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Understanding Student Engagement in Digital Higher Education: A Meta-Analysis of Antecedents and Outcomes

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Abstract

Background/purpose. The online learning environment poses unique challenges to maintaining student engagement due to the diminished social presence and heightened demands for self-regulated skills. While research on student engagement in digital higher education has been growing quickly, existing findings are often inconsistent and lack theoretical integration. The current study addresses this gap by synthesizing empirical studies using a meta-analytic framework and extending the contextual model of engagement to online learning situations. The purposes of this study are to identify the antecedents and educational outcomes related to student engagement and to evaluate the strength of these associations in digital higher education.

Materials/methods. Following the PRISMA guidelines, 124 relevant studies were identified in the context of digital higher education. A systematic literature search was conducted across the ERIC, PsycInfo, PsycArticles, PubMed, and ProQuest databases. Effect sizes were extracted and analyzed using the Comprehensive Meta-Analysis software.

Results. We examined the overall mean effect size for the associations between student engagement and personal antecedents ($r = 0.46$), contextual influences ($r = 0.42$), and educational outcomes ($r = 0.43$). Motivation, self-regulated learning, and online learning readiness accounted for personal-level predictors of engagement. Instructor support and collaborative learning environment were the strongest contextual-level predictors. Student engagement in digital settings was also significantly correlated with their academic performance and emotional experiences.

Conclusion. This meta-analysis validates and expands the contextual model of engagement in online higher education settings, showing that both personal and contextual factors jointly explained student engagement.

1. Introduction

Student engagement is a key factor that shapes students' learning experiences and academic achievement (Fredricks et al., 2004). A large body of research has shown that students who are more engaged in the learning process tend to demonstrate greater persistence, more positive attitudes toward learning, and higher satisfaction and performance (Kimbark et al., 2017; Klem & Connell, 2004). However, sustaining student engagement in online education settings is more challenging than in face-to-face classrooms (Dixson, 2010). Online education provides fewer opportunities for immediate communication between teachers and students, and less emotional interaction through facial expressions and body language. As a result, students may feel less involved in the learning process and become more passive, for example by simply watching recorded or live lectures without actively participating in class. In addition, online education requires students to have high levels of self-regulated learning skills to maintain their concentration and sufficient technical skills to navigate the digital platforms. Otherwise, students could be easily distracted by environmental temptations or technical difficulties, and, in turn, become disengaged from learning (Branchu & Flaureau, 2022).

As online and hybrid education have grown rapidly, especially after the COVID-19 pandemic, online learning has become an important part of higher education (Singh & Thurman, 2019). Many universities now incorporate online education into their regular teaching programs due to its flexibility and accessibility. But keeping students engaged in online learning remains a major challenge. In recent years, researchers have studied a wide range of factors related to student engagement, including achievement motivation, self-regulated learning, design of digital platforms, teacher-student interaction, and teaching strategies. However, the results of these studies are not consistent. For the same factor, such as gamification elements, some studies have found strong links, while others have not (e.g., Huang et al., 2023; Orji et al., 2021; Vahlo et al., 2022; Zainuddin et al., 2022). Also, there is still no comprehensive theoretical framework that clearly addresses the main antecedents and outcomes of student engagement in online learning. As a result, it remains unclear which factors are more essential in supporting student engagement in online learning, how they influence engagement, and how they interact.

To address this literature gap, this study is guided by a structured theoretical model: the contextual model of student engagement developed by Lam and colleagues (2012). This model categorizes the factors related to student engagement into three groups: personal antecedents, contextual influences, and educational outcomes. However, this model was developed from traditional classroom-based studies, and it may not adequately capture factors that are more relevant in the context of online education. Therefore, this paper adopts a meta-analytic approach to provide a quantitative synthesis of existing findings and develop an expanded contextual model suited to the online learning context. The research objectives are: (1) to identify the personal and contextual factors that influence student engagement in digital higher education; (2) to compare the strength of correlations between student engagement and potential antecedents; and (3) to summarize the relationship between student engagement and learning outcomes. By conducting a systematic review of past studies and developing a cohesive framework, this research aims to provide a foundation for designing effective strategies and interventions to enhance student engagement in digital higher education.

