Educational Administration: Theory and Practice
2023, 29(4), 3988 - 4000
ISSN: 2148-2403
https://kuey.net/

Research Article

Exploring Learning Styles, Learner Characteristics, and Technology Acceptance: A Study on Student Engagement and Behavioral Intention in E-Learning Environments for Secondary and Senior Secondary Students

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Citation: Vidhu Vijayan, et.al (2023), Exploring Learning Styles, Learner Characteristics, and Technology Acceptance: A Study on Student Engagement and Behavioral Intention in E-Learning Environments for Secondary and Senior Secondary Students, *Educational Administration: Theory and Practice*, 29(4) 3988 - 4000
Doi: 10.53555/kuey.v29i4.8792

ARTICLE INFO

ABSTRACT

This study investigates the interplay between learning styles, learner characteristics, and technology acceptance in shaping student engagement and behavioral intention in e-learning environments for secondary and senior secondary students. Using a mixed-methods approach, data from 500 students were analyzed to explore correlations between the Felder-Silverman learning styles, self-efficacy, perceived usefulness, and engagement. Results highlight that visual and active learning styles significantly influence behavioral intention, mediated by engagement and technology acceptance. Findings underscore the importance of aligning e-learning platforms with learner preferences to optimize engagement and learning outcomes. The study provides actionable insights for educators and policymakers to enhance digital education strategies.

Keywords: Learning styles, Learner characteristics, Technology acceptance, E-learning environments, Student engagement

Introduction:

In the 21st century, education has undergone a transformative shift, moving away from traditional brick-and-mortar classrooms to embrace the digital age. The advent of technology has given rise to new paradigms of education, with e-learning emerging as a powerful tool in enhancing the learning experiences of students at various educational levels. E-learning, characterized using digital platforms, multimedia resources, and online communication tools, has gained widespread recognition as a valuable supplement to or replacement for traditional classroom instruction. Its flexibility, accessibility, and potential for personalized learning make it particularly appealing for secondary and senior secondary school students. Here is an expanded version of the introduction for the topic, aimed at developing it into approximately 3000 words. Education has always been a cornerstone of human development, fostering intellectual growth, societal progress, and individual success. In the 21st century, the landscape of education is evolving rapidly, driven by advancements in technology and the increasing integration of digital tools into teaching and learning processes. Among these advancements, e-learning has emerged as a transformative force, offering new opportunities for personalized, flexible, and accessible education. E-learning environments are particularly relevant in the secondary and senior secondary levels of education, where students are at a critical juncture in their academic and personal development.

The transition from traditional classroom teaching to digital learning platforms has brought with it both opportunities and challenges. While e-learning promises flexibility and inclusivity, its success depends on various factors, such as the adaptability of students to digital platforms, the alignment of educational content with individual learning preferences, and the willingness of learners to embrace technology as a medium of instruction. Understanding these factors is crucial for optimizing the e-learning experience and ensuring that it serves the diverse needs of students in secondary and senior secondary education.

Learning Styles and Learner Characteristics

Learning styles refer to the unique ways in which individuals acquire, process, and retain information. These styles are shaped by cognitive, emotional, and environmental factors, and they significantly influence how students interact with educational content. Commonly recognized learning styles include visual, auditory, kinesthetic, and reading/writing preferences. In traditional classroom settings, teachers often rely on their observations to tailor their teaching methods to suit these preferences. However, in an e-learning environment, the lack of direct interaction makes it imperative to design platforms and content that can cater to a wide range of learning styles. Learner characteristics, including motivation, self-regulation, and prior knowledge, also play a pivotal role in determining educational outcomes. Secondary and senior secondary students, who are in their formative years, exhibit a diverse range of characteristics that influence their learning experiences. For instance, some students may demonstrate a high level of self-motivation and discipline, enabling them to thrive in an e-learning environment, while others may require additional support and engagement strategies to stay on track.

Technology Acceptance in E-Learning

The success of e-learning initiatives is closely tied to the acceptance of technology by learners. The Technology Acceptance Model (TAM), introduced by Davis in 1989, provides a framework for understanding how perceived usefulness and ease of use influence individuals' attitudes toward technology. Over the years, TAM has been extended to include additional variables, such as social influence and facilitating conditions, resulting in models like the Unified Theory of Acceptance and Use of Technology (UTAUT). These models have been widely applied in higher education settings but remain underexplored in the context of secondary education. For secondary and senior secondary students, technology acceptance is influenced by several factors, including the design and usability of e-learning platforms, the availability of technical support, and the relevance of the content to their academic goals. A positive attitude toward technology can enhance engagement, while resistance or anxiety about using digital tools can hinder the learning process. Therefore, understanding the determinants of technology acceptance among younger learners is essential for creating effective e-learning environments.

Student Engagement and Behavioral Intention

Engagement is a multifaceted concept that encompasses cognitive, emotional, and behavioral involvement in the learning process. In an e-learning environment, student engagement is influenced by various factors, including the quality of instructional design, the interactivity of the platform, and the alignment of content with individual learning needs. Engaged students are more likely to demonstrate higher levels of academic achievement, satisfaction, and retention.

Behavioral intention, as defined in the context of technology acceptance, refers to the likelihood of an individual continuing to use a particular technology. In e-learning, behavioral intention is shaped by factors such as perceived usefulness, ease of use, and the overall learning experience. A positive behavioral intention indicates a high probability of students actively participating in and benefiting from e-learning platforms. Exploring the relationship between engagement, attitude, and behavioral intention can provide valuable insights into how to enhance the effectiveness of e-learning for secondary students.

Literature Review:

Chang et al. (2017) utilized the General Extended Technology Acceptance Model for E-Learning (GETAMEL) to analyze factors influencing Azerbaijani students' behavioral intention to use e-learning systems. This study involved 714 participants and identified subjective norms, experience, and enjoyment as positive predictors of perceived usefulness and ease of use. Conversely, computer anxiety negatively impacted these perceptions. Results underscored the moderating role of technological innovation in shaping behavioral intentions. These insights offer actionable strategies for educational policymakers to enhance e-learning adoption by addressing technological barriers and fostering positive user experiences.

