational outcomes, and learner engagement that form the foundation of a successful e-learning environment (Azmi et al., 2023). Vocational institutions are grappling with the challenge of aligning conventional teaching styles with the evolving demands of online education to maintain educational quality and equip students for the contemporary workforce amidst disruptions (Yeap et al., 2021). Consequently, there’s a consensus on the imperative to cultivate novel educational atmospheres and pedagogical strategies that bolster student capabilities and active participation in online learning environments.

The rapid expansion of e-learning as a fundamental educational tool has brought forth a blend of benefits and challenges, underscoring the need for a comprehensive evaluation of its effectiveness across various dimensions. The success of e-learning is intricately tied to critical factors such as the foundational technological infrastructure, the flexibility of instructional approaches, and robust assessment strategies (Abdullah & Ward, 2016). Notably, scholarly discourse has pinpointed a significant concern regarding the adaptation of educational content delivery and teaching methodologies to align
with the virtual learning environment, prompting a reexamination of traditional pedagogical models (Al-Hawamdeh & Alam, 2022). This shift advocates for an integrated approach that harmonizes advanced technological support with dynamic teaching practices and effective evaluation mechanisms (Dolmark et al., 2022). Recent research emphasizes the importance of a unified framework that encompasses the Pedagogy, Evaluation, and Technology Dimensions (PET-D) of e-learning, fostering interactive learning environments, catering to diverse learning preferences, and enabling continuous feedback (Väätäjä & Ruokamo, 2021). The establishment of such e-learning ecosystems necessitates collaborative efforts from all educational stakeholders to tailor digital learning experiences to meet the evolving needs of students and the educational landscape (Aini et al., 2020).

Scholarly research has identified various strategies that can enhance the effectiveness of e-learning in vocational higher education. Customization of pedagogical approaches to align with the specific requirements of online learning is crucial (Gormley et al., 2009). This customization often involves the adoption of blended learning models that integrate diverse learning activities to create a more adaptive educational experience. Additionally, the strategic use of multimedia and interactive tools can deepen students’ comprehension of course material (Yeou, 2016). These innovative approaches highlight the importance of educators enhancing their digital pedagogy skills, emphasizing the need for professional development programs tailored to equip teachers proficiently for the online educational realm (Gagnon et al., 2020). The success of e-learning in vocational education is closely tied to the strength of the digital infrastructure. Comprehensive support systems such as reliable internet connectivity and user-friendly learning management systems are essential to ensure accessibility and minimize barriers to learning (Zhou, 2023). Effective assessment in e-learning includes a range of strategies such as formative and summative evaluations, peer feedback, and the use of analytics to tailor personalized teaching approaches. These strategies collectively foster an environment conducive to student reflection, engagement, and performance enhancement (Ye et al., 2022).

Although e-learning’s effectiveness has been extensively researched, there are significant gaps in understanding the key success factors specific to vocational higher education, indicating a critical need for further empirical investigation (Nabi et al., 2017). This research should focus on examining the interplay between technological tools, pedagogical methods, and evaluation frameworks within e-learning systems to enhance educational outcomes (Akkerman & Bakker, 2011). Currently, there is a lack of a unified approach outlining best practices for deploying e-learning that can effectively cater to the diverse needs of learners and educators (Lee & Hsu, 2021). This ambiguity underscores the importance of conducting in-depth studies to identify and validate the essential elements crucial for the success of e-learning, especially in the context of the evolving educational landscapes influenced by the COVID-19 pandemic (Ye et al., 2022). Moreover, despite the recognized benefits of e-learning, there is a compelling need for comprehensive analyses that evaluate its impact on student outcomes and satisfaction from both quantitative and qualitative perspectives (Xiong et al., 2022). This evaluation should encompass an exploration of instructor behaviors, community dynamics within the learning environment, and the influence of user interface designs on the overall learning experience (Carlsson et al., 2023). Delving into these areas is essential for advancing the strategic development of e-learning methodologies and enhancing the quality of online vocational education (Zhou, 2023).