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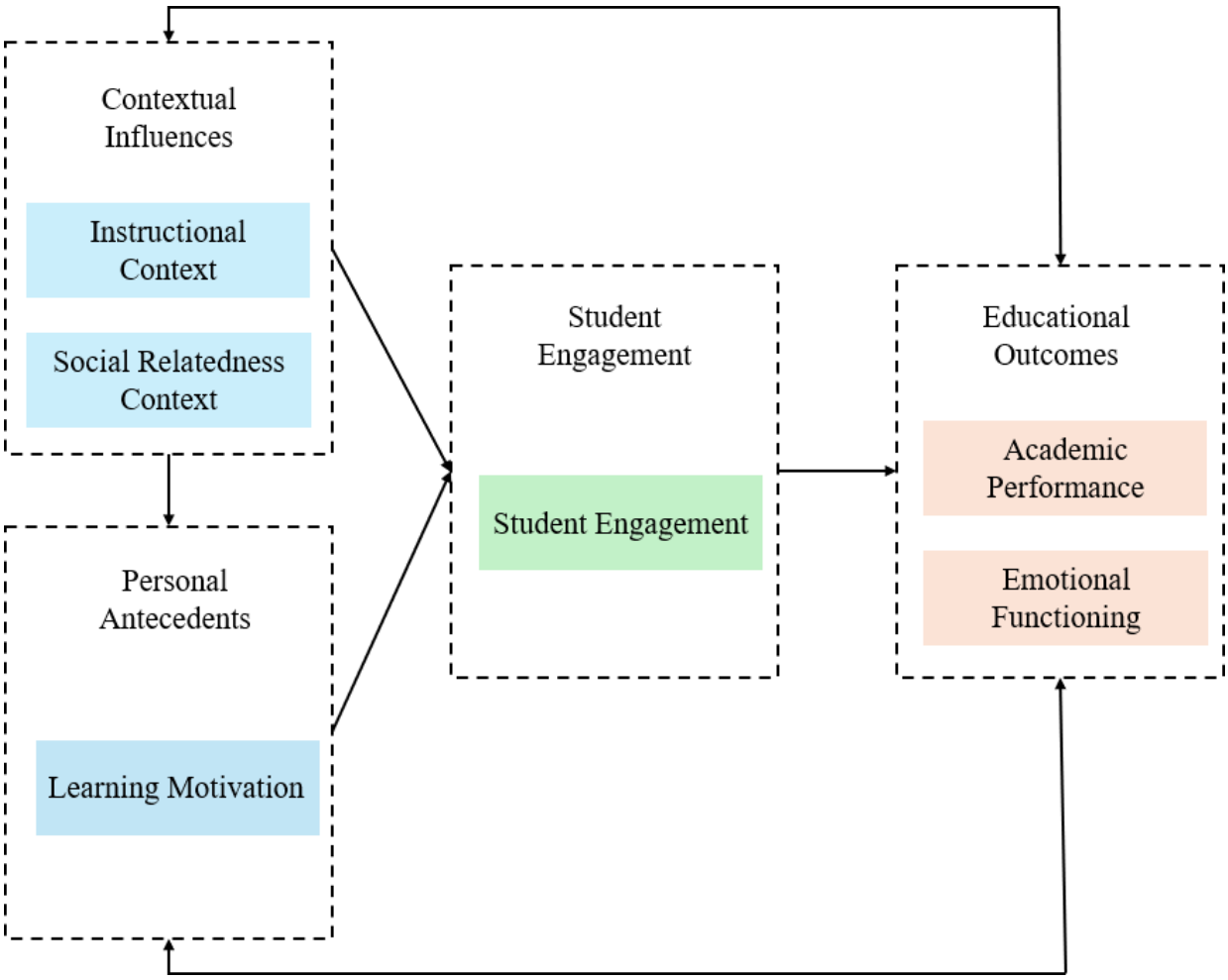

Figure 1. Contextual Model of Student Engagement.

