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**ORIGINAL**

# Enhancing the Effectiveness of Learning Models: Key Factors Explored Higher Education

## Mejora de la eficacia de los modelos de aprendizaje: factores clave explorados Educación superior

Ika Parma Dewi[1], Doni Tri Putra Yanto[2], Ilmiyati Rahmy Jasri[1], Afif Rahman Riyanda[3], Mastri Dihita Sagala[4], Cherifa Boudia[5], Dedy Irfan[1], Asmaa Bengueddach[6]

[1]Universitas Negeri Padang, Electronics Engineering Department. Padang, Indonesia.
[2]Universitas Negeri Padang, Electrical Engineering. Padang, Indonesia.
[3]Universitas Lampung, Faculty of Teacher Training and Education. Lampung, Indonesia.
[4]Universitas Tanjungpura, Department of Performing Arts Education. Pontianak, Indonesia.
[5]Computer Science Department, Technological Laboratory in Artificial Intelligence and Food Security (LABTEC-IA), University Mustapha Stambouli of Mascara. Algeria.
[6]LIO Laboratory, University Oran 1 Ahmed Ben Bella. El M'nouer, Oran, Algeria.

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**Corresponding Author:** Ika Parma Dewi

## ABSTRACT

Enhancing the effectiveness of learning models remains a challenge in the digital era, making it crucial to understand the factors that influence learning outcomes. This study aims to analyze the factors affecting the effectiveness of learning models in a digital context. A quantitative survey was conducted using questionnaires as the primary data collection instrument, involving 144 students from the Informatics Study Program at the Faculty of Engineering, Universitas Negeri Padang. Data were analyzed using Structural Equation Modeling (SEM) with Smart PLS 4.0 software, and the measurement model was found to be valid and reliable. The results indicate that student characteristics and learning quality have positive but modest effects on learning effectiveness, while the learning environment and learning models show minimal negative correlations. Learning technology was identified as the most influential factor, significantly enhancing the effectiveness of learning models. These findings suggest that prioritizing learning technology can substantially improve the effectiveness of digital learning, whereas other factors have relatively smaller impacts.

**Keywords:** Student Characteristics; Learning Quality; Learning Environment; Learning Technology.

## RESUMEN

Mejorar la efectividad de los modelos de aprendizaje sigue siendo un desafío en la era digital, lo que hace crucial comprender los factores que influyen en los resultados del aprendizaje. Este estudio tiene como objetivo analizar los factores que afectan la efectividad de los modelos de aprendizaje en un contexto digital. Se llevó a cabo una encuesta cuantitativa utilizando cuestionarios como instrumento principal de recolección de datos, involucrando a 144 estudiantes del Programa de Estudios de Informática de la Facultad de Ingeniería de la Universitas Negeri Padang. Los datos se analizaron mediante el Modelado de Ecuaciones Estructurales (SEM) con el software Smart PLS 4.0, y se encontró que el modelo de medición era válido y confiable. Los resultados indican que las características de los estudiantes y la calidad del aprendizaje tienen efectos positivos pero modestos sobre la efectividad del aprendizaje, mientras que el entorno de

aprendizaje y los modelos de aprendizaje muestran correlaciones negativas mínimas. La tecnología de aprendizaje se identificó como el factor más influyente, mejorando significativamente la efectividad de los modelos de aprendizaje. Estos hallazgos sugieren que priorizar la tecnología de aprendizaje puede mejorar sustancialmente la efectividad del aprendizaje digital, mientras que otros factores tienen impactos relativamente menores.

**Palabras clave:** Características de los Estudiantes; Calidad del Aprendizaje; Entorno de Aprendizaje; Tecnología de Aprendizaje.

## INTRODUCTION

Education in the 21st century plays a central role in preparing graduates to navigate increasingly complex global challenges.[1,2,3] In Indonesia, educational transformation continues to accelerate as institutions adapt to the demands of a rapidly evolving digital era. As a key driver of national progress, the quality of learning remains crucial for shaping students' competencies, knowledge, and behaviors.[4,5,6] Learning thus serves as a fundamental process through which values, concepts, and theoretical foundations are cultivated.[1,7,8] In line with the importance of learning quality, curriculum reforms are increasingly emphasizing modern, student-centered, and competency-based learning approaches.