Dahleez et al. (2021) examined how e-learning system usability and teacher behavior influenced various dimensions of student engagement during the COVID-19 pandemic. This study surveyed 418 students and found that usability positively impacted agentic, behavioral, and cognitive engagement but had no significant effect on emotional engagement. Teacher behavior mediated these relationships, amplifying the usability effects on all engagement types. These findings emphasize the dual importance of user-friendly e-learning systems and supportive instructor interactions in fostering holistic student engagement during crises.

Alkandari (2015) explored the determinants of e-learning acceptance at Kuwait University using an extended Technology Acceptance Model (TAM1). The study revealed that perceived usefulness, ease of use, and self-efficacy were critical factors influencing students' intention to use e-learning systems. Findings highlighted the significance of technical support and training in fostering acceptance. This research provides valuable insights into designing e-learning systems that align with user expectations and technological capabilities to enhance adoption rates in higher education.

Alqahtani et al. (2022) investigated factors influencing satisfaction and acceptance of e-learning technologies in Saudi higher education institutions, aligned with the Saudi Vision 2030 initiative. The study highlighted that

user satisfaction with e-learning platforms depends significantly on technological ease of use, interactivity, and alignment with student needs. Additionally, faculty support and integration of digital tools were crucial for acceptance. These findings underscore the importance of tailored e-learning solutions in advancing educational objectives and fostering digital readiness among students in Saudi Arabia.

Zhao et al. (2021) proposed a comprehensive model linking environmental psychology, e-learning, learning styles, and school design to elementary students' behavior. Using data from 400 teachers in Iranian elementary schools, the study validated the model's components, demonstrating that school design and tailored e-learning approaches positively influence student behavior. The findings underscore the importance of integrating architectural considerations with psychological and pedagogical strategies to create optimal learning environments. This research provides actionable insights for administrators and architects in enhancing educational facilities.

Seyal and Rahman (2015) examined how learning styles and attitudes influence students' intentions to use e-learning platforms in a higher education setting in Brunei. This study utilized the VARK questionnaire to assess learning styles among 120 students and found significant correlations between learning styles, positive attitudes toward educational technologies, and behavioral intentions to adopt e-learning platforms. The findings highlight the importance of considering individual learning preferences in system design to enhance usability and engagement. These insights offer guidance for tailoring e-learning systems to diverse learner needs effectively.

Almagro et al. (2023) explored how the e-learning educational atmosphere and technology integration predict student engagement in agribusiness programs. This study analyzed data from 127 college students, finding significant correlations between e-learning environments characterized by support, ethics, and accessibility and student engagement across cognitive, affective, and behavioral dimensions. The integration of user-friendly technologies further enhanced engagement levels. These findings underscore the importance of fostering supportive e-learning ecosystems with robust technological tools to boost participation and learning outcomes.

Purpose of the research:

The primary purpose of this research is to investigate the influence of individual learner characteristics and preferred learning styles on the effectiveness of e-learning in secondary and senior secondary school education. By understanding these factors, the study aims to identify strategies to optimize e-learning experiences and improve student outcomes.

Research Gap:

While doing the literature review, it was found that research on these domains have not been done in Indian school education.

a) Influence of learning style and learner characteristics on e-learning environment in the school system.

b) The acceptance of e-learning environment by the students and the school system and the measurement of e-learning environment's effectiveness.

Research Objectives:

a) To determine and analyze the various learning style and learner characteristics and technology acceptance in Secondary and Sr. Secondary students in an e-learning environment.

b) To determine the student engagement and relationship among the learner's attitude, technological acceptance, and behaviour intention in the e-learning environment in Secondary and Sr. Secondary students.

Research Hypothesis:

H_a1: There is a significant association between learning style and the effectiveness of e-learning in secondary and senior secondary schools

H_a2: There is a significant association between learners' characteristic and the effectiveness of e-learning in secondary and senior secondary schools

H_a3: There is a significant association between technology acceptance of the e-learning environment and the effectiveness of e-learning in secondary and senior secondary schools

Research Methodology:

Type of research: Causal Research
Data sources: Primary and secondary.
Data collection: Survey
Research instruments: Questionnaire
Contact method: Face to face interview.
Sampling decision: Sample size 383
Statistical Technique: Structure Equation Modelling