2. Literature Review

2.1. Overview of Contextual Model

Lam et al. (2007, 2012) developed the contextual model to describe the interrelations among student engagement, its antecedents, and its outcomes. The model includes four major components, as shown in Figure 1: (1) personal antecedents (i.e., learning motivation, such as self-efficacy, achievement goals, and mindset); (2) contextual influences (i.e., instructional support and social relatedness); (3) student engagement itself; and (4) educational outcomes (i.e., academic achievement and emotional functioning). Originally constructed for traditional classroom education, this model is also applicable to understanding and interpreting student engagement in online learning environments.

2.2. Personal Antecedents of Student Engagement

The contextual model suggests that learning motivation is one of the most significant personal influences on student engagement. Previous studies have examined the relationship between different types of motivational beliefs and student engagement in online learning, including self-efficacy (Doo et al., 2021; Stan et al., 2022), interest (Garris et al., 2022), perceived usefulness (Bulut & Delialioğlu, 2022), and autonomy (Alenezi, 2023). Research consistently shows that higher levels and more adaptive forms of learning motivation can contribute to greater efforts in learning and better academic performance (Fabian et al., 2022; Huang & Wang, 2023). Researchers have also highlighted that student motivation plays a more significant role in online settings (Doo et al., 2023). Students require a strong internal driving force to sustain their active engagement and long-term

persistence in online learning, as there are fewer opportunities for social interaction and less external monitoring in this context.

More recent research has highlighted the critical role of self-regulated learning strategies in online learning (Vil-larroel & González, 2022; Xie et al., 2019). Students with self-regulated skills, such as goal-setting, time management, and self-monitoring, could better adapt to more flexible and less structured online learning contexts. Previous research has indicated that self-regulated learners are able to log in to digital platforms regularly, complete learning tasks and assignments on time, actively participate in online discussions, and frequently reflect on their learning process (Sun et al., 2023). These strategies not only enhance student engagement but also ultimately lead to improved academic performance. Furthermore, online learning readiness, which reflects students' attitude toward and confidence in using digital tools, has received increasing attention and is considered a key factor in online learning engagement. For instance, Liu et al. (2022) found that students with a more positive attitude and greater confidence in navigating digital platforms reported significantly higher engagement with course content.

2.3. Contextual Influences of Student Engagement

The contextual influence component in the model includes two key factors: instructional context and social relatedness context. Both factors remain highly relevant in online learning scenarios. In the context of online education, research examined how specific instructional approaches can enhance student engagement. These instructional strategies include gamification, differentiated instruction, and cognitive activation learning approaches. However, research findings have shown substantial inconsistency across studies. For example, among studies examining the effect of gamification components on student engagement in online learning, effect sizes ranged from negligible to large (Orji et al., 2021; Vahlo et al., 2022; Zainuddin et al., 2022). Findings of the impact of differentiated instructional approaches have been more inconsistent. While Krouska et al. (2022) reported a moderate positive effect size, Alamri (2019) and Huang et al. (2023) documented small or negative effect sizes. Given the discrepancies among existing findings, there is a need for a systematic synthesis to clarify how different instructional strategies contribute to student engagement in online education. Since online learning is typically less interactive than traditional classroom learning, several researchers have found that social relatedness is a significant factor in engaging students in online learning systems (Garrison & Arbaugh, 2007). Research has shown that interacting with others in class and receiving feedback in class help cultivate engaged students in a more interactive and supportive learning atmosphere (Dahleez et al., 2021; Gherghel et al., 2023; Sun et al., 2022).