Curriculum reforms increasingly emphasize technology-supported, student-centered, and competency-oriented learning approaches.[9,10,11] The rapid advancement of science and technology further intensifies the need for human resources capable of operating in digital environments. Consequently, educators must design learning experiences that are relevant, engaging, and aligned with evolving student characteristics.[12,13,14] Selecting appropriate learning models that reflect instructional goals and classroom contexts is essential to ensuring effective learning. In this context, the use of digital technology becomes increasingly crucial to enhance accessibility, engagement, and the relevance of learning.

The widespread adoption of digital tools—such as online platforms, simulations, videos, and educational applications—has expanded access and engagement in higher education.[15,16,17] Yet, inconsistencies in learning outcomes suggest that not all technology-supported learning models are equally effective. A systematic evaluation is therefore necessary to determine how digital learning models influence learning achievement, student engagement, and the development of digital-era competencies.[18,19] Such evaluation is crucial for educators and policymakers seeking to enhance the relevance and quality of digital learning.[17,20] However, the potential of digital learning is not without challenges, including infrastructure limitations, device availability, and teacher competence, which can hinder its effectiveness.

Despite its potential, digital learning remains constrained by unequal technological infrastructure, unstable internet connectivity, and disparities in device availability.[21,22,23] Issues related to data privacy, cybersecurity, and institutional digital readiness further widen the digital divide.[24,25,26,27] At the pedagogical level, limited digital competence among educators restricts the optimal use of technology for instructional purposes.[28,29] Addressing these barriers requires coordinated action from government agencies, institutions, and communities.. Moreover, previous studies tend to examine these factors in isolation, providing only a partial understanding of the mechanisms that influence digital learning effectiveness.

Empirical studies have explored technological readiness, infrastructure, teacher competence, student motivation, and digital learning perceptions; however, these factors are typically examined in isolation.[30,31,32,33,34,35] This fragmented approach provides limited insight into the integrated mechanisms that shape learning effectiveness. Institutional readiness and the combined influence of psychosocial, technological, and pedagogical dimensions remain underexplored.[36,37] These gaps highlight the need for a comprehensive and integrative analytical framework. Therefore, this study proposes a multidimensional framework that integrates technological, pedagogical, environmental, and psychosocial aspects to comprehensively assess the effectiveness of digital learning.

This study addresses these limitations by examining the effectiveness of learning models in the digital era through a multidimensional framework that integrates technological, pedagogical, environmental, and psychosocial factors.[38,39] By analyzing learning models, student characteristics, teaching quality, learning environments, and digital technologies collectively, the study offers a rigorous assessment of digital learning effectiveness.[40,41,42,43] The findings are expected to guide policymakers, educators, and practitioners in developing adaptive, evidence-based learning strategies aligned with contemporary educational demands.[44,45,46,47] By adopting this approach, the study aims to provide guidance for policymakers and educators in developing adaptive, evidence-based strategies for digital learning.

Most existing studies on digital learning tend to investigate individual factors—such as technological readiness, student motivation, infrastructure, or teacher competence—without examining how these dimensions

interact holistically. As a result, current evidence provides only partial explanations of what determines the effectiveness of learning models in digital environments. Moreover, institutional readiness and the combined influence of psychosocial, technological, and pedagogical factors remain insufficiently explored. This creates a critical gap that necessitates an integrated framework capable of evaluating multiple determinants of digital learning effectiveness simultaneously. Therefore, this study seeks to address these limitations by developing a multidimensional approach that integrates all key factors simultaneously.

## METHOD

This study employed a quantitative cross-sectional survey to examine factors influencing students' collaborative competence. The survey design, using a structured questionnaire as the primary data collection instrument, is particularly suitable for examining large populations and allows for the measurement and statistical analysis of numerical data, identification of trends, and generalization of findings. The study population consisted of all 144 students enrolled in the Informatics Study Program, Faculty of Engineering, Padang State University, adopting a census approach to enhance the precision and validity of the results. Participants ranged in age from 19 to 22 years and included 82 males (57 %) and 62 females (43 %) across all academic years, ensuring comprehensive representation of the population.