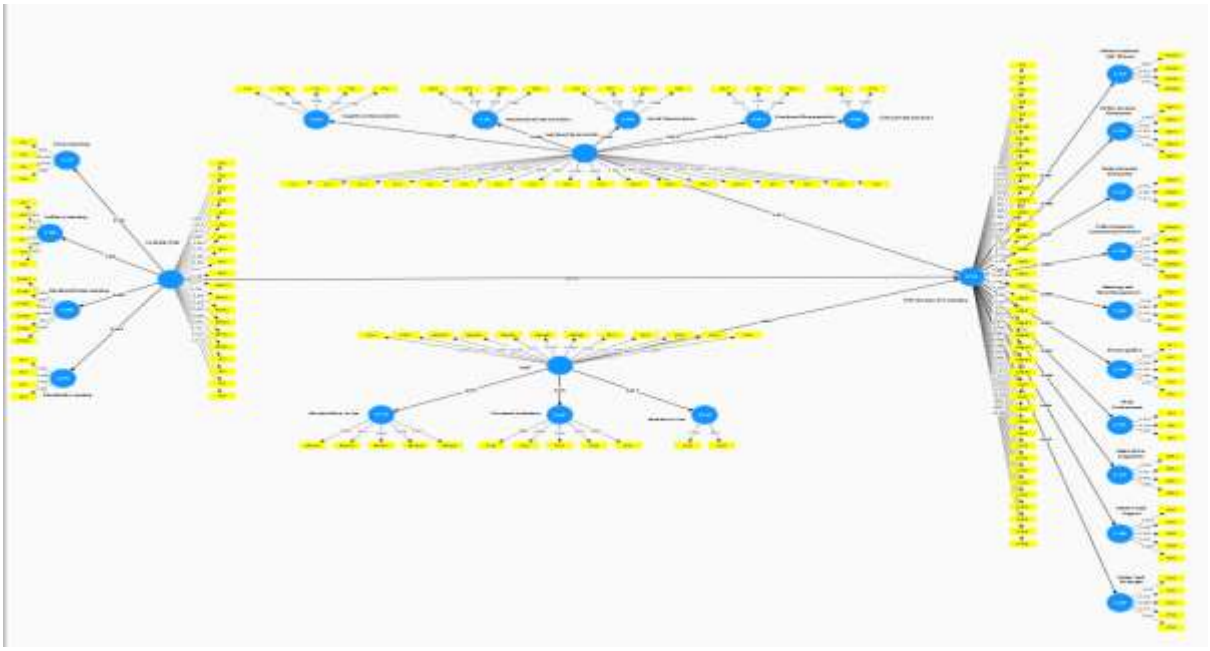
List of Variables and measurement tools

Variables	Theory/Model	Tool	Operational Definition
Learning Style	VARK learning style or Kolb's learning Style Four modalities of student learning proposed by Neil D Flemming and Coleen E.Mills. It includes Visual, Auditory, Reading/Writing and Kinesthetic learning styles.	Standardized VARK questionnaire tool (Adapted Scale)	Learning Style of each student is different and based on the learning style, educators can develop strategies for reaching every student in their classroom effectively.
Learner Characteristics	Systematic literature review - Qualitative research	Based on the qualitative research design, tool was designed to study the learner characteristics.	Learner characteristics can be described as measuring the characteristics of learners such as attitude, mode and style of learning etc. It can vary with gender, level of education and type of Schools.
Technology Acceptance	Technology Acceptance Model By Fred Davis and Richard Bagozzi	Standardized tool of TAM model was used(Adapted Scale)	The effectiveness of E- learning depends on a lot on Perceived Ease of Use, Perceived Usefulness and Behavioural intention of the student.
Effectiveness of E Learning	The self-regulation for learning online (SRL-O) questionnaire Broadbent, J., Panadero, E., Lodge, J.M. et al. The self-regulation for learning online (SRL-O) questionnaire. Metacognition Learning 18, 135–163 (2023)	Standardized SRL-O Questionnaire was used(Adapted Scale)	Learners differ in the extent to which they use self-regulation by setting goals, planning, and engaging in strategies to achieve their learning objectives. Through evaluation and reflection, learners monitor and modify these strategies to enhance their progress toward goal achievement (Zimmerman, 1986).

Data Analysis

Descriptive Analysis – Five number summary of Latent Variable Scores

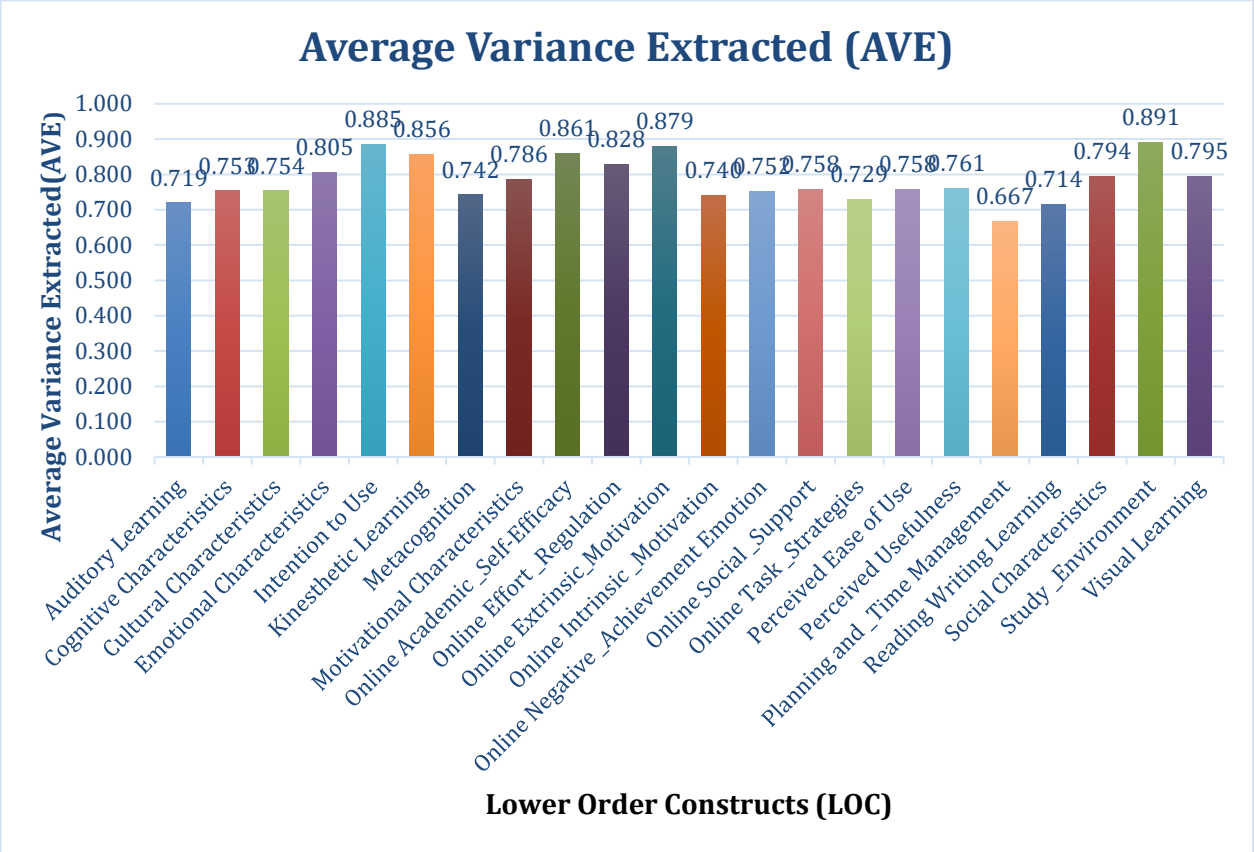
Construct	Minimum	First Quartile	Median	Third Quartile	Maximum
Effectiveness of E-Learning	1.01	2.003913146	3.5513	5	5
Learning Characteristics	1	1.856046228	3.4449	5	5
Learning Style	1.01	1.888468133	3.4082	5	5
TAM	1	1.783773639	3.5065	5	5



Stage 1: Measurement Model for Lower-Order Constructs (LOC)

Validity Analysis:

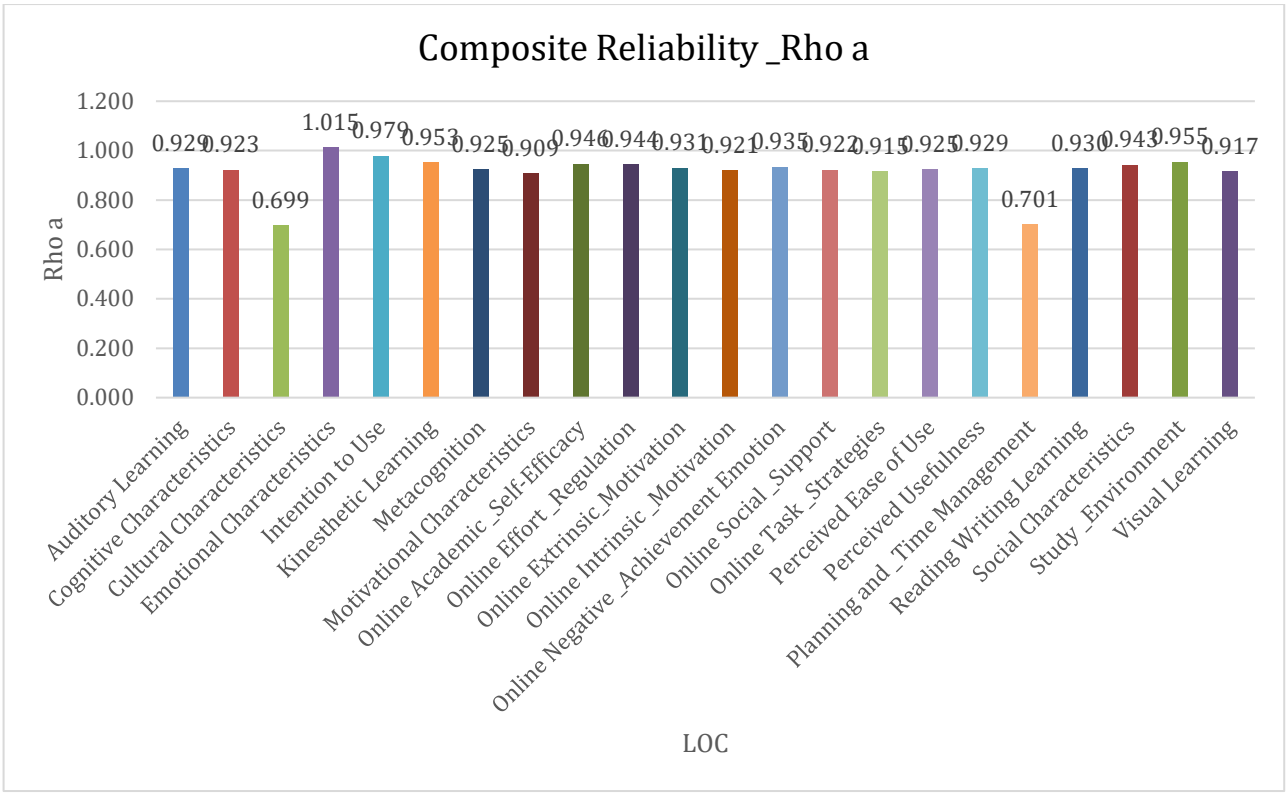
- **Convergent Validity**:
  - **Outer Loadings**: All outer loadings are greater than 0.70, indicating convergent validity.
  - **Average Variance Extracted (AVE)**: All AVEs are greater than 0.50, confirming convergent validity.



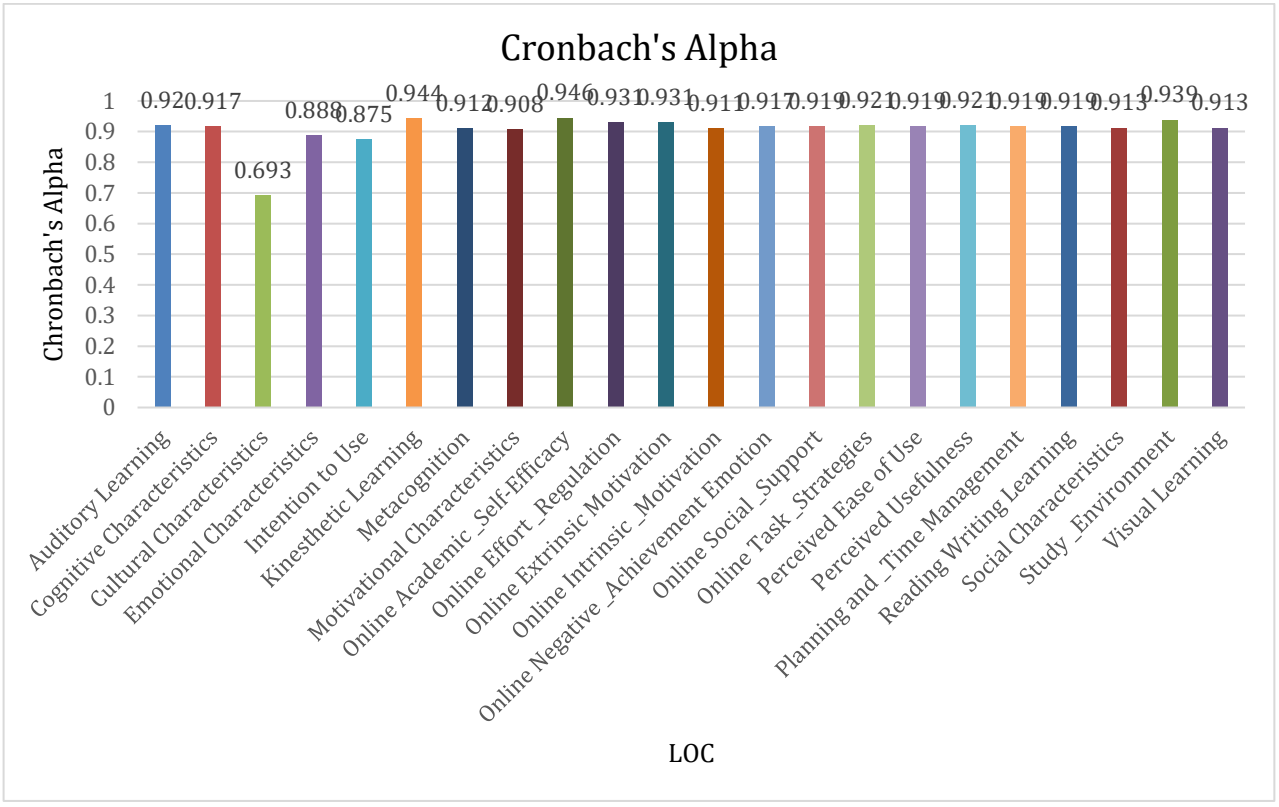
- **Discriminant Validity**:
  - **Fornell-Larcker Criterion**: Each value on the diagonal is the largest in its row and column, meeting the criterion for discriminant validity.
  - **Heterotrait-Monotrait Ratio (HTMT)**: All HTMT values are below 0.90, establishing discriminant validity.