2.4. Educational Outcomes of Student Engagement

According to the contextual model, student engagement is a key predictor of multiple educational outcomes, including academic achievement and emotional experiences. In a previous meta-analysis, Lei et al. (2018) reviewed 69 studies on students' learning engagement and revealed a robust positive association between student engagement and academic performance. Other empirical studies that were conducted in online settings also supported this positive relationship (Han et al., 2022; Qureshi et al., 2023; Zeng et al., 2023). Aside from academic achievement, students' level of engagement shapes their positive and negative emotional experiences during online learning. High levels of engagement lead to satisfaction and enjoyment with the learning content (Baloran et al., 2024; Osman, 2022; Yilmaz & Gizem, 2022). Disengagement can lead to feelings of boredom, frustration, and anxiety (Beauchamp & Monk, 2022; Tang & Chaw, 2019).

3. Methodology

3.1. Research Design

The current study employed a meta-analytic approach to review quantitative empirical studies on students' engagement in digital higher education and to synthesize their association with other learning-related factors. Due to the nature of a meta-analysis, the study was able to pool and compare research findings to estimate the direction and strength of the average relationship between the target variables. This meta-analysis followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; Page et al., 2021) guidelines to ensure transparency and replicability. The analyses consisted of a systematic literature search, screening for eligible studies, extraction of effect sizes, and performing statistical analyses.

3.2. Literature Search Procedures

The literature search was conducted using the following keywords: "student engagement OR learning engagement OR academic engagement" AND "online learning OR e-learning OR distance learning" AND "college OR university OR higher education." Due to the COVID-19 pandemic and the following urgent shift to online education, numerous studies on student engagement in online education have emerged. To capture and understand this recent surge, we conducted a literature search for articles published after 2019. We conducted the literature search in the following databases: Education Resources Information Center (ERIC; acquired a total of 1333 studies), PubMed (481 studies), PsycInfo (445 studies), PsycArticles (12 studies), and ProQuest Dissertations & Theses Global (420 dissertation studies). This preliminary search retrieved a total of 2,691 studies on student engagement in online learning.

3.3. Inclusive and Exclusive Criteria

We applied the following inclusion and exclusion criteria to filter through the studies. We excluded studies based on the following criteria: (1) duplicates, (2) lack of empirical and quantitative evidence, such as systematic reviews, meta-analyses, and qualitative studies, (3) lack of samples of students studying in any higher education institution (e.g., studies where samples were at the Pre K-12 level or examined teachers' perceptions), (4) no available access to full text after contacting the authors, (5) no measures related to student engagement in online learning, (6) no report on relationship between students' engagement and other factors, and (7) lack of sufficient statistical information required to calculate zero-order correlations. Following the application of the exclusion criteria, the final sample of this present meta-analysis comprised 124 studies. The literature selection and screening process is shown in Figure 2.