**Table 1.** Research variables

| Variable | Measurement Items | Indicator |
|---|---|---|
| Student Characteristics | SC 1- SC2 | **Motivation and Interests:** |
| | SC 3- SC4 | Cognitive Ability |
| | SC 5- SC6 | Personality |
| | SC 7- SC8 | Communication Skills |
| | SC 9- SC10 | Information Technology and Literacy |
| Teaching Quality | LQ 1-LQ 2 | Technology Integration |
| | LQ 3-LQ 4 | Use of Interesting Materials |
| | LQ 5-LQ 6 | Variation in Teaching Models |
| | LQ 7-LQ 8 | Clarity in Content Delivery |
| | LQ 9-LQ 10 | Lecturer-Student Interaction |
| Learning Technology | LT 1 - LT 2 | Technology Adoption: |
| | LT 3 - LT 4 | Availability and Effectiveness of Educational Applications |
| | LT 5 - LT 6 | Use of the App and Use of Technology |
| | LT 7 - LT 8 | Evaluation of the Impact of Technology Use on Student Academic Achievement |
| | LT 9 - LT 10 | Implementation of advanced and innovative technology to improve the learning process. |
| Learning Environment (LE) | LE 1 - LE 2 | Classroom Conditions |
| | LE 3 - LE 4 | Integration of Technology in Learning |
| | LE 5 - LE 6 | Flexibility in Space Arrangement |
| | LE 7 - LE 8 | Study Time Management |
| | LE 9 - LE 10 | Material Visualization |
| Learning Model Effectiveness (LME) | LME 1-LME 2 | Availability and Effectiveness of Educational Applications |
| | LME 3-LME 4 | Diversity of Digital Materials Accessible to Students |
| | LME 5-LME 6 | Evaluation of the Impact of Technology Use on Student Academic Achievement |
| | LME 7-LME 8 | Implementation of advanced and innovative technology to improve the learning process. |
| | LME 9-LME 10 | Achievement of Learning Objectives |

Data were collected using a structured questionnaire developed based on established indicators for each variable. The exogenous variables included student characteristics (SC), learning quality (LQ), and learning

environment (LE), while learning model effectiveness (LME) served as the endogenous variable, and learning technology (LT) was included as a mediator. Each variable was operationalized into multiple statement items designed to capture its specific aspects and conditions.[41,48] Content validity was ensured through expert review, and a pilot test with 20 students outside the study population confirmed reliability, with a Cronbach's alpha exceeding 0,85, indicating high internal consistency.

The questionnaire was administered online via Google Forms, and participants provided written informed consent after being fully informed about the study purpose, voluntary participation, anonymity, and the right to withdraw at any time. Data collection was conducted over seven days, after which responses were screened for completeness and accuracy. Data were analyzed using SPSS 26 for descriptive statistics and SmartPLS 4 for structural equation modeling, including assessment of construct reliability, validity, and model fit indices to ensure robustness of the findings. The study protocol was approved by the Universitas Negeri Padang, and all data were anonymized and securely stored with access restricted to the research team.

The five variables to be analyzed in this study were changed into 50 questionnaire items included in the research instrument. The blueprint of the instrument can be observed in the table 1.

**Measurement and Structure Models**

Measurements and structural models describe the functions of individual questionnaire items in variables and describe the intricate network of connections between exogenous, endogenous, and mediator variables. Measurement and structural models are presented as follows figure 1.

**Data Collection and Analysis**

Primary data were collected using a structured questionnaire designed to measure student characteristics, learning quality, learning environment, learning technology, and learning model effectiveness. The questionnaire was administered online via Google Forms, with written informed consent obtained from all participants prior to data collection. Responses were screened for completeness and consistency before analysis. Collected data were analyzed using SmartPLS 4.0, which allows for simultaneous assessment of predictor, mediator, and outcome variables within the structural equation model. The software also supports evaluation of both measurement and structural models, providing reliable estimation of direct and indirect effects among variables, thereby facilitating rigorous hypothesis testing.

