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MODELING THE CAUSAL RELATIONS BETWEEN MIND WANDERING, DIGITAL READINESS AND ACADEMIC ENGAGEMENT IN E-LEARNING AMONG UNIVERSITY STUDENTS

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Abstract

This study modeled causal relations between mental wandering, digital readiness, and academic engagement among 298 university students in e-learning contexts. Quantitative analysis uncovered a high level of mind wandering and uneven digital readiness among participants. Academic engagement was moderately developed across behavioral, emotional, and cognitive domains. Structural equation modeling validated a proposed model of causal mechanisms linking these factors based on cognitive load, connectivism, and flow theories. Mental wandering demonstrated direct negative effects on engagement by disrupting cognitive focus and meta-awareness. Poor digital readiness also dampened engagement by overloading mental capacities and inhibiting access to online learning communities. The model provides a framework for investigating predictors of mind wandering and digital readiness and examining moderators of their impacts on engagement. Findings inform potential interventions to strengthen engagement and performance in e-learning through mindfulness training, digital skills development, and promoting social connections, interest, and cognitive absorption. This research elucidates the intersection of psychological dispositions, technological competencies, and embeddedness in digital learning and charts future inquiry directions.

Keywords: *Mental Wandering, Digital Readiness, Academic Engagement, E-Learning, Structural Equation Modeling.*

INTRODUCTION

The use of digital technologies for learning has become ubiquitous in higher education. Most universities now offer some form of e-learning, whether fully online courses or blended models that incorporate digital components into face-to-face instruction. This digital transformation of education brings many potential benefits, including increased flexibility, personalized learning, and expanded access. However, it also requires students to engage with course material and collaborate online in new ways that can be challenging. In particular, staying focused on online learning activities may be difficult for some students who are prone to mental wandering or daydreaming. At the same time, students' own digital readiness, in terms of their skills, preferences, and access to technology, likely also impacts their ability to integrate into e-learning environments. This highlights the need to model the causal relations between these factors to better understand how to support students in digital learning contexts.

Mental wandering refers to shifts in attention away from external tasks and towards internal thoughts and feelings (Seli et al., 2016). It is a common experience for most people, often occurring unintentionally during learning activities. Research suggests that mental wandering negatively impacts comprehension and retention of information (Varao-Sousa & Kingstone, 2019). This effect

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can be pronounced in online learning, where there are limited social cues to reorient attention and shallow information processing during mind wandering may go unnoticed (Szpunar, Khan, & Schacter, 2013). Those prone to mental wandering may therefore face difficulties focusing on digital course activities like video lectures, discussions, and self-paced modules. Understanding the antecedents and consequences of mind wandering in e-learning contexts is thus an important issue.

Digital readiness encompasses the skills, preferences, and access to technology that allow students to effectively engage with digital learning (Yu, 2018). Technical skills include computer proficiencies as well as online learning skills like self-regulation and collaboration. Preferences reflect attitudes towards technology and e-learning, including perceived usefulness and ease of use. Access considers whether students have appropriate devices and internet connectivity to fully participate. Students who enter e-learning programs with poor digital readiness may face difficulties completing online activities, interacting with peers, and regulating their own learning, potentially also contributing to mental wandering. Aptitude and comfort with technology is not evenly distributed, so digital readiness represents an essential factor to consider in e-learning.

Given the likely relations between mental wandering, digital readiness, and engagement into e-learning, modeling causal connections between these variables has important implications. Engagement refers to students' ability to become embedded participants in the social and academic systems of an educational program (Tinto, 1993). In e-learning contexts, this requires actively engaging with course content, instructors, and fellow students through computer-mediated activities. Mental wandering and poor digital readiness may both reduce engagement by interfering with cognitive engagement, diminishing collaboration skills, and lowering motivations to persist through challenges. Understanding the magnitude and directions of these causal effects could help identify struggling students and lead to interventions that remove barriers to their engagement into e-learning.