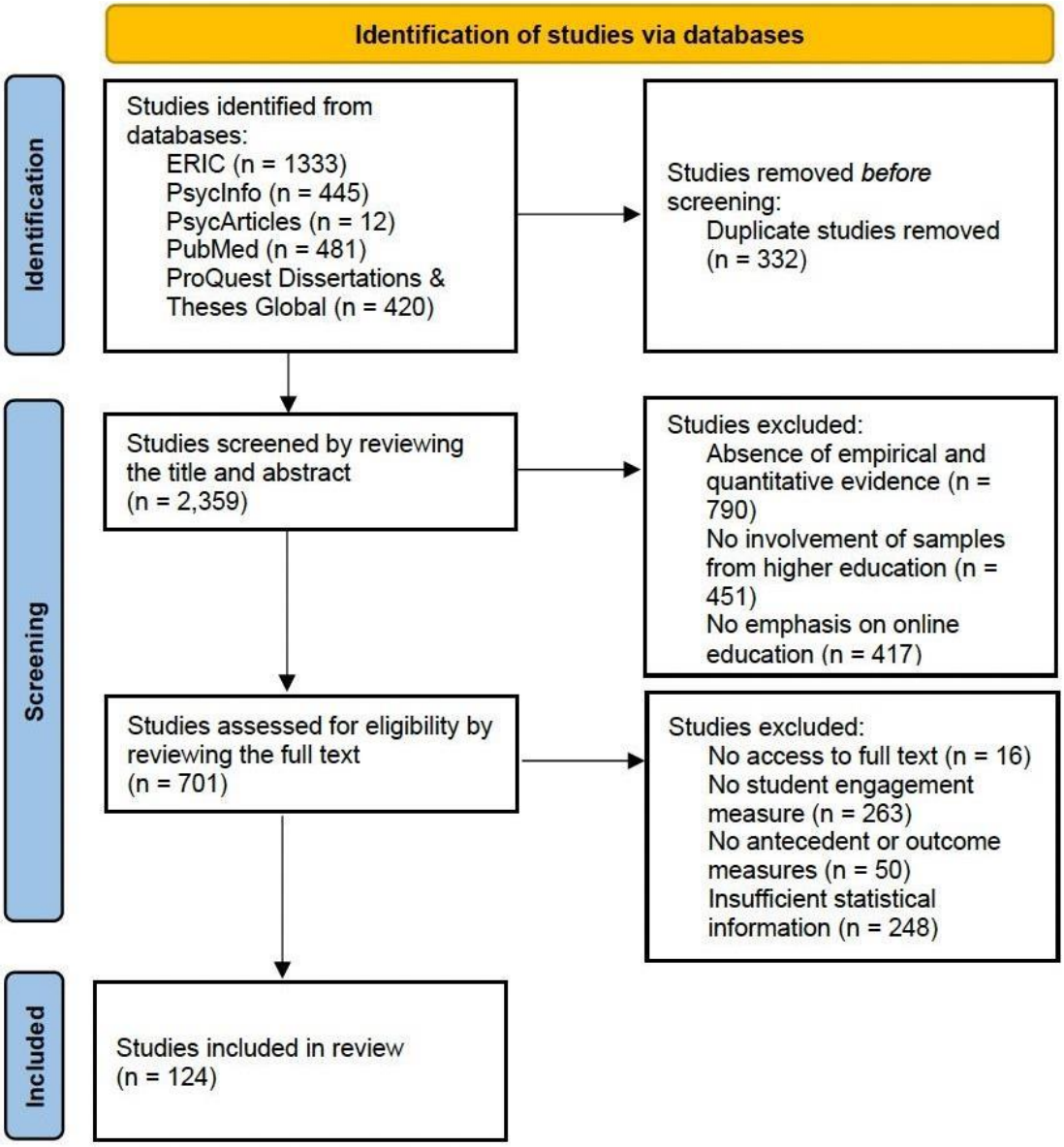

Figure 2. Literature Screening and Selection Process Following the PRISMA Procedure.

3.4. Effect Size Extraction

This meta-analysis investigated the extent to which student engagement in online learning relates to its potential antecedents and its learning outcomes. For each included study, we extracted the main effect size of the studied relations by Pearson's correlation coefficient (*r*). If Pearson's *r* was not directly provided in the article, we then calculated the effect size using other available statistical information. For example, for studies that focused on the comparison between the intervention groups and control groups, we calculated the effect size (Cohen's *d*) based on the information on means values, standard deviations, or sample sizes of experimental and control groups and converted Cohen's *d* into Pearson's *r* using standard formulas (Borenstein et al., 2009). Overall, we extracted 807 effect sizes from 131 independent samples in 124 studies. The studies included in this meta-analysis had sample sizes ranging from 27 to 14,935, with a total of 64,361 participants.

3.5. Effect Sizes Aggregation

Among the 124 studies included in this review, 112 of them provided more than one effect size from the same sample. For instance, some studies included correlations between different dimensions of student engagement and the same outcome variable. Other studies examined the

relationship between engagement and one or more antecedent variables, such as students' motivation and self-regulated learning (e.g., Bulut & Delialioğlu, 2022; Sun et al., 2009). To ensure that the statistical analysis did not violate the independence assumption, we adopted the shifting-unit-of-analysis approach (Scammacca et al., 2014), which can ensure that even though each independent sample only contributed one effect size for the analysis, this study kept the largest amount of the effect size information reported by each study.