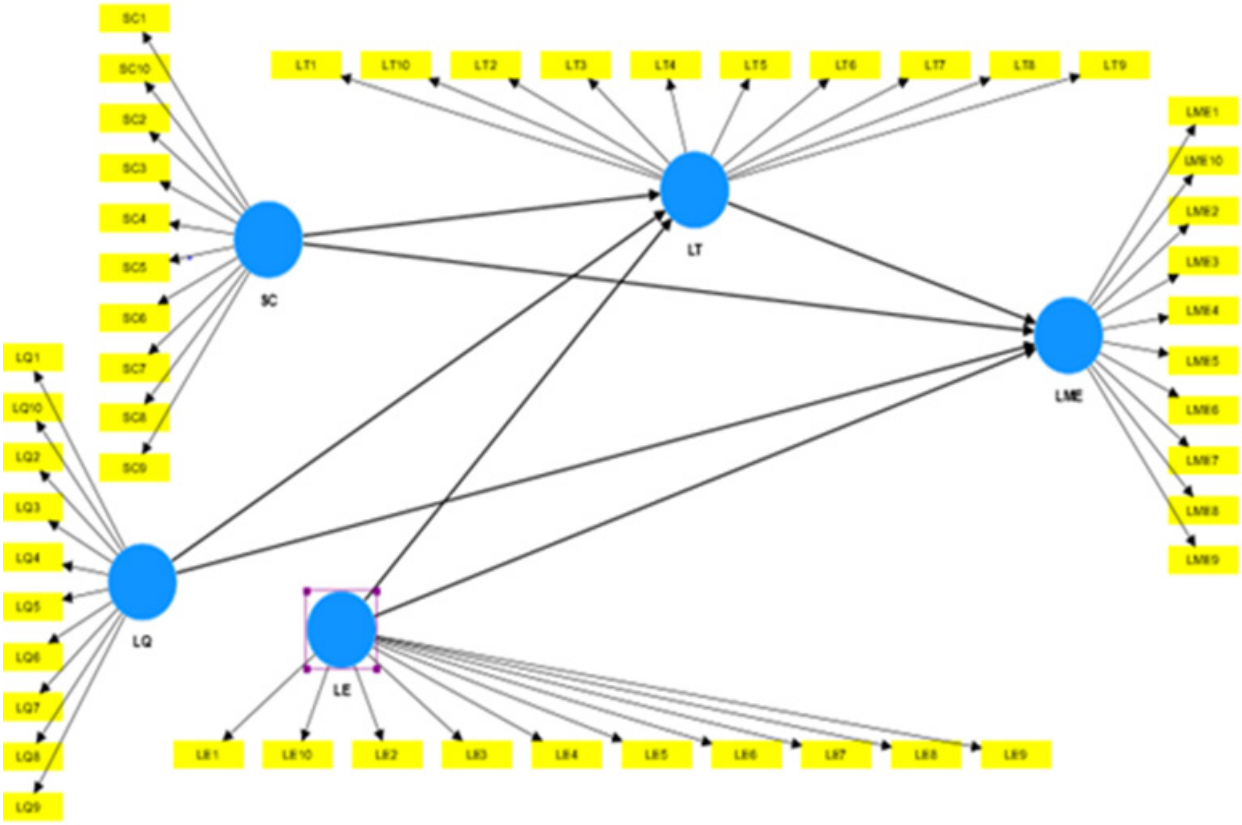


**Figure 1.** Structural measurements and models

## RESULTS

### Validity

Convergent Validity and Discriminatory Validity are used to evaluate validity. Convergent validity checks validity by assessing the Loading Factor and Average Variance Extracted (AVE) values. The validity of the measurement model is confirmed when the Loading Factor exceeds 0,7, and the AVE is higher than 0,5. The results of the Loading Factor analysis showed that all items in the instrument were valid in all variables, namely Learning Models Effectiveness (LME), Student Characteristics (SC), Teaching Quality (LQ), Learning Environment (LE), and Learning Technology (LT). Furthermore, the tabulation data below shows the results of the AVE analysis in table 2.

**Table 2.** Ave results

| | Extracted mean variance (AVE) | Validity |
|---|---|---|
| LE | 0,768 | Legitimate |
| LME | 0,675 | Legitimate |
| LQ | 0,759 | Legitimate |
| LT | 0,754 | Legitimate |
| SC | 0,713 | Legitimate |

According to the test results given earlier, it is clear that all the values exceeded 0,5. This signifies that all variables can be asserted as valid. In addition, the validity test of discrimination involves the Fornell Larcker Criterion and Cross Loading values. A variable reaches validity when its core correlation with other variables exceeds the value of the variable's correlation with other variables. The test results are as follows in table 3.