Various theoretical frameworks provide a foundation for hypothesizing causal relations in this domain. Cognitive load theory suggests that demands on working memory inhibit learning when exceeding mental resources (Sweller, Ayres, & Kalyuga, 2011). Mental wandering and poor digital skills may both impose extraneous cognitive load that detracts from necessary learning processes. Connectivism emphasizes that constructing knowledge requires forming connections between ideas, resources, and people across digital networks (Siemens, 2005). Students' engagement into these networks through meaningful engagement enables learning, which mental wandering and technical deficiencies could impede. Finally, flow theory highlights focused engagement as crucial for motivation and perseverance in learning activities (Shernoff, Csikszentmihalyi, Shneider, & Shernoff, 2003). Mental wandering is essentially the opposite of flow, while poor digital readiness inhibits accessing this optimal psychological state in e-learning.

Together, these perspectives indicate that mental wandering and digital readiness could have direct causal impacts on engagement into e-learning through interrelated cognitive and motivational mechanisms. Statistical modeling can be used to quantify the magnitudes of these causal relations and test their directionality. This knowledge can then guide interventions, such as mindfulness training to reduce mind wandering (Mrazek, Franklin, Phillips, Baird, & Schooler, 2013) or technical skill development to improve digital readiness (Kim & Park, 2019). Exploring moderating effects of individual differences like cognitive abilities or learning preferences may also help target supports to students who need them most. In summary, modeling the complex causal pathways between students' psychological dispositions, technology skills, and engagement into digital learning will provide both theoretical insights and practical guidance to improve e-learning outcomes as higher education continues rapid digital transformation.

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Research Questions

1. What is the level of mental wandering among university students during e-learning?
2. What is the level of digital readiness of university students in the e-learning environment?
3. What is the level of academic engagement of university students in the e-learning environment?
4. What is the best causal structural model that illustrates the path of direct and indirect effects between mental wandering, digital readiness, and academic engagement among university students in the e-learning environment?

Research Hypotheses

1. There are no statistically significant differences between the hypothetical mean and the average scores of the experimental sample on the mental wandering scale during e-learning.
2. There are no statistically significant differences between the hypothetical mean and the average scores of the experimental sample on the digital readiness scale among university students during e-learning.
3. There are no statistically significant differences between the hypothetical mean and the average scores of the experimental sample on the scale of academic engagement during e-learning.
4. Empirical data support the validity of the proposed constructivist model of direct and indirect relations and effects between mental.

RESEARCH METHODOLOGY

The study adopted a descriptive approach and utilized structural equation modeling (SEM) to examine the proposed structural model's validity. This methodology facilitated the verification of relations between mental wandering, digital readiness, and academic engagement among university students engaged in e-learning.

Research Community and Sample

The research community encompassed male and female students of King Khalid University participating in e-learning during the academic year 1443. The research sample comprised two groups: a psychometric proficiency sample (84 students: 43 males / 41 females) and a basic research sample (298 students: 158 males / 140 females). These students were randomly selected from the Faculties of Education for Boys and Girls, along with the College of Education at King Khalid University. The average age for the psychometric proficiency sample was 22.74 years (SD = 2.22), and for the basic research sample, it was 22.2 years (SD = 1.53).

Research Tools

1. Mind Wandering Scale (Shalaby & Ayed, 2021):

- The Mind Wandering Scale developed by Shalabi & Ayed in 2021 is designed to gauge the frequency and intensity of mind wandering among individuals, particularly in the context of e-learning. The scale likely includes a series of statements or questions measuring various aspects such as the frequency of mind wandering during e-learning sessions, the ability to maintain focus, intrusiveness of unrelated thoughts, distraction levels, and the impact of mind wandering on the learning process. Participants typically rate these statements on a scale reflecting the frequency or intensity of their mind wandering experiences. The scale's validation process likely

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involves statistical analyses to ensure reliability and validity, encompassing internal consistency, test-retest reliability, and factor analysis to determine its underlying structure and effectiveness in measuring mind wandering in e-learning settings. Further details and specifics about the scale's items and response options could be obtained from the original research or the scale itself if publicly available. Comprising 20 items measured on a quadruple scale (always, often, sometimes, rarely) to assess the degree of mental wandering.

- Psychometric properties included:
- Hypothetical Composition Authenticity: Correlation coefficients ranged between 0.61 to 0.79, indicating high significance at $p < 0.01$.
- Factor Honesty: Exploratory factor analysis demonstrated the existence of a general factor labeled "mental wandering."
- Scale Stability: Verified using alpha-Cronbach (0.91) and Spearman–Brown (0.88) coefficients.