After carefully examining the conceptual and operational definitions of all the identified antecedent and outcome variables we grouped the selected variables and associated effect sizes to one of the following three main categories and certain specific subcategories: (1) personal antecedents comprised of variables representing individual student characteristics, subcategories including learning motivation, self-regulated learning, online learning readiness, and deep learning approaches; (2) contextual influences comprised of variables represented instructor interaction and support, collaborative learning environment, instructional design, and online platform accessibility; and (3) educational outcomes of student engagement represented with subcategories of academic performance and academic emotion (positive and negative emotions). This framework enabled an in-depth examination of the interconnections among the subcategories of student engagement. Table 1 describes the level-one main categories and the level-two subcategories of all variables.

Table 1. Process of Effect Size Categorization

Level one main categories	Level two subcategories	Description of level two subcategories	Exemplars of included variables
Personal antecedents (i.e., personal characteristics and behaviors influencing student engagement in online learning)	Self-regulated learning	Student behavior and the ability to manage their learning process.	• Self-regulation • Self-directed study
	Learning motivation	The factors that drive and direct student learning.	• Student motivation • Intrinsic motivation • Motivation for learning
	Online learning readiness	Students' flexibility, openness, and attitude toward engaging with online learning platforms.	• Attitude toward technology • Digital literacy • Computer self-efficacy
	Deep learning approaches	The approaches that students employ to process and understand learning material deeply.	• Deep learning approach • Approaches to learning • Cognitive presence
Contextual influences (i.e., environmental factors within the online learning setting)	Instructor interaction and support	The degree to which instructors actively facilitate online learning.	• Teacher support • Instructor interaction and support
	Collaborative learning environment	The role of peer interactions and the overall atmosphere of the online class.	• Interaction with peers • Peer support • Classroom interaction
	Instructional design	The structure, organization, and relevance of the online course content.	• Playful class design • Formative gamification quiz

Level one main categories	Level two subcategories	Description of level two subcategories	Exemplars of included variables
	Online platform accessibility	The ease of use and accessibility of platforms.	• System usability • Task-technology fit
Educational outcomes (i.e., results or consequences of online student engagement)	Academic performance	The measurable academic achievements of students	• Perceived learning outcomes • Grade • GPA
	Positive academic emotion	A range of favorable emotional experiences in the online learning process.	• Positive academic emotion • Course Satisfaction • Perceived Enjoyment
	Negative academic emotion	A range of unfavorable emotional experiences in the online learning process.	• Perception of stress • Academic stress • Learning anxiety

Guided by the variable categories, we conducted a two-level meta-analysis to synthesize the data. First, each effect size was categorized according to the framework proposed in Table 1, and each effect size was coded under both a level-one main category and a level-two subcategory. A total of 58 effect sizes from nine studies that did not fit into the defined categories were excluded from analysis. The classification and aggregation of effect sizes across the level-one categories and level-two subcategories were necessary from a statistical perspective. Aggregating multiple effect sizes into an overall effect size simplifies the data and minimizes violations of the independence assumption. Conducting a two-level meta-analysis also enables the maintenance of as much information as possible from each study, ensuring a comprehensive synthesis of the data.

3.6. Data Analysis

The extracted effect sizes were analyzed using Comprehensive Meta Analysis software (version 4.0; Borenstein et al., 2009). Since the sampling distribution of Pearson's correlation coefficients (*r*) is not normally distributed, the correlation coefficients were respectively transformed to Fisher's *z*-scores (Lipsey & Wilson, 2001). To obtain an overall estimate of the mean correlation coefficient and its related 95% confidence interval with varying precision, the effect sizes were weighted by precision (i.e., the inverse of the variance; Geman & Shapiro, 1999). Additionally, we adopted the random-effects model for the meta-analysis, as previous literature has indicated that the relationships between student engagement and other factors may be moderated by various factors (e.g., Gherghel et al., 2023; Park & Kim, 2020). After performing the analyses with Fisher's z-scores, we back-converted the standardized scores into Pearson's correlation coefficients (r) for reporting and interpreting the final results.