**Table 3.** Fornell Larcker Criteria Results

| | Fornell Larcker Criteria | | | | | |
|---|---|---|---|---|---|---|
| | LE | LME | LQ | LT | SC | Result |
| LE | 0,876 | | | | | Legitimate |
| LME | 0,874 | 0,822 | | | | Legitimate |
| LQ | 0,942 | 0,878 | 0,871 | | | Legitimate |
| LT | 0,937 | 0,89 | 0,898 | 0,868 | | Legitimate |
| SC | 0,897 | 0,861 | 0,898 | 0,887 | 0,845 | Legitimate |

The results of the test mentioned above show that the validity of all variables can be confirmed. This determination is based on the fact that the core correlation value of each variable surpasses its correlation with other variables.

### Reliability

Testing for reliability is carried out through the examination of Composite Reliability and Cronbach's Alpha scores. Variables and indicators can be considered reliable if the Reliability of Composite and Alpha Cronbach exceeds 0,7. The test results are presented below in table 4.

**Table 4.** Composite Reliability Results And Crobach's Alpha

| | Composite and Alpha Crobach Reliability | | | |
|---|---|---|---|---|
| | Alfa Cronbach | Composite reliability (rho_a) | Composite reliability (rho_c) | Result |
| LE | 0,966 | 0,967 | 0,971 | Reliable |
| LME | 0,946 | 0,948 | 0,954 | Reliable |
| LQ | 0,965 | 0,966 | 0,969 | Reliable |
| LT | 0,964 | 0,964 | 0,968 | Reliable |
| SC | 0,955 | 0,957 | 0,961 | Reliable |

The results presented above provide information that the scores for Composite Reliability and Alpha Cronbach exceed 0,7 for all variables. It demonstrates the reliability of the variables, indicators, and items investigated in this study.

**Results of the Structural Model Assessment**

Correlation Test: correlation analysis involves assessing the R-squared value to determine the extent to which endogenous variables can be predicted by exogenous variables. The results are presented in the following table 5.

**Table 5.** Results From R Square

| | R-square | Predictability |
|---|---|---|
| LME | 0,829 | 82,9 % |
| LT | 0,889 | 88,9 % |

From the above results, it can be concluded that the Learning Technology (LT) variable functions as a mediator variable that can act as both exogenous and endogenous variables. As an endogenous variable, Learning Technology (LT) can be predicted by 88,9 % by the predictor variable. Furthermore, the Learning Models Effectiveness (LME) variable can be predicted by 82,9 % by the exogenous variable. Further analysis is carried out to find out whether the relationship between these variables is positive or negative based on the value of the path coefficient. If the value of the path coefficient is greater than 0, then the relationship between the variables can be considered positive. The results of the analysis are presented as follows in table 6.

**Table 6.** Path Coefficient Results

| | Path Coefficient | Correlation |
|---|---|---|
| LE -> LME | -0,042 | Negative |
| LE -> LT | 0,703 | Positive |
| LQ -> LME | 0,329 | Positive |
| LQ-> LT | 0,027 | Positive |
| LT -> LME | 0,464 | Positive |
| SC -> LME | 0,192 | Positive |
| SC-> LT | 0,232 | Positive |

The table above provides an overview of the values of the path coefficients for the various inter-variable correlations. Analysis of the data revealed that one path coefficient was negative while the other was positive.

Significance Test: the significance test is subject to analysis through the calculation of statistical T-values. It is considered that there is a significant influence between variables if the Statistical T score exceeds 1,96. The test results are presented below in table 7.

**Table 7.** Statistical Results T

| | T Statistics | Result |
|---|---|---|
| LE -> LME | 0,236 | Small |
| LE -> LT | 4,644 | important |
| LQ -> LME | 1,591 | Small |
| LQ-> LT | 0,158 | Small |
| LT -> LME | 4,032 | important |
| SC -> LME | 1,675 | Small |
| SC-> LT | 2,22 | important |

The results of the test showed that there were four insignificant influences between the variables, namely the influence of the Learning Environment on the Effectiveness of the Teaching Model, the Quality of Teaching on the Effectiveness of the Teaching Model, the Quality of Teaching on Learning Technology, and the Characteristics of Students on the Effectiveness of the Teaching Model. Meanwhile, the influence between other variables was declared significant.

**Size Effect**

In this study, the effect size analysis will be categorized into two parts, namely, the direct effect size and the indirect effect size mediated by the intermediate variable. The direct effect examination involves the F

Square assessment using SmartPLS software, while the indirect effect assessment is carried out by utilizing the Upsilon V formula with the SmartPLS output. The results of the securities size assessment are presented table 8.