2. Academic Engagement in E-Learning Scale (El-Kasaby, 2022):

- The Academic Engagement in E-Learning Scale developed by El-Kasabyin 2022 is crafted to evaluate the degree of academic engagement among individuals in the context of e-learning. This scale likely encompasses 24 statements distributed across three dimensions: behavioral, emotional, and cognitive engagement. The scale's questions or items may address various aspects such as the level of active participation in e-learning activities, emotional connection or involvement with the learning material, and the cognitive engagement of knowledge acquired during the e-learning process. Participants typically rate these statements on a five-point scale, indicating the degree of their academic engagement. The scale's validation process likely involves establishing its reliability and validity, including assessing internal consistency, correlation between items and dimensions, and calculating stability coefficients. For specific details regarding the scale's items and their application, one might refer to the original research or the scale itself if publicly available, Consisted of 24 items across three dimensions: behavioral, emotional, and cognitive engagement.
- Psychometric properties included:
- Sincerity of Internal Consistency: Correlation coefficients between statements and dimensions showed significance at $p < 0.01$.
- Scale Stability: Confirmed by alpha-Cronbach coefficients (total scale: 0.95; dimensions: 0.86, 0.84, 0.89) and Spearman–Brown coefficients (total scale: 0.94; dimensions: 0.84, 0.85, 0.86).

3. Digital Readiness Scale for University Students (Hong & Kim, 2018):

- The Digital Readiness Scale for University Students, formulated by Hong & Kim in 2018, aims to measure the digital preparedness and competence of students in a university setting. This scale typically comprises 17 items divided into five dimensions, which assess various facets of digital readiness, including the application of digital tools, information exchange behaviors, information search skills, awareness of digital media, and utilization of digital applications. Participants likely rate their agreement or proficiency on a five-point scale. To ensure the scale's reliability and validity, the development process typically involves translating and adapting the scale for linguistic accuracy and then examining the scale's psychometric properties. This validation process might encompass tests for internal consistency, correlation between items and total scores, and stability coefficients, ensuring the scale's effectiveness in evaluating students' readiness for digital engagement in a university context. For comprehensive information on the scale's specific items and dimensions, reference to the original research or

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the scale itself would be advisable if available in the public domain. Comprised 17 items across five dimensions evaluating digital readiness skills.

- Psychometric properties:
- Validity of Hypothetical Formation: Significant correlation coefficients ranged between 0.39 to 0.65.
- Internal Consistency: Correlation coefficients demonstrated significance between statements and dimensions at $p < 0.01$.
- Scale Stability: Confirmed using Cronbach's alpha coefficients (total scale: 0.88; sub-dimensions: ranging from 0.68 to 0.88).

RESULTS

Table (1) provides insights into the comparison between the hypothetical mean and the actual average scores on the Mental Wandering scale within the sample of 298 participants engaged in e-learning. The analysis exhibited a substantial statistical difference ($p < 0.01$) favoring the sample's scores, with an average weight of 3.07. This significant disparity highlights a notably high level of mental wandering among the sample members during their e-learning experiences, emphasizing a pervasive occurrence of cognitive drift and disengagement during the learning process. The observed average, far exceeding the hypothetical mean, indicates a prevalent tendency for students to experience mental wandering, echoing findings by Risko et al. (2012) that reported a similar high incidence of such wandering, possibly influenced by various factors including internal cognitive drifts and the allure of external stimuli such as technology and social media, diverting attention from learning tasks.