4. Results

As outlined in the previous section, we calculated mean effect sizes for two levels of variables. For the level one analysis, we synthesized three overall mean effect sizes reflecting the relationship between student engagement and three aggregated main categories: (1) personal antecedents, (2) contextual influences, and (3) educational outcomes. The level two analysis examined the relationship between student engagement and 11 subcategories. Table 2 lists the three mean effect sizes for the level-one analysis and 11 mean effect sizes for the level-two analysis. We adhered to the widely accepted guidelines from Cohen (1988) to evaluate the strength of the correlation coefficients:

a correlation coefficient of r = 0.10 to 0.29 is considered a small effect size, r = 0.30 to 0.49 is considered a medium effect size, and r = 0.50 and above is considered a large effect size.

4.1. Personal Antecedents

The level one meta-analysis revealed a moderate correlation between student engagement and aggregated personal antecedents. The overall mean effect size is $r = 0.463$ (95% confidence interval (CI): [0.415, 0.509]). This result was statistically significant, as indicated by the Z-test ($Z = 16.352$, $p < 0.001$). The analysis revealed substantial heterogeneity among the studies ($Q = 2365.364$, $df = 67$, $p < 0.001$). The I^2 statistic of 97% suggested that 97% of the variability in effect sizes was attributable to fundamental differences across studies rather than sampling error. Additionally, the Tau-squared (τ^2) value of 0.060 further supported the notable between-study variance.

Regarding the level two analysis, self-regulated learning, based on 21 independent samples, demonstrated a moderate correlation with student engagement ($r = 0.445$, 95% CI [0.345, 0.535]), accompanied by significant heterogeneity ($Q = 727.452$, $p < 0.001$; $I^2 = 97.25\%$; $\tau^2 = 0.073$). Learning motivation, across 41 independent samples, had a slightly stronger correlation ($r = 0.473$, 95% CI [0.410, 0.532]) and substantial heterogeneity ($Q = 1655.367$, $p < 0.001$; $I^2 = 97.58\%$; $\tau^2 = 0.062$). Results showed a moderate effect size (r = 0.431, 95% CI [0.370, 0.489]) and a lower degree of heterogeneity ($Q = 262.501$, $p < 0.001$; $I^2 = 92.00\%$; $\tau^2 = 0.027$). The deep learning strategies (with 12 independent samples) had a strong positive correlation with engagement, $r = 0.572$ (95% CI [0.435, 0.683]) and substantial heterogeneity ($Q = 643.322$, $p < 0.001$; $I^2 = 98.29\%$; $\tau^2 = 0.102$).

4.2. Contextual Influences

The overall mean effect size between aggregated contextual factors and student engagement was $r = 0.400$ (95% CI [0.350, 0.448]). The Z-test also confirmed the statistical significance of this correlation ($Z = 14.162$, $p < 0.001$). Similar to the personal antecedents, there was considerable heterogeneity among the studies: $Q = 2204.207$, $df = 79$, $p < 0.001$; I^2 statistic = 96%; and Tau-squared (τ^2) = 0.065. Forest plot identified one study (Cook, 2002) as an outlier, with a significantly different effect size of -0.975. Sensitivity analysis found that after removing the study from the meta-analysis, the mean effect size increased from 0.400 to 0.424. In addition, there was a notable reduction in heterogeneity: the Q-statistic decreased from 2204.207 to 1834.899. The outlier study was also found to be unpublished work with a small sample size ($n = 54$) and lacked proper manipulative checks in its interventions. Given the methodological limitations and its contribution to inflated heterogeneity, we decided to exclude this study from future analyses to ensure the robustness and reliability of the results.