This research endeavors to delineate and assess the array of elements influencing e-learning efficacy among vocational higher education students amid the COVID-19 pandemic, focusing on various critical dimensions such as technology, pedagogy, evaluation, instructor attitudes, and student satisfaction, among others. It sets out to deliver an in-depth analysis of these determinants, thereby enriching the discourse for educators, practitioners, and policymakers involved in e-learning’s deployment. Markedly, the study distinguishes itself by adopting a comprehensive approach to investigate the multifaceted nature of e-learning effectiveness, a departure from prior research which often isolated single aspects for scrutiny. Concentrating on vocational higher education in Indonesia, the study offers distinct insights into the e-learning paradigm within this context, highlighting both the hurdles and prospects it presents. Ultimately, this investigation seeks to augment the dialogue surrounding educational evolution in the digital era, aiming to furnish actionable strategies for enhancing online learning environments.

2. Methods

This study employed a quantitative research design to examine the construct model and hypotheses through a survey methodology, identifying relationships and impacts among variables. Questionnaires were first, second, and third-year fashion design students from Yogyakarta State University, Indonesia, selected through purposive random sampling, totaling 472 respondents.

In this study, the instruments designed to measure E-learning Effectiveness (EE) encompassed Attitude toward Technology (ATT) and Pressure to Use Technology (PUT), anchored in a theoretical foundation laid out by B H Khan et al. (2021). Four question items were crafted for each of ATT and PUT, receiving the labels EE1, EE2, EE3, and EE4 for identification. The Pedagogy Dimension (PD) was assessed using a framework derived from the suggestions of Coman et al. (2020); Khan et al. (2021), with Teacher Technical Skills (TTS) and Teaching Style (TSe) as the primary indicators. These indicators were each expanded into four questions, tagged as PD1, PD2, PD3, and PD4, with the overall quality of PD being influenced significantly by Instructor Attitude (IA) and Learning Quality (LQ).

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For the Evaluation Dimension (ED), a theoretical framework designed to assess e-learning utilization (Khan et al., 2021; McGrew et al., 2018) was employed, focusing on Instructional Evaluation (IEs) and Learning Environment (LEt) tailored to the demands of e-learning. These were broken down into four components each, labeled ED1 through ED4, with the effectiveness of ED being dependent on Learning Community (LC) and Student Satisfaction (SS). The Technology Dimension (TD) was analyzed through a lens examining skills, supportive measures, and encountered challenges (Almaiah et al., 2020; Khan et al., 2021), resulting in two main facets: Technological Challenges (TCs) and Technical Skills and Support (TSp), each decomposed into four questions coded TD1 to TD4. Notably, TD’s efficacy was gauged through Interface Design (IDn) and Mastery Technology (MTy), with the former’s assessment method being adapted from Badrul H Khan & Joshi (2006); Nordin et al. (2021) and the latter from Martzoukou et al. (2020).

The data collection was conducted via questionnaires containing statements pertaining to the pedagogy, evaluation, and technology dimensions, alongside instructor attitudes, learning quality, learning community, student satisfaction, interface design, and technology mastery. The survey utilized a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), covering 10 construct variables and 40 measurement items. Structural Equation Modeling (SEM) served as the primary analysis technique, facilitating the simultaneous testing of multiple hypotheses while accounting for errors and enabling the examination of complex models. SEM-PLS combined confirmatory factor analysis (CFA) and path analysis, with an objective to maximize the $R^2$ value and minimize residuals or prediction errors. This methodological approach provided a comprehensive framework for understanding the interrelations between various dimensions of e-learning effectiveness within the vocational education context.

The analysis of hypotheses H1 through H11 provided critical insights into the dynamics of e-learning effectiveness within the context of higher education (see Figure 1).

![Research Conceptual Framework of E-Learning Effectiveness.](image)

Hypotheses H1, H2, and H3, focusing on the pedagogy, evaluation, and technology dimensions, established a foundational understanding that these core dimensions are intrinsically linked to the effectiveness of e-learning. This alignment underscores the multifaceted approach required to enhance e-learning platforms, where pedagogical strategies, evaluative processes, and technological infrastructures must be optimized to foster an effective learning environment. Hypotheses H4 and H5 extended this analysis by examining the interplay between the pedagogy and technology dimensions, moderated by the evaluation dimension. The positive relationships identified here highlight the nuanced mechanism through which e-learning effectiveness can be amplified, suggesting that the integration of evaluative feedback within pedagogical and technological frameworks can significantly enhance e-learning outcomes. This integration is pivotal in creating adaptive e-learning systems that respond dynamically to the evolving educational needs and preferences of students.