Table 1: Test - T for one sample to indicate the differences between the hypothetical mean and the average scores Sample on the mental wandering scale (n=298)

Sample average	Hypothetical mean	Standard deviation	Value of t	Degree of freedom	Significance	Average Weight	Level
61.55	50	17.36	11.17	297	0.01	3.07	High

Table (2) showcases the results of the statistical analysis examining the discrepancy between the hypothetical mean and the actual average scores of the sample across various dimensions in the Digital Readiness Scale. It contains essential metrics such as the number of observations (298), sample averages, hypothetical means, standard deviations, t-values, degrees of freedom, and significance levels. The findings indicate statistically significant differences ($p < 0.01$) between the sample's average scores and the hypothesized means. Notably, the dimensions of Digital Gadget Application and Information Search Skills exhibit lower sample averages compared to their hypothetical means, signifying a low level of readiness in these specific areas among the research participants. Conversely, the Information exchange behavior and Digital Media Awareness dimensions display higher sample averages, suggesting a relatively higher level of readiness in these aspects. Overall, the analysis illustrates distinct variations in digital readiness across diverse dimensions, emphasizing areas that may necessitate improvement or attention in the context of the e-learning environment.

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Table 2: Test results for one sample to indicate the difference between the hypothetical mean and the average scores of the sample on Digital Standby Meter

Dimension	Number	Sample average	Hypothetical mean	Standard deviation	Value of T	Degree of freedom	Significance level
Digital Gadget Application	**298**	**14.27**	**27**	**3.67**	**47.78**	**297**	**0.01**
Information exchange behavior	298	**22.84**	**21**	**4.28**	**5.94**	**297**	0.01
Information Search Skills	298	**9.1**	**12**	**2.36**	**17.52**	**297**	0.01
Digital Media Awareness	298	**22.82**	**27**	**9.22**	**6.25**	**297**	0.01
Use of digital applications	298	**22.39**	**21**	**3.84**	**5.024**	**297**	**0.01**
Overall Scale	298	**91.39**	**108**	**16.97**	**13.51**	**297**	**0.01**

Table (3) displays the test results comparing the average scores of the sample on the Academic Inclusion Scale during E-Learning with the hypothetical mean. Each dimension, including Behavioral, Emotional, and Cognitive Engagement, as well as the Overall Scale, presented non-significant differences between the sample average and the imposed mean. This indicates that, according to the statistical analysis, there were no substantial variances between the sample's observed scores and the expected mean values for the dimensions of Academic Engagement during E-Learning, suggesting an average level of academic engagement within the sample. The 'Non-Significant' results across all dimensions imply that the sample's scores align closely with the hypothetical mean, reflecting an average degree of behavioral, emotional, and cognitive engagement as well as an overall moderate level of academic engagement in the e-learning context among the study participants.

Table 3: Test results for one sample to indicate the difference between the hypothetical mean and the average scores of the sample on Academic Inclusion Scale during E-Learning

Dimension	Number	Sample average	Hypothetical mean	Standard deviation	Value of t	Degree of freedom	Significance level
Behavioral engagement	**298**	**28.23**	**27**	**6.04**	**1.68**	**297**	**Non-Significant**
Emotional engagement	298	**22.7**	**21**	**6.86**	**2.11**	**297**	**Non-Significant**
Cognitive engagement	298	**23.92**	**24**	**6.93**	**2.03**	**297**	**Non-Significant**
Overall Scale	298	**74.92**	**72**	**19.54**	**2.12**	**297**	**Non-Significant**

To verify the validity of the proposed structural model, the correlation matrix for these variables was calculated, and then that matrix was used to test the proposed model using the path analysis method. Using AMOS program version no. (25) Figure (1) shows the proposed structural model

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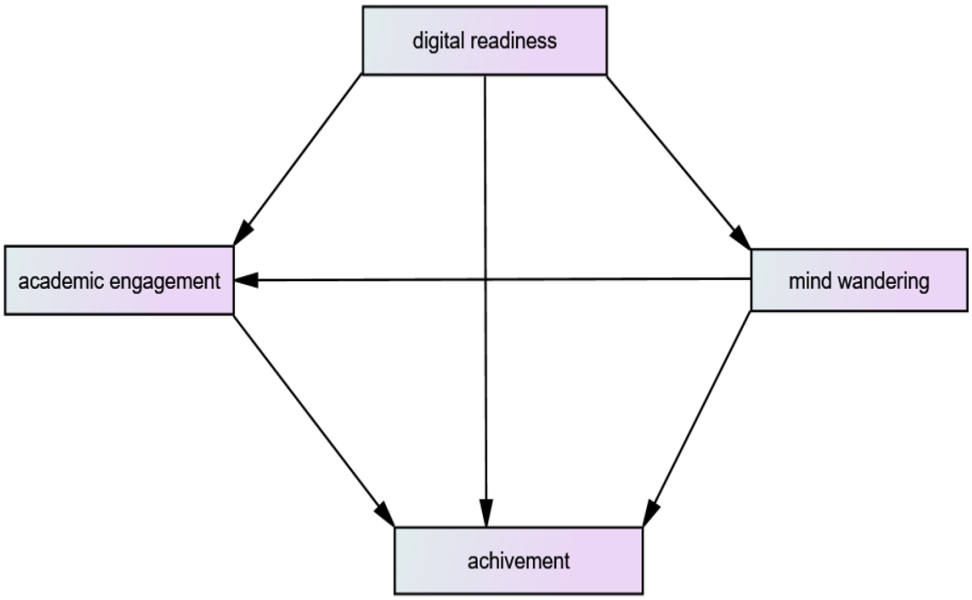