**Live Effect Size**

The size of the immediate effect is checked by assessing the value of F Square. This value is then juxtaposed with a defined categorical threshold that designates the immediate effect as low (0,005), medium (0,01), or high (0,025). The results of this analysis are presented below in table 8.

**Table 8.** Square Result

| | LME | Live Effect Size |
|---|---|---|
| LE | 0,001 | Low |
| LQ | 0,062 | Tall |
| LT | 0,14 | Tall |
| SC | 0,034 | Tall |

From the above analysis, it can be concluded that three variables (LQ, LT, and SC) have a high effect size on the Learning Method Effectiveness variable. Meanwhile, the LE variable has a low effect size on the Learning Models Effectiveness variable.

**Indirect Effect Measures**

Indirect effect size analysis involves calculating the output value of SmartPLS using the formula Upsilon V. SmartPLS output detailing the effect size among the variables is presented below in figure 2:

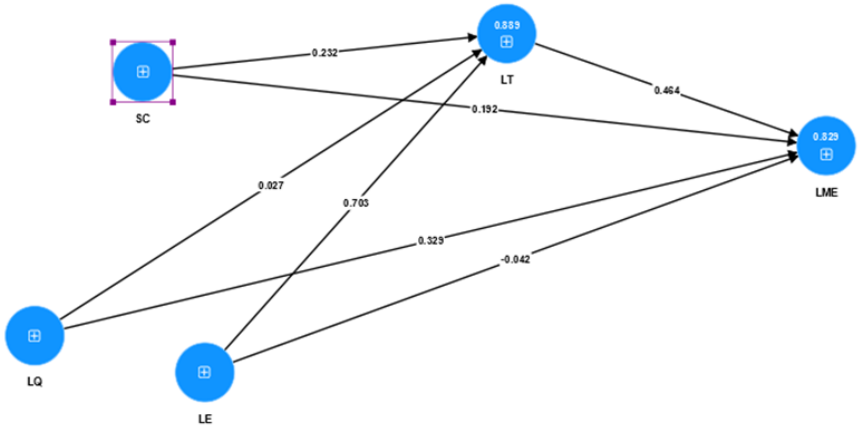


**Figure 2.** Output of SmartPLS-related effect measures

The above values are then calculated using the Upsilon V formula as depicted by the β2 equation. MX.β2YM.X. The resulting calculation is then juxtaposed with a predefined standard category, which classifies the size of the indirect effect as low (0,01), medium (0,075), or high (0,175). The calculated results are presented as follows in table 9.

**Table 9.** Results Of Indirect Effect Measures

| | | | Indirect Effect Measures | Group |
|---|---|---|---|---|
| SC-LT-LME | 0,232 | 0,464 | 0,011588 | Moderate |
| LQ-LT-LME | 0,027 | 0,464 | 0,000157 | Low |
| LE-LT-LME | 0,703 | 0,464 | 0,106401 | Tall |

The results of the above analysis show that indirect effects have different categories. In this context, the variable "Student Characteristics on the Effectiveness of Learning Models through Learning Technology" is in the medium category, the variable "Teaching Quality on the Effectiveness of Learning Models through Learning Technology" is in the low category, and the variable "Learning Environment on the Effectiveness of Learning Models through Learning Technology" is in the high category. Learning Technology's role as a mediator variable

changes the degree of correlation between exogenous variables (Student Characteristics, Teaching Quality, and Learning Environment) and endogenous variables (Learning Model Effectiveness). The role of learning technology as a mediator variable can be analyzed by comparing the size of direct effects with indirect effects. The results of the comparison are as follows in table 10.

**Table 10.** The Role Of The Mediator Variable

| | Direct Effects | Indirect Effects Through Mediator Variables (SM) | The Role of Mediation |
|---|---|---|---|
| SC-LME | Tall | Moderate | Full Mediation |
| LQ-LME | Tall | Low | Full Mediation |
| LE-LME | Low | Moderate | Full Mediation |

The above results illustrate the role of learning technology as a mediator variable. The findings of the analysis concluded that learning technology plays a full mediator role in the correlation between all variables (Student Characteristics, Teaching Quality, and Learning Environment). However, the role of the mediator variable varies; it has a positive role, increasing the level of correlation in the LE-LME relationship. In addition, the mediator variable also has a negative role, decreasing the level of correlation in the SC-LME and LQ-LME relationships.