Reliability Analysis:

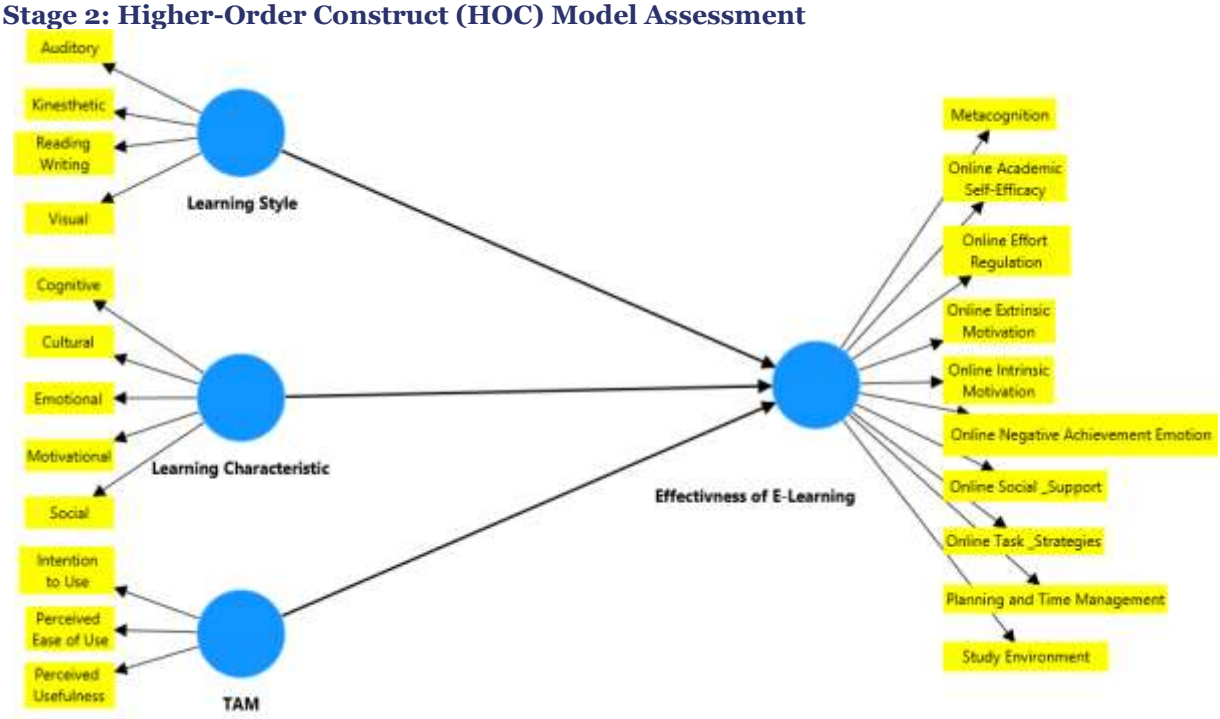
- **Composite Reliability (Rho a)**: All values are above 0.70, except for "Cultural Characteristic" (0.699), which is considered acceptable.



- **Indicator Reliability**: Squared values of all outer loadings are greater than 0.50.
- **Internal Consistency Reliability (Cronbach's Alpha)**: All values are above 0.70, indicating internal consistency.



2. Stage 2: Higher-Order Construct (HOC) Model Assessment



Validity Analysis:

- **Convergent Validity**:
  - **Outer Loadings**: All loadings are greater than 0.70, except for "Auditory" and "Social" constructs. These were retained due to acceptable Cronbach Alpha, Rho a, and AVE values.
  - **Average Variance Extracted (AVE)**:

	Average variance extracted (AVE)
Effectiveness of E-Learning	0.735
Learning Characteristic	0.668
Learning Style	0.759
TAM	0.884

All AVEs are above 0.50.

Discriminant (Divergent) Validity - Fornell- Larcker criterion and Heterotrait-Monotrait ratio (HTMT)

a) Fornell- Larcker criterion

	Effectiveness of E-Learning	Learning Characteristic	Learning Style	TAM
Effectiveness of E-Learning	0.858			
Learning Characteristic	-0.083	0.817		
Learning Style	0.047	-0.204	0.871	
TAM	-0.030	-0.004	-0.077	0.940

It can be seen that along the diagonal each value is largest in its row and in its column thus meeting the Forner Larcker Criterion for convergent validity

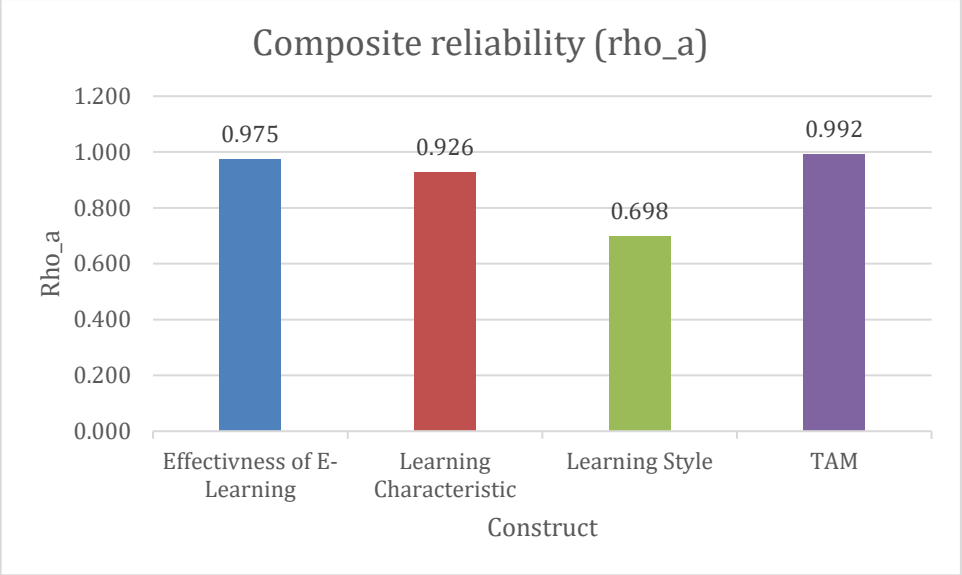
b) Heterotrait-Monotrait ratio (HTMT)