Figure 1: Proposed Structural Model

Table (4) provides essential indicators evaluating the goodness of fit between the empirical data from the study sample and the final proposed model. With a sample size of 298, the chi-squared statistic (Chi2) is 4.13, calculated against 4 degrees of freedom (df). The resulting p-value of 0.31 indicates that the model fits the data reasonably well. The CMIN/df ratio is 1.05, below the threshold of 2, suggesting a good fit. Moreover, the goodness-of-fit indices (GFI, AGFI, CFI) are notably high, with values of 0.994, 0.98, and 0.99, respectively, indicating strong agreement between the model and the actual data. Additionally, the RMSEA value of 0.013, well below the benchmark of 0.09, further reinforces the model's strong fit with the empirical data, providing confidence in the reliability and accuracy of the proposed structural model in explaining the relations among the studied variables in the e-learning context.

Table 4: shows the indicators of good of fit between the data of the study sample and the final model

indicators	n	Chi2	df	P	CMIN/df	GFI	AGFI	CFI	RMSEA
Value	298	4.13	4	0.31	1.05	0.994	0.98	0.99	0.013

DISCUSSION

The present study aimed to model the causal relations between mental wandering, digital readiness, and academic engagement among university students engaged in e-learning contexts. The results provide valuable insights into the complex interplay between these factors and their impacts on students' experiences and outcomes in online learning environments.

Prevalence of Mental Wandering

The statistical analysis uncovered a significantly high level of mental wandering within the sample during e-learning activities, as evidenced by the large disparity between the hypothetical mean and observed average score on the Mind Wandering Scale. This aligns with previous studies demonstrating the pervasiveness of mind wandering across diverse settings, with estimates of task-unrelated thoughts occupying between 25-50% of waking life (Killingsworth & Gilbert, 2010; Song & Wang, 2012). The data corroborate the considerable susceptibility of university students to frequent mind

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wandering episodes when learning online, often stimulated by internal cognitive events or external digital distractions. This high incidence of mental wandering likely exerts detrimental effects on comprehension, retention, and overall academic performance, requiring interventions to improve students' cognitive focus and metacognitive awareness.

Variations in Digital Readiness

The analysis of the Digital Readiness Scale uncovered statistically significant differences between sample means and hypothesized values across all dimensions assessed. Notably, scores were lower for Digital Application Skills and Information Search Skills, implying deficiencies among students in effectively utilizing digital tools and searching for information online(Barboutidis & Stiakakis, 2023). Given the centrality of these skills for participation in e-learning, addressing these gaps through technical training could be beneficial. Conversely, higher readiness in Information Exchange Behaviors and Digital Media Awareness indicates relative strengths that could be leveraged to improve other aspects of readiness(Rawashdeh et al., 2021). Overall, the unevenness in digital readiness highlights the need for a differentiated approach considering the multidimensional nature of digital preparedness and targeting capacity building in areas of weakness(Martínez-Peláez et al., 2023).