The examination of Hypotheses H6 and H7 further illuminated the indispensable role of instructors in shaping the pedagogy dimension. The positive influence of instructors’ attitudes and the quality of learning on the pedagogy dimension underscores the necessity for educators to possess not only the requisite digital competencies but also a positive disposition towards e-learning methodologies. This combination is essential for cultivating a learning environment that is both technologically proficient and pedagogically sound. Additionally, Hypotheses H8 and H9 underscored the significance of the learning community and student satisfaction in relation to the evaluation dimension. These findings accentuate the importance of fostering a supportive and engaging online learning community, wherein student satisfaction serves as both a goal and an
indicator of e-learning success. The correlation between these factors and the evaluation dimension highlights the critical role of continuous assessment and feedback in enhancing the quality and effectiveness of e-learning experiences. Lastly, Hypotheses H1a and H1c focused on the technology dimension, revealing that interface design and technology mastery are crucial for e-learning effectiveness. The positive correlations emphasize the importance of intuitive interface designs and the mastery of technology among students and educators alike. These elements are vital for reducing barriers to e-learning engagement and ensuring that technology serves as an enabler rather than a hindrance to the learning process.

In conclusion, the hypothetical analysis elucidates the complex interdependencies among pedagogical strategies, evaluative feedback, and technological advancements in determining e-learning effectiveness. It highlights the critical need for a holistic approach that encompasses educator preparedness, student engagement, and technological optimization to maximize the potential of e-learning in higher education settings.

3. Result

3.1. Evaluation of Measurement Model

The initial criterion assessed within the measurement model was internal consistency reliability. Reliability testing utilized Cronbach's alpha (α), rho_A, and composite reliability (CR) indicators, with values deemed reliable if exceeding 0.70. Analysis of Table 1 revealed that all constructs ranged from 0.752 to 0.849 for (α), 0.766 to 0.852 for rho_A, and 0.843 to 0.898 for CR, indicating that every construct measurement surpassed the 0.7 threshold, affirming their reliability in measuring e-learning effectiveness. Subsequent evaluation focused on convergent validity, aimed at determining the validity of each indicator's relationship with its latent variable. This was quantified using the Average Variance Extracted (AVE), with an indicator meeting convergent validity criteria if AVE ≥ 0.50 (Chin & Todd, 1995). The table presented AVE values ranging from 0.573 to 0.688, signifying that all constructs concerning e-learning effectiveness comprehensively captured information from the indicators beyond 57.3%.

<table>
<thead>
<tr>
<th>Construct</th>
<th>α ≥0.70</th>
<th>rho_A ≥0.7</th>
<th>CR ≥0.70</th>
<th>AVE ≥0.50</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-Learning Effectiveness</td>
<td>0.836</td>
<td>0.847</td>
<td>0.890</td>
<td>0.671</td>
</tr>
<tr>
<td>Evaluation Dimension</td>
<td>0.786</td>
<td>0.789</td>
<td>0.862</td>
<td>0.610</td>
</tr>
<tr>
<td>Pedagogy Dimension</td>
<td>0.839</td>
<td>0.845</td>
<td>0.892</td>
<td>0.674</td>
</tr>
<tr>
<td>Technology Dimension</td>
<td>0.840</td>
<td>0.841</td>
<td>0.893</td>
<td>0.676</td>
</tr>
<tr>
<td>Learning Community</td>
<td>0.830</td>
<td>0.835</td>
<td>0.887</td>
<td>0.663</td>
</tr>
<tr>
<td>Students Satisfaction</td>
<td>0.800</td>
<td>0.805</td>
<td>0.870</td>
<td>0.626</td>
</tr>
<tr>
<td>Instructor Attitudes</td>
<td>0.752</td>
<td>0.766</td>
<td>0.843</td>
<td>0.573</td>
</tr>
<tr>
<td>Learning Quality</td>
<td>0.814</td>
<td>0.823</td>
<td>0.877</td>
<td>0.641</td>
</tr>
<tr>
<td>Interface Design</td>
<td>0.849</td>
<td>0.852</td>
<td>0.898</td>
<td>0.688</td>
</tr>
<tr>
<td>Mastery Technology</td>
<td>0.839</td>
<td>0.847</td>
<td>0.892</td>
<td>0.674</td>
</tr>
</tbody>
</table>