	Heterotrait-monotrait ratio (HTMT)
Learning Characteristic <-> Effectiveness of E-Learning	0.084
Learning Style <-> Effectiveness of E-Learning	0.028
Learning Style <-> Learning Characteristic	0.329
TAM <-> Effectiveness of E-Learning	0.031
TAM <-> Learning Characteristic	0.077
TAM <-> Learning Style	0.086

All HTMT ratios are less than 0.90 Thus, with a and b above Discriminant Validity is established

Reliability Analysis
Composite Reliability- Rho a

	Composite reliability (rho_a)
Effectiveness of E-Learning	0.975
Learning Characteristic	0.926
Learning Style	0.698
TAM	0.992



All values of rho a are greater than 0.70 except in case of Learning Style for which it 0.698 which can approximately be taken as 0.70

Thus, composite reliability is established

Indicator Reliability: All squared loadings are greater than 0.50, except for "Auditory" and "Social" constructs, which were retained as per previous rationale.

Internal Consistency Reliability (Cronbach's Alpha): All values exceed 0.70, indicating internal consistency.

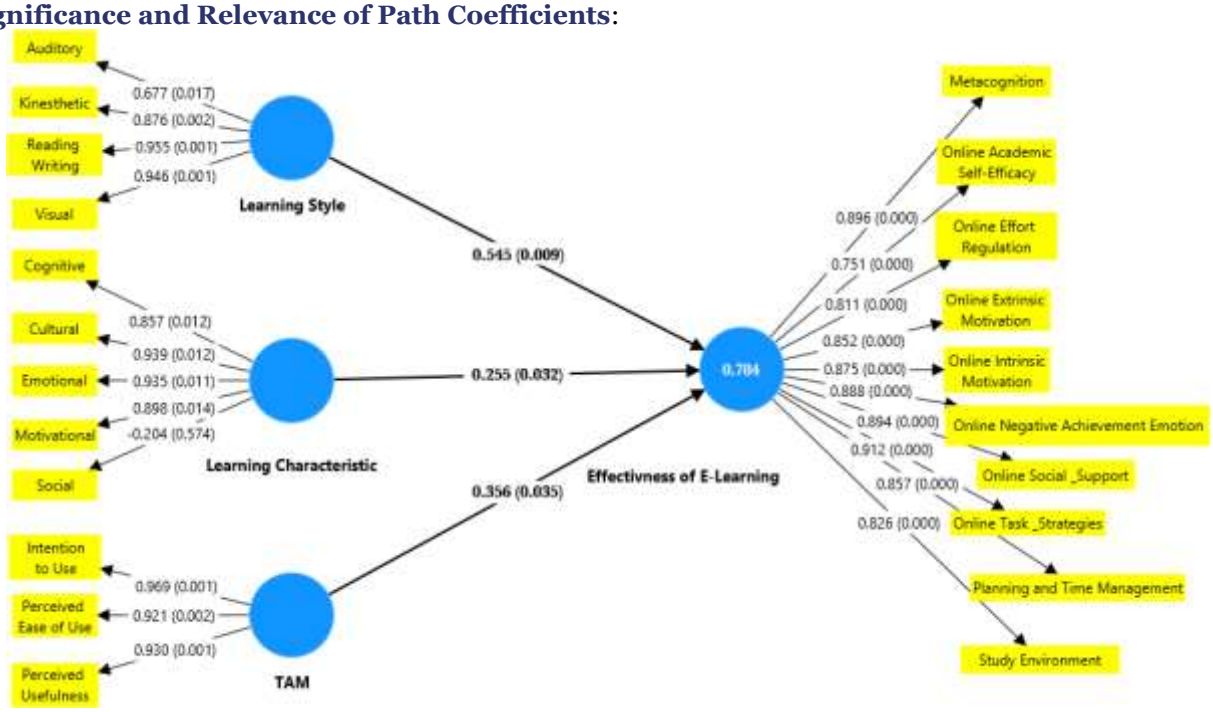
	Cronbach's alpha
Effectiveness of E-Learning	0.960
Learning Characteristic	0.807
Learning Style	0.955
TAM	0.945

3. Structural Model Evaluation
Collinearity Analysis:

	Average variance extracted (AVE)
Effectiveness of E-Learning	0.735
Learning Characteristic	0.668
Learning Style	0.759
TAM	0.884

It can be seen that all AVE's are less than 5, therefore, there is no issue of multicollinearity.
No significant multicollinearity, with all AVEs being below the threshold of 5.

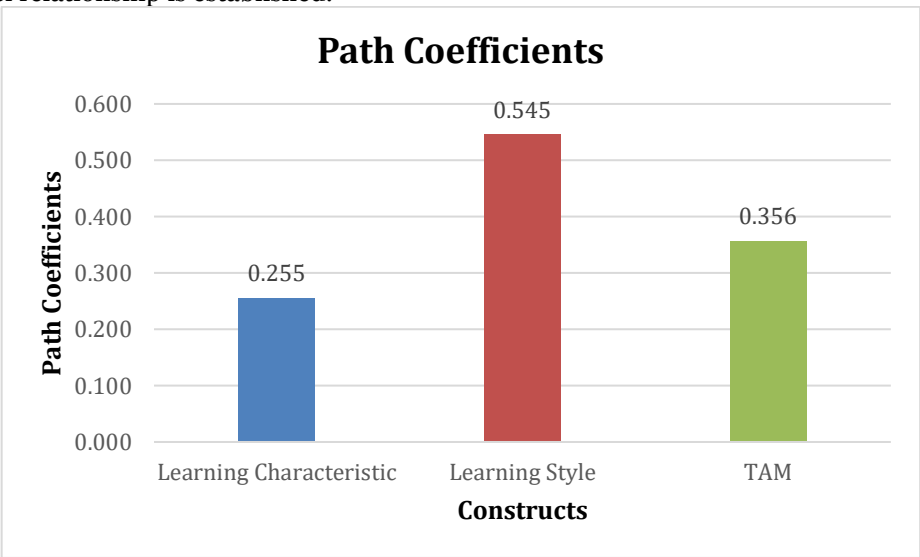
Significance and Relevance of Path Coefficients:



Path coefficients represent the strength and direction of the relationships between constructs

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Learning Characteristic -> Effectiveness of E-Learning	0.255	0.245	0.080	3.207	0.032
Learning Style -> Effectiveness of E-Learning	0.545	0.533	0.090	6.026	0.009
TAM -> Effectiveness of E-Learning	0.356	0.343	0.069	5.132	0.035

Since all T statistics are more than 1.96 and all p values are less than 0.05 significance and relevance of the structural model relationship is established.



Explanatory Power of the Model

R^2 indicates the proportion of variance explained by the model, helping to assess the overall model fit

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Effectiveness of E-Learning	0.784	0.699	0.011	71.246	0.000

Since R Sq = 0.784 and p-Value< 0.05 the model has substantial explanatory power

Effect Size

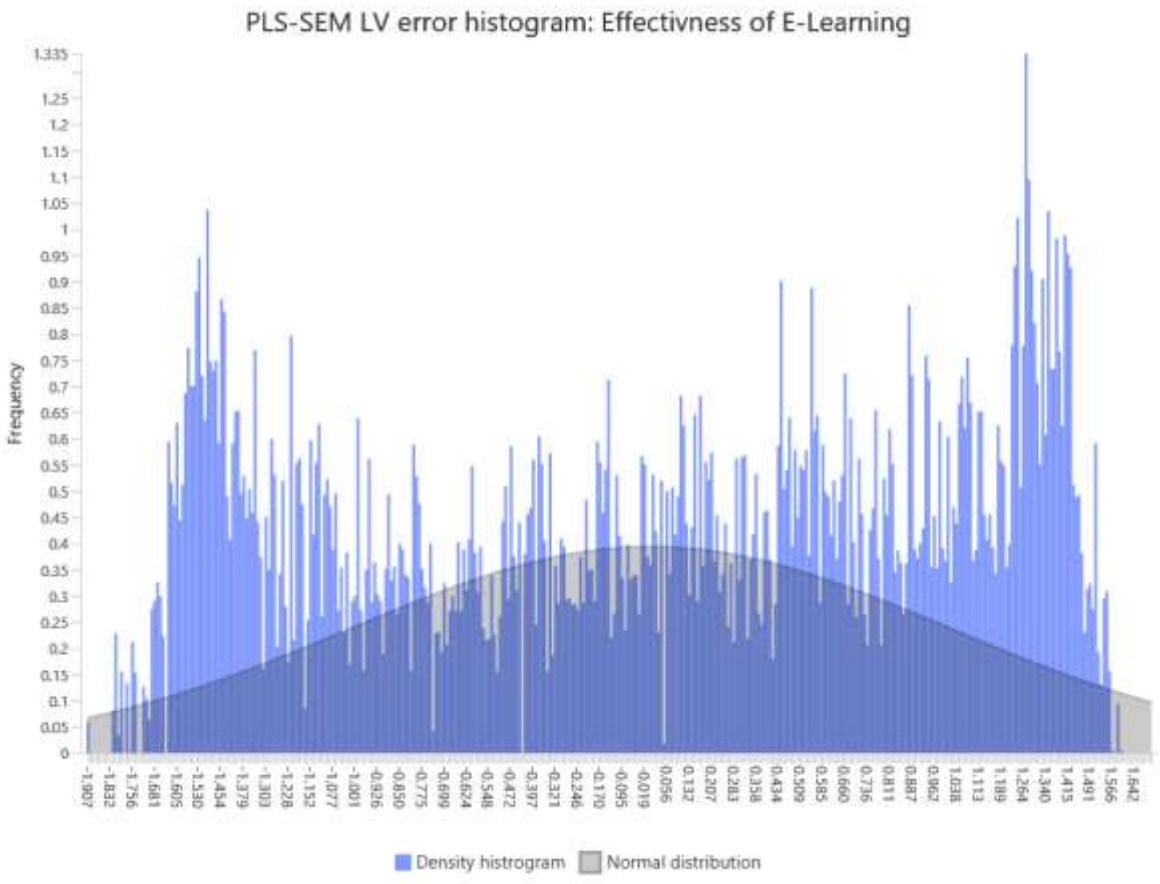
Effect sizes measure the relative impact of predictors on endogenous constructs, providing insight into the practical significance of the relationships.

	f-square
Learning Characteristic -> Effectiveness of E-Learning	0.312
Learning Style -> Effectiveness of E-Learning	0.322
TAM -> Effectiveness of E-Learning	0.293

Since all f Square are greater than 0.15 and less than 0.35 , the model has medium effect size

Predictive Power

Number of sub samples/ Number of folds K = 10
Number of observations = 383
Observations in each subsample = 383/10= 38.3 ~ 38 Observations
Number of subsamples in training data = K-1=9
Number of observations in training data = 9 x 38.3 = 344.7 ~345 Observations
Number of observations in testing data = 38.3 ~ 38 Observations



It can be seen that the errors of endogenous variables are approximately normally distributed

Cramer-Von Mises test for normality of endogenous variable- Effectiveness of E-Learning

H_o: Sample data comes from a normal distribution with a mean of 0 and a standard deviation of 1.
H_a: Sample data does not come from a normal distribution with a mean of 0 and a standard deviation of 1.