## DISCUSSION

### Student Characteristics on the Effectiveness of Learning Models

The findings suggest that student characteristics have a positive, though statistically insignificant, influence on the effectiveness of the learning model. This indicates that while factors such as motivation, learning style, prior knowledge, social interaction, reasoning skills, and personality can support students' engagement and learning processes, their direct impact on overall learning effectiveness may be moderated by other elements, such as teaching methods or learning environment. In other words, student traits provide potential for learning, but they are not sufficient alone to guarantee measurable improvements in learning outcomes.[49]

These results align with previous studies highlighting the important but often subtle role of student characteristics in learning effectiveness. While some research has reported a significant effect of these traits, other studies suggest that the influence of motivation, learning style, and academic skills may vary depending on contextual factors, such as classroom dynamics or instructional methods.[60,61] The current findings suggest that student characteristics may operate more indirectly, enhancing students' ability to engage with learning materials and collaborate with peers, rather than producing immediate, statistically significant improvements.[62,63]

From a theoretical perspective, this supports constructivist approaches to learning, which emphasize that the interaction between learners' internal traits and external learning conditions shapes learning outcomes. Students' prior knowledge, academic skills, and learning styles create a foundation upon which effective learning models can build; however, the effectiveness of these models also depends on how well the learning environment and teaching strategies facilitate engagement and comprehension.[64,65]

In practical terms, the findings imply that educators should design instructional strategies that leverage student traits. For example, aligning teaching methods with diverse learning styles, fostering motivation through engaging activities, and providing opportunities to apply prior knowledge can help maximize the potential of students' characteristics in improving learning effectiveness.

### Quality of Learning on the Effectiveness of Learning Models

The findings indicate that the quality of learning has a positive, yet statistically insignificant, effect on the effectiveness of the learning model. This suggests that although factors such as material relevance, teaching quality, lecturer-student interaction, variations in teaching models, use of technology, and clarity in instruction contribute to student engagement, their individual impact may not be immediately measurable through statistical tests.[56] Nevertheless, the effect size analysis indicates that these factors collectively play a meaningful role in supporting learning outcomes.[67,68]

This aligns with prior research emphasizing the critical role of learning quality in enhancing learning model effectiveness. While some studies report significant effects, others find that the impact of teaching quality may be context-dependent, influenced by factors such as students' prior knowledge, motivation, and classroom dynamics.[59] The current findings suggest that the true influence of learning quality may be underestimated if measured solely through statistical significance; in practice, high-quality teaching can substantially improve students' understanding, motivation, and engagement.[60]

From a theoretical perspective, these results reinforce the idea that effective learning is a product of the interaction between instructional design and learner engagement. The quality of learning functions as

a mediator that amplifies the benefits of student characteristics and technological resources, creating an environment conducive to active learning and collaboration.

In practical terms, educators should focus on enhancing the relevance and clarity of instructional materials, fostering meaningful lecturer-student interactions, and integrating appropriate technological tools. By prioritizing these aspects of learning quality, instructors can create a more engaging and effective learning experience, particularly in collaborative or digital learning contexts.

**Learning Environment on the Effectiveness of the Learning Model**

The analysis indicates that the learning environment has a negative, yet statistically insignificant, effect on the effectiveness of the learning model, with a very small effect size.[61,62,63] This suggests that, within the studied context, variations in physical facilities, classroom flexibility, and environmental conditions may not directly translate into measurable improvements in learning outcomes. However, these factors likely contribute indirectly by shaping students' comfort, focus, and ability to engage in learning activities.[64]

Despite the statistical insignificance, the learning environment remains an important contextual factor that supports effective learning. Well-being, including both physical and mental comfort, enables students to concentrate and participate actively in learning activities.[65] Access to adequate facilities and resources facilitates comprehension and supports collaborative learning, while flexible classroom arrangements and environments that stimulate creativity can enhance engagement and motivation. These findings suggest that the learning environment functions more as a supportive framework rather than a primary driver of learning effectiveness in this study.

When compared with prior research, these results are consistent with studies indicating that the learning environment alone may not produce significant improvements unless combined with high-quality instruction, student motivation, and technological support. This underscores the view that effective learning is shaped by the interaction between learner characteristics, instructional quality, and environmental conditions rather than by any single factor.