High outer loadings indicated that indicators were effectively explained by the measured constructs, with the prerequisite that outer loadings should exceed 0.70. Additionally, elevated Average Variance Extracted (AVE) values signified that, on average, a construct elucidated the variance of its indicators (Hair et al., 2017). The PLS Algorithm results, detailed in the appendix table, showed outer loading values for all indicators ranging between 0.743 and 0.912, surpassing the 0.7 acceptance threshold. This requirement for outer loadings above 0.7 suggested that each indicator’s variance was approximately 50% explained (as the square of 0.7 is close to 50%).

Discriminant validity assessed the extent to which a construct variable differed from other constructs. Three approaches were utilized to evaluate discriminant validity: Cross-loading, Fornell-Larcker criterion, and the Heterotrait-Monotrait (HTMT) ratio. The HTMT approach was selected for its foundation in the multitrait-multimethod matrix for measurement. According to the output from Table 2, the HTMT values for each construct ranged from 0.073 to 0.891, satisfying the criterion of being less than 0.900 (Henseler et al., 2015), thereby affirming the constructs' discriminant validity within the study.

In this study, three tests were employed to assess the model's goodness-of-fit, namely Chi-Square, Standardized Root Mean Square (SRMR), and Normal Fit Index (NFI). According to Garson (2016), a model would be regarded as having an acceptable goodness-of-fit if the SRMR value fell below 0.10. Bentler & Bonett (1980) stated that a model could be deemed acceptable if the Chi-Square value exceeded 0.90. The NFI values, which range from 0 to 1, indicate a high goodness-of-fit for values approaching 1. The results from Table 5 showed that both the saturated and estimated models had an SRMR of 0.080, each falling below the 0.10 threshold. The Chi-Square values for the saturated and estimated models were 7037.084 and 7393.755, respectively, both surpassing the 0.90 mark. However, the NFI values for both the saturated and estimated models were recorded at 0.540, indicating room for improvement in model fit (see Table 3).
10 evidenced by path coefficient values $\beta$ (0.483, and 0.400) and a $p$-value (0.007 and 0.004) < 0.01, resulting in the acceptance of $H_5$ and $H_7$. Furthermore, the pedagogy dimension and technology dimension, moderated by the evaluation dimension, significantly and positively influenced e-learning effectiveness, as shown by path coefficient values $\beta$ (0.037, and 0.074) and $p$-values (0.001 and 0.001) < 0.01, leading to the acceptance of $H_4$ and $H_6$. Instructor attitudes and learning quality also positively and significantly affected the evaluation dimension, with path coefficient values $\beta$ (0.199, and 0.188) and a $p$-value (0.000) < 0.01, confirming $H_6$ and $H_7$. Additionally, the learning community and student satisfaction significantly positively influenced the evaluation dimension, indicated by path coefficient values $\beta$ (0.199, and 0.305) and $p$-values (0.001 and 0.000) < 0.01, leading to the acceptance of $H_5$ and $H_8$. Finally, interface design and mastery technology had a positive and significant impact on the technology dimension, as evidenced by path coefficient values $\beta$ (0.483, and 0.400) and a $p$-value (0.000) < 0.01, resulting in the acceptance of $H_{10}$ and $H_{11}$.