Indicators of Effectiveness of E-Learning	Mean	Median	Standard deviation	Number of observations used	Cramér-von Mises p value
Metacognition	0	0.078	1.001	3830	0.072
Online Academic Self-Efficacy	0	0.069	1.006	3830	0.054
Online Effort _Regulation	0	0.105	1.003	3830	0.063
Online extrinsic Motivation	-0.001	0.177	1.033	3830	0.052
Online intrinsic Motivation	0	0.18	1	3830	0.057
Online Negative Achievement Emotion	-0.001	0.145	1.032	3830	0.05
Online Social _Support	0	0.131	1.005	3830	0.058
Online Task _Strategies	0	0.174	1.007	3830	0.063
Planning and Time Management	0	0.105	1.045	3830	0.055
Study Environment	0	0.124	1	3830	0.073

Since all p-Values are more than 0.05, fail to reject null hypothesis. Therefore, the indicators of endogenous variables Effectiveness of E-Learning are normally distributed.

Since the data is normally distributed, in the prediction summary , MAE values were ignored and instead RMSE Values were checked. The difference between PLS-SEM_RMSE and LE_RMSE were calculated

Indicators of Effectiveness of E-Learning	Q^2predict	PLS-SEM_RMSE	LM_RMSE	Difference: (PLS-SEM_RMSE) - (LM_RMSE)
Metacognition	0.016	1.461	1.48	-0.019
Online Academic Self-Efficacy	0.007	1.326	1.355	-0.029
Online Effort _Regulation	0.012	1.342	1.363	-0.021
Online extrinsic Motivation	0.012	1.394	1.42	-0.026
Online intrinsic Motivation	0.014	1.381	1.399	-0.018
Online Negative Achievement Emotion	0.018	1.393	1.408	-0.015
Online Social _Support	0.021	1.387	1.402	-0.015
Online Task _Strategies	0.015	1.406	1.419	-0.013
Planning and Time Management	0.008	1.454	1.475	-0.021
Study Environment	0.006	1.482	1.501	-0.019

Since all differences are negative and all Q2 values are greater than 0 , the model has high (out of sample) predictive power

Findings and Conclusion:

The reasoning behind the varying degrees of impact these constructs have on the effectiveness of E-Learning.

1. Learning Style (Most Influential)

Learning Style refers to the preferred way in which individuals absorb, process, and retain information. In the context of E-Learning, it plays a pivotal role in determining how effectively learners engage with and benefit from online educational materials.

Individualized Learning Preferences: E-Learning platforms often provide a variety of content delivery modes, such as video, text, interactive simulations, and quizzes. Learners with specific learning styles (e.g., visual, auditory, kinesthetic) are more likely to succeed in environments that align with their preferences. For instance, a visual learner may find video lectures or infographics more engaging and easier to understand compared to traditional text-based content.

Engagement and Motivation: Learners who can engage with materials in a way that suits their learning style tend to show higher levels of motivation, which is directly correlated with better learning outcomes. When E-Learning systems accommodate these preferences, learners are more likely to remain engaged, leading to higher retention of information and better overall effectiveness.

Customization of Learning Experience: Many modern E-Learning platforms allow for a degree of personalization, where learners can select content or adjust the pace of learning according to their style. This customization ensures that learners are exposed to content in ways that enhance their natural cognitive strengths, improving both the efficiency and effectiveness of the learning process.

Due to these factors, Learning Style is identified as the most significant predictor of E-Learning effectiveness.

2. Technology Acceptance (Moderately Influential)

Technology Acceptance refers to the degree to which a learner is willing to use and integrate technology into their learning experience. This construct is critical in the context of E-Learning because the medium itself is inherently technological.

Perceived Ease of Use and Usefulness: According to the Technology Acceptance Model (TAM), the more a learner perceives the E-Learning platform to be user-friendly and effective, the more likely they are to use it consistently. If learners find the platform difficult to navigate or do not believe it offers substantial value, they are less likely to engage fully, reducing the effectiveness of the learning process.

Technological Comfort and Familiarity: Learners who are comfortable with digital tools and have prior experience using technology are likely to interact more effectively with E-Learning platforms. For learners who are less familiar or comfortable with technology, however, the platform might present barriers that inhibit their learning experience, such as frustration with software or difficulty understanding online instructions.

External Factors: Technology acceptance is also influenced by external factors such as access to devices, internet connectivity, and technical support. These factors can enhance or hinder the learner's ability to fully engage with E-Learning environments, and consequently, impact its effectiveness.

While Technology Acceptance plays a significant role in determining the success of E-Learning, it ranks second because, although essential, the effectiveness of the technology itself is often secondary to how well it matches a learner's personal needs, particularly their learning style.

3. Learner's Characteristic (Least Influential)

Learner's Characteristic encompasses a variety of factors, such as motivation, prior knowledge, cognitive ability, and self-regulation skills, that shape an individual's approach to learning. While these characteristics are undeniably important, their influence on the effectiveness of E-Learning is often more indirect or context-dependent.

Individual Variability: Learners with strong characteristics—such as high self-discipline, intrinsic motivation, and prior knowledge in a subject—may naturally excel in E-Learning environments, but these characteristics can vary widely across the learner population. While important, the impact of these characteristics may not be as immediately apparent as learning styles or technology acceptance, especially when learners are engaged in structured or guided E-Learning experiences.

Role of External Supports: In many cases, E-Learning platforms and instructors can provide the necessary scaffolding (e.g., clear instructions, timely feedback) to support learners who may have varying levels of motivation or self-regulation. As a result, the characteristics of the learner may be somewhat mitigated by the design and structure of the learning environment, making it less influential than other factors.

Context-Dependent Impact: The influence of Learner's Characteristics can fluctuate depending on the learner's context, the subject matter, and the E-Learning platform used. For example, highly motivated and self-regulated learners might perform well in an open-ended, self-paced E-Learning environment, while less self-motivated learners may struggle, regardless of their characteristics. However, in a more structured learning environment, the learner's characteristics may play a less prominent role.

Given these factors, Learner's Characteristic ranks last in terms of influence on E-Learning effectiveness, although it remains an important variable, particularly when considering the need for tailored interventions to support learners who may struggle with self-regulation or motivation.

Ultimately, the effectiveness of E-Learning is a dynamic result of these interconnected factors, with **Learning Style** standing out as the most critical determinant in ensuring an optimal learning experience.

This research is significant in light of the growing importance of e-learning in secondary education, especially in the context of evolving pedagogical strategies and the integration of technology into the learning process.

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