Theoretically, this supports ecological and socio-constructivist perspectives, which emphasize that learning outcomes emerge from interactions within a learning system rather than isolated variables. Practically, it highlights the need for educators and institutions to maintain supportive learning environments that complement teaching strategies and learning technologies, particularly in collaborative or digital learning contexts. Although the direct effect may be small, attention to environmental factors ensures students can fully engage with learning models and maximize the benefits of other contributing factors.

**Learning Technology on the Effectiveness of Learning Models**

The findings indicate that learning technology has a positive and significant effect on the effectiveness of the learning model, with a relatively high effect size.[66,67,68] This suggests that technology is a critical factor in facilitating student engagement, collaboration, and communication, particularly in digital or distance learning contexts. The integration of technology allows students to interact, share resources, and participate in collaborative projects more efficiently, creating a learning environment that supports active engagement and knowledge construction.

These results are consistent with prior research showing that technology-based learning platforms, online forums, video conferencing tools, and collaborative software can significantly enhance student interaction and the quality of collaborative learning experiences. By enabling students to communicate and work together regardless of physical location, technology contributes to the effectiveness of learning models in ways that traditional methods alone may not achieve.

From a theoretical perspective, these findings support socio-constructivist and connectivist approaches, which emphasize that learning is a process of knowledge construction through social interaction and networked collaboration. Learning technology amplifies the opportunities for these interactions, allowing students to apply prior knowledge, share insights, and co-create understanding within a flexible and adaptive learning environment.

Practically, the results suggest that educators and institutions should prioritize the integration of technology to enhance learning outcomes. By leveraging online platforms and collaborative tools, students can engage more actively in group work, discussions, and project-based learning, improving both individual learning and overall model effectiveness. Moreover, technology can help bridge gaps caused by physical distance, limited access to resources, or variations in student readiness, making learning more inclusive and adaptable.

**Limitations and future research**

We honestly assume some limitations that pave the way for future research. First, our data was collected only from a limited sample of 144 students distributed across the Electronics department. This issue limits the generalizability of our findings due to the disparity in terms of cultural, social, and technological factors that may influence the adoption of educational platforms, such as Key Factors Explored in Higher Education.

Therefore, future research could enrich the sample of students, giving us the possibility to determine whether similar results are obtained. Secondly, we recognize that there may be bias in the responses, especially in the case of students with limited knowledge about the effectiveness of the Learning Model still facing barriers and challenges. This study aims to analyze the factors that influence the effectiveness of the Learning Model in the digital era. Thus, future research will consider experimental Learning Models in the digital era. And the metaverse media platform, where students will be invited to actively engage and provide us with qualitative insights.

## CONCLUSIONS

This study highlights several key factors influencing the effectiveness of the learning model. Student characteristics, learning quality, and the use of learning technology play important roles in enhancing learning outcomes, with technology showing the most substantial impact. In contrast, the learning environment appears to have limited influence and requires more attention to support effective learning. These findings suggest that prioritizing the integration of technology and improving student engagement and learning quality can significantly enhance the effectiveness of learning models. The results provide a solid foundation for educators and policymakers to focus on technological investments and strategies that foster active learning and collaboration.

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## AUTHORSHIP CONTRIBUTION

*Conceptualization:* Ika Parma Dewi.
*Data curation:* Doni Tri Putra Yanto, Ilmiyati Rahmy Jasri.
*Formal analysis:* Afif Rahman Riyanda, Mastri Dihita Sagala.
*Research:* Ika Parma Dewi, Afif Rahman Riyanda.
*Methodology:* Ika Parma Dewi, Doni Tri Putra Yanto, Dedy Irfan.
*Project management:* Ika Parma Dewi, Asmaa Bengueddach, Cherifa Boudia.
*Resources:* Afif Rahman Riyanda, Mastri Dihita Sagala, Cherifa Boudia, Dedy Irfan.
*Software:* Doni Tri Putra Yanto, Ilmiyati Rahmy Jasri.
*Supervision:* Cherifa Boudia, Dedy Irfan, Asmaa Bengueddach.
*Validation:* Dedy Irfan.
*Display:* Ika Parma Dewi, Afif Rahman Riyanda.
*Drafting - original draft:* Ika Parma Dewi.
*Writing - proofreading and editing:* Ika Parma Dewi, Afif Rahman Riyanda, Cherifa Boudia, Asmaa Bengueddach.