### Table 2 Discriminant Validity Heterotrait - Monotrait (HTMT) Ratio.

<table>
<thead>
<tr>
<th></th>
<th>EE</th>
<th>ED</th>
<th>IA</th>
<th>ID</th>
<th>LC</th>
<th>LQ</th>
<th>MT</th>
<th>PD</th>
<th>SS</th>
<th>TD</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ED</td>
<td>0.750</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IA</td>
<td>0.085</td>
<td>0.132</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ID</td>
<td>0.826</td>
<td>0.709</td>
<td>0.073</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LC</td>
<td>0.626</td>
<td>0.845</td>
<td>0.119</td>
<td>0.660</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LQ</td>
<td>0.135</td>
<td>0.209</td>
<td>0.185</td>
<td>0.163</td>
<td>0.087</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MT</td>
<td>0.891</td>
<td>0.716</td>
<td>0.061</td>
<td>0.742</td>
<td>0.605</td>
<td>0.110</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PD</td>
<td>0.823</td>
<td>0.717</td>
<td>0.255</td>
<td>0.637</td>
<td>0.619</td>
<td>0.253</td>
<td>0.644</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS</td>
<td>0.478</td>
<td>0.847</td>
<td>0.165</td>
<td>0.470</td>
<td>0.756</td>
<td>0.194</td>
<td>0.534</td>
<td>0.486</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>TD</td>
<td>0.716</td>
<td>0.876</td>
<td>0.120</td>
<td>0.865</td>
<td>0.699</td>
<td>0.182</td>
<td>0.831</td>
<td>0.639</td>
<td>0.594</td>
<td>1</td>
</tr>
</tbody>
</table>

### Table 3 Result of Model Fit.

<table>
<thead>
<tr>
<th></th>
<th>Saturated Model</th>
<th>Estimated Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRMR</td>
<td>0.080</td>
<td>0.080</td>
</tr>
<tr>
<td>Chi-Square</td>
<td>7037.084</td>
<td>7393.755</td>
</tr>
<tr>
<td>NFI</td>
<td>0.540</td>
<td>0.540</td>
</tr>
</tbody>
</table>

### 3.2. Evaluation of Structural Model

Path analysis was utilized to investigate both the direct and indirect effects of exogenous variables on endogenous variables, allowing for the testing of causal hypotheses and the interpretation of specific relationships. Table 4 illustrated the examination of eleven hypotheses. The pedagogy dimension, evaluation dimension, and technology dimension were found to have a positive and significant impact on e-learning effectiveness (see Figure 2), indicated by path coefficient values $\beta$ (0.456, 0.211, and 0.209) and $p$-values (0.000, 0.001, and 0.001) < 0.01, leading to the acceptance of $H_1$, $H_2$, and $H_3$. Furthermore, the pedagogy dimension and technology dimension, moderated by the evaluation dimension, significantly and positively influenced e-learning effectiveness, as shown by path coefficient values $\beta$ (0.037, and 0.074) and $p$-values (0.007 and 0.004) < 0.01, resulting in the acceptance of $H_4$ and $H_5$. Instructor attitudes and learning quality also positively and significantly affected the pedagogy dimension, with path coefficient values $\beta$ (0.179, and 0.188) and a $p$-value (0.000) < 0.01, confirming $H_6$ and $H_7$. Additionally, the learning community and student satisfaction significantly positively influenced the evaluation dimension, indicated by path coefficient values $\beta$ (0.199, and 0.305) and $p$-values (0.001 and 0.000) < 0.01, leading to the acceptance of $H_8$ and $H_9$. Finally, interface design and mastery technology had a positive and significant impact on the technology dimension, as evidenced by path coefficient values $\beta$ (0.483, and 0.400) and a $p$-value (0.000) < 0.01, resulting in the acceptance of $H_{10}$ and $H_{11}$.