Moderate Academic Engagement

For each dimension of the Academic Engagement Scale, the sample means did not substantially deviate from the hypothetical values, suggesting an average degree of behavioral, emotional, and cognitive engagement among students in the e-learning setting(Al-Adwan et al., 2023). While not indicating severe challenges, this moderate level of engagement implies room for improvement to more fully embed students within online learning communities. Fostering greater social connections, enhancing interest and positive sentiments toward learning tasks, and deepening cognitive absorption in course materials could strengthen engagement(Gray & Diloreto, 2016). Mental wandering likely impedes engagement by disrupting cognitive focus and impeding participation, while poor digital readiness skills inhibit accessing and utilizing the necessary platforms and tools, warranting attention to these areas(Jana & Aron, 2022).

Validating the Structural Model

Statistical analysis provided support for the validity of the proposed model of the causal relations between mental wandering, digital readiness, and academic engagement in e-learning contexts. The model demonstrated strong goodness-of-fit with the empirical sample data, as evidenced through the chi-square test's non-significant p-value, CMIN/df ratio below 2, and high GFI, AGFI, and CFI values. The RMSEA of 0.013 further confirms the model's precision in explaining the observed relations. This lends confidence in the hypothesized causal pathways based on cognitive and motivational mechanisms from relevant learning theories. Mental wandering and digital readiness deficits likely directly reduce engagement by compromising cognitive focus, overloading mental resources, disrupting motivational flow states, and inhibiting social connections(Lawrence; A.S. & Manivannan, 2022). The model provides a valuable framework for exploring intervention targets to strengthen engagement and performance in online learning.

Research Implications

This study generates several meaningful implications for research. It empirically highlights the high susceptibility of students to mind wandering and charts variations in digital readiness, laying the groundwork for investigating predictors of these two critical variables. Examining the roles of individual differences, contextual factors, and the interactions between dispositional and environmental influences could enrich understanding of antecedents. Additionally, testing the model across divergent disciplines, course formats, and student demographics might reveal moderating

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effects, providing more nuanced insights into the modeled relations. Longitudinal tracking of the variables over time could also determine how they evolve and intersect through different online learning stages. Further, the strong statistical fit of the model warrants additional validation through studies in other e-learning settings. Overall, the research creates multiple springboards for extended scholarly inquiry to deepen comprehension of the complex dynamics between mental wandering, digital readiness, and engagement in digital learning.

Practical Implications

Alongside research advancements, the findings hold meaningful practical implications. The data highlights the need for interventions to curtail the pervasiveness of mind wandering among students to sustain engagement during online classes. Mindfulness training programs could help strengthen attentional control by promoting metacognitive awareness and reducing susceptibility to distraction (Mrazek et al., 2013). Additionally, designing course activities that emphasize interactive and problem-based learning may counteract mind wandering by continually reengaging cognitive resources (Szpunar, Khan, & Schacter, 2013). Providing digital skills training tailored to identified weaknesses also appears crucial to equip students with the readiness to fully participate in e-learning environments. Particularly focusing training on enhancing digital navigation, usage fluency, information search abilities, and responsible social media habits could optimally prepare students for online learning contexts (Yu, 2018). Such initiatives to minimize mind wandering and build digital capacities may allow students to gain greater benefit from e-learning experiences.

Furthermore, the moderate academic engagement documented highlights the need for multifaceted strategies to increase engagement. Promoting social connections through group work, peer mentoring, and instructor interactions can augment behavioral engagement (Tinto, 1993). Making course content interesting and relevant can potentially stimulate greater emotional investment and cognitive absorption. Allowing personalization of learning and providing ongoing support may also facilitate engagement by meeting individual needs and nurturing motivational resilience. A multidimensional approach targeting engagement on the behavioral, emotional, and cognitive dimensions could empower students to become more embedded within and gain enriching value from e-learning communities.

CONCLUSION

This research proposed and statistically validated a model elucidating the causal mechanisms linking mental wandering, digital readiness, and academic engagement in e-learning settings among university students. The prevalence of mind wandering, unevenness in digital readiness, and moderate engagement uncovered reinforce the significance of investigating their complex interrelations. The model provides a framework for explicating how mental and cognitive dispositions intersect with technological contexts to shape student outcomes. The research stands to inform both theoretical directions and practical initiatives to promote the effectiveness of online learning and empower students to thrive within these rapidly expanding digital spaces. With technology-enabled education representing the future, continuing to build knowledge regarding how to maximize learning within these environments remains an essential endeavor.

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