### Table 4 Path Coefficient of Research Direct Hypothesis.

<table>
<thead>
<tr>
<th>$H$</th>
<th>Path</th>
<th>$B$</th>
<th>$M$</th>
<th>STDEV</th>
<th>$T$-statistics</th>
<th>$P$-values</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_1$ Pedagogy Dimension → E-learning Effectiveness</td>
<td>0.456</td>
<td>0.457</td>
<td>0.055</td>
<td>8.276</td>
<td>0.000</td>
<td>Accepted</td>
<td></td>
</tr>
<tr>
<td>$H_2$ Evaluation Dimension → E-learning Effectiveness</td>
<td>0.211</td>
<td>0.208</td>
<td>0.064</td>
<td>3.293</td>
<td>0.001</td>
<td>Accepted</td>
<td></td>
</tr>
<tr>
<td>$H_3$ Technology Dimension → E-learning Effectiveness</td>
<td>0.209</td>
<td>0.213</td>
<td>0.060</td>
<td>3.457</td>
<td>0.001</td>
<td>Accepted</td>
<td></td>
</tr>
<tr>
<td>$H_4$ Pedagogy Dimension → Evaluation Dimension → E-Learning Effectiveness</td>
<td>0.037</td>
<td>0.036</td>
<td>0.014</td>
<td>2.690</td>
<td>0.007</td>
<td>Accepted</td>
<td></td>
</tr>
<tr>
<td>$H_5$ Technology Dimension → Evaluation Dimension → E-Learning Effectiveness</td>
<td>0.074</td>
<td>0.072</td>
<td>0.026</td>
<td>2.901</td>
<td>0.004</td>
<td>Accepted</td>
<td></td>
</tr>
<tr>
<td>$H_6$ Instructor Attitudes → Pedagogy Dimension</td>
<td>0.179</td>
<td>0.185</td>
<td>0.043</td>
<td>4.131</td>
<td>0.000</td>
<td>Accepted</td>
<td></td>
</tr>
<tr>
<td>$H_7$ Learning Quality → Pedagogy Dimension</td>
<td>0.188</td>
<td>0.193</td>
<td>0.046</td>
<td>4.134</td>
<td>0.000</td>
<td>Accepted</td>
<td></td>
</tr>
<tr>
<td>$H_8$ Learning Community → Evaluation Dimension</td>
<td>0.199</td>
<td>0.200</td>
<td>0.057</td>
<td>3.457</td>
<td>0.001</td>
<td>Accepted</td>
<td></td>
</tr>
<tr>
<td>$H_9$ Student Satisfaction → Evaluation Dimension</td>
<td>0.305</td>
<td>0.305</td>
<td>0.055</td>
<td>5.594</td>
<td>0.000</td>
<td>Accepted</td>
<td></td>
</tr>
<tr>
<td>$H_{10}$ Interface Design → Technology Dimension</td>
<td>0.483</td>
<td>0.482</td>
<td>0.065</td>
<td>7.427</td>
<td>0.000</td>
<td>Accepted</td>
<td></td>
</tr>
<tr>
<td>$H_{11}$ Mastery Technology → Technology Dimension</td>
<td>0.400</td>
<td>0.401</td>
<td>0.063</td>
<td>6.372</td>
<td>0.000</td>
<td>Accepted</td>
<td></td>
</tr>
</tbody>
</table>

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The second step in the structural model evaluation involved assessing the coefficient of determination ($R^2$) values. According to Hair et al. (2017), $R^2$ values can be categorized into substantial (0.75), moderate (0.50), and weak (0.25) predictive powers. Analysis of Table 5 revealed that e-learning effectiveness was explained by 57.7%, the evaluation dimension by 69.4%, the pedagogy dimension by 7.7%, and the technology dimension by 63.6%. Subsequently, the predictive relevance ($Q^2$) test was conducted using the blindfolding procedure in PLS-SEM. $Q^2$ effect sizes are classified into three categories: weak (0.02), medium (0.15), and large (0.35), as defined by Hair et al. (2017); Kock (2011). The predict relevance ($Q^2$) values for cross-validity redundancy across all endogenous variables showed e-learning effectiveness at 37.7%, evaluation dimension at 41.7%, pedagogy dimension at 4.8%, and technology dimension at 42.4%, all exceeding zero ($Q^2 > 0$), indicating a positive predictive relevance.

![Figure 2 Structural Model Analysis Results for PET-D of E-Learning Effectiveness.](https://www.malque.pub/ojs/index.php/msj)

<table>
<thead>
<tr>
<th>Construct</th>
<th>$R^2$</th>
<th>$R^2$ adjusted</th>
<th>Predictive Power</th>
<th>$Q^2$ Redundancy</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-Learning Effectiveness</td>
<td>0.577</td>
<td>0.574</td>
<td>Moderat</td>
<td>0.377</td>
<td>Large</td>
</tr>
<tr>
<td>Evaluation Dimension</td>
<td>0.694</td>
<td>0.691</td>
<td>Moderat</td>
<td>0.417</td>
<td>Large</td>
</tr>
<tr>
<td>Pedagogy Dimension</td>
<td>0.077</td>
<td>0.073</td>
<td>Weak</td>
<td>0.048</td>
<td>Weak</td>
</tr>
<tr>
<td>Technology Dimension</td>
<td>0.636</td>
<td>0.634</td>
<td>Moderat</td>
<td>0.424</td>
<td>Large</td>
</tr>
</tbody>
</table>

3. Discussion

Since 2010, Yogyakarta State University (UNY) has developed a Moodle-based LMS platform named BeSmart, which effectively replaced face-to-face classroom interactions, making learning more flexible and efficient, especially during the COVID-19 pandemic. Consequently, this study explored the effectiveness of e-learning during the pandemic among fashion design students at UNY, revealing three main dimensions (pedagogy, evaluation, and technology) and supporting factors (instructor attitudes, learning quality, learning community, student satisfaction, interface design, and mastery technology) that influence e-learning effectiveness for these students.

The hypothesis tests $H_1$, $H_2$, and $H_3$, revealed significant positive relationships between the pedagogy dimension, evaluation dimension, and technology dimension with UNY students’ e-learning effectiveness. The path coefficient values ($β$) were 0.456, 0.211, and 0.209, respectively, with $p$-values below 0.01 (Priatna et al., 2020). Both students and instructors have reaped benefits from online teaching methods and pedagogies during the pandemic, with teaching methods tailored to objectives, study fields, philosophies, and class demographics. This finding is in line with Alda et al. (2020), who emphasized the necessity for universities to train instructors on developing online learning, navigating online platforms, and leveraging these platforms innovatively to enhance classroom learning processes (AlDhahi et al., 2022). Furthermore, digital skills and internet technology usage are directly linked to the pedagogy dimension, a critical factor in enhancing university students’ digital competencies to support their academic pursuits. Naveed et al. (2019) highlighted that the presence of e-learning enhances the flexibility, ease, and comfort of the teaching and learning process, facilitating knowledge transfer (Naveed et al., 2019).

Tests of hypotheses $H_4$ and $H_5$ demonstrated that the pedagogy dimension and technology dimension, moderated by the evaluation dimension, significantly and positively impacted UNY students’ e-learning effectiveness. The path coefficient

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values (β) were 0.037 and 0.074, with p-values below 0.01. A comprehensive evaluation of online learning implementation, digital content, and ease of access is imperative. E-learning offers numerous advantages, particularly in terms of the convenience of accessing and acquiring information. Adedoyin & Soykan (2020) emphasized that e-learning provides educators with a clear roadmap to make decisions that enhance learning and teaching methods accepted by university students (Ngatman et al., 2022). Proper technology and teaching methods play a crucial role in enhancing university students’ digital competence, with e-learning exposing students to various online platforms for information and skills, especially in navigating the digital society.

Hypotheses H6 and H7 were supported by the data, showing that instructor attitudes and learning quality had a significant positive impact on the pedagogy dimension for UNY students. This was evidenced by path coefficient values β (0.179 and 0.188) and p-values below 0.01 (Cidral et al., 2018). The shift to more student-centered teaching methods during the COVID-19 pandemic, facilitated by e-learning platforms, was driven by the urgent need for learning. Previous research has highlighted the crucial role of instructors’ behaviors and teaching methods in motivating students in e-learning environments (Pham et al., 2019). Effective communication and interaction between students and instructors are essential for enhancing learning quality and instructor attitudes in e-learning settings. The study emphasizes the importance of a comprehensive evaluation of online learning implementation, encompassing digital content and accessibility. E-learning offers various advantages, particularly in terms of the ease of accessing information. Adedoyin & Soykan (2020) emphasized that e-learning equips educators with the tools to enhance learning and teaching methods that resonate with university students (Cheng, 2012). Adequate technology and teaching strategies are vital for improving university students’ digital skills, with e-learning serving as a platform to introduce students to diverse online resources for information and skills needed in the digital era (Al-Rahmi et al., 2019; Nurtanto et al., 2020).

Tests of hypotheses H8 and H9 demonstrated that the learning community and student satisfaction significantly and positively influenced the evaluation dimension for UNY students, with path coefficient values β (0.199 and 0.305) and p-values below 0.01 (Pham et al., 2019). The positive impacts of online learning, such as improved information assimilation, course customization, flexibility, and student-centeredness, have been highlighted in previous studies (Chen & Tat Yao, 2016; Chopra et al., 2019; Gurcan et al., 2022). These aspects motivate students to engage in discussions, exchange opinions, and enhance satisfaction in the e-learning process (Eishaer & Sobaib, 2022). Peer support and a conducive environment play crucial roles in improving the online learning community, with the academic culture and knowledge-sharing behavior within the university environment being key factors influencing the speed of online learning adoption by students (Rughooobur-Seetah & Hosanoo, 2021). Effective communication and interaction between students and instructors are essential for enhancing learning quality and instructor attitudes in e-learning settings (Kassab et al., 2015; Wagiran et al., 2022). By prioritizing the development of a supportive learning community and ensuring high levels of student satisfaction, educational institutions can create engaging and effective e-learning environments that cater to the diverse needs of learners.

The hypothesis tests for H10 and H11, focusing on interface design and technology mastery, yielded path coefficient values of β (0.483 and 0.400) with p-values of (0.000) < 0.01, establishing a significant and positive link to the technology dimension for students at Yogyakarta State University. Most studies have reported that university students typically hold positive views towards online learning (Burac et al., 2019; Garrison & Kanuka, 2004), although they occasionally face technical issues like unstable internet connections (Aprian et al., 2021). Several researchers have advised that educational institutions need not create separate platforms for learning digital skills; rather, these should be integrated into the curriculum across all subjects, and learners should be encouraged to acquire digital competencies to remain aligned with contemporary demands (Nguyen et al., 2019; Nurtanto et al., 2022; Shahzad et al., 2021). Mastery of technology facilitates easier access to information sources, thereby enhancing students’ interest and learning capabilities. Frolova et al. (2019) have outlined numerous benefits of technological proficiency, including increased motivation, modernization of practical tools, reduced misinformation, and overall flexibility and efficiency in learning processes.

This research at UNY demonstrates the significant impact of pedagogy, evaluation, and technology dimensions on the effectiveness of e-learning among fashion design students during the COVID-19 pandemic. With path coefficients indicating strong positive relationships and the necessity for tailored online teaching methodologies, the study highlights the importance of digital competencies and innovative use of e-learning platforms to enhance educational outcomes. Despite its insights, the study is limited by its focus on a specific student group and discipline, suggesting the need for broader investigations across different fields and institutions. Further research should explore the long-term effects of e-learning post-pandemic and examine the integration of emerging technologies to optimize online education’s effectiveness. Additionally, addressing the challenges of digital access and the digital divide could provide a more comprehensive understanding of e-learning’s potential to transform higher education.

5. Conclusions

The research conducted at Yogyakarta State University demonstrates significant positive relationships between the pedagogy, evaluation, and technology dimensions with e-learning effectiveness among fashion design students. The study underscores the importance of digital competencies, tailored teaching methods, and the innovative use of e-learning platforms
in enhancing educational outcomes during the COVID-19 pandemic. However, it faces limitations due to its focus on a specific group of students and discipline, suggesting the need for further research across different fields and institutions. Future studies should investigate the long-term effects of e-learning post-pandemic, the integration of emerging technologies, and address digital access challenges to understand e-learning's potential to transform higher education comprehensively.

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Ethical considerations

Before filling out the online questionnaire, all respondents gave their consent voluntarily without any element of coercion. Furthermore, researchers maintain confidentiality regarding personal data in the data analysis process. Before use, the questionnaire was submitted to the Yogyakarta State University ethics commission with number: B/12.63/UN43.9/EC.00.01.05/2023. All researchers actively participated in the preparation, development, and analysis of data.

Conflict of Interest

There is no conflict of interest in this research.

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References