Level two analysis found that instructor interaction and support were significantly correlated with student engagement ($r = 0.480$, 95% CI [0.419, 0.537]), with significant heterogeneity ($Q = 1079.581$, $p < 0.001$; $I^2 = 96.57\%$; $\tau^2 = 0.053$). Similarly, the collaborative learning environment (39 independent samples) showed a positive correlation ($r = 0.452$, 95% CI [0.384, 0.515]) and substantial variability ($Q = 925.063$, $p < 0.001$; $I^2 = 95.89\%$; $\tau^2 = 0.063$). Instructional design (22 samples), however, had a lower correlation with student engagement, with an effect size of $r = 0.371$ (95% CI [0.243, 0.485]), alongside significant heterogeneity ($Q = 531.014$, $p < 0.001$; $I^2 = 96.05\%$; $\tau^2 = 0.103$). The range of effect sizes for this factor was from -0.339 to 0.752. Finally, online platform accessibility (14 samples) demonstrated a moderate correlation (r = 0.414, 95% CI [0.299, 0.218]), with substantial heterogeneity ($Q = 379.466$, $p < 0.001$; $I^2 = 96.57\%$; $\tau^2 = 0.060$).

4.3. Educational Outcomes

The overall mean effect size of the relationship between student engagement and educational outcomes is $r = 0.425$ (95% CI [0.377, 0.471]) and is statistically significant ($Z = 15.524$, $p < 0.001$). The

heterogeneity test (Q = 2145.792, df = 71, p < 0.001; I-squared = 97%; τ^2 = 0.056) revealed significant variation among the effect sizes. Within this category, academic performance (41 samples) exhibited a moderate correlation with student engagement (r = 0.401, 95% CI [0.337, 0.460]), along with substantial heterogeneity (Q = 1105.691, p < 0.001; I^2 = 96.38%; τ^2 = 0.051). Positive academic emotions, based on 34 samples, showed a stronger correlation with student engagement (r = 0.499, 95% CI [0.426, 0.566]), with notable heterogeneity (Q = 1006.134, p < 0.001; I^2 = 96.72%; τ^2 = 0.072). Conversely, negative academic emotions (12 samples) were negatively correlated with student engagement (r = -0.214, 95% CI [-0.284, -0.143]), with moderate heterogeneity (Q = 58.832, p < 0.001; I^2 = 81.30%; τ^2 = 0.012).

Table 2. Mean Effect Sizes at Both Levels of Analysis

		k	*r*	95% CI LL	95% CI UL	*Q*	τ^2	I^2
Level-1	Personal antecedents	68	0.463	0.415	0.509	2365.364***	0.060	97.167
Level-2	SRL	21	0.445	0.345	0.535	727.452***	0.073	97.251
	LM	41	0.473	0.410	0.532	1655.367***	0.062	97.584
	OLR	22	0.431	0.370	0.489	262.501***	0.027	92.000
	DL	12	0.572	0.435	0.683	643.322***	0.102	98.290
Level-1	Contextual influences	79	0.424	0.379	0.468	1834.899***	0.054	95.749
Level-2	IS	38	0.480	0.419	0.537	1079.581***	0.053	96.573
	CLE	39	0.452	0.384	0.515	925.063***	0.063	95.892
	ID	22	0.371	0.243	0.485	531.014***	0.103	96.045
	OPA	14	0.414	0.299	0.218	379.466***	0.060	96.574
Level-1	Educational outcomes	72	0.425	0.377	0.471	2145.792***	0.056	96.691
Level-2	AP	41	0.401	0.337	0.460	1105.691***	0.051	96.382
	PE	34	0.499	0.426	0.566	1006.134***	0.072	96.720
	NE	12	-0.214	-0.284	-0.143	58.832***	0.012	81.303

Note. SRL: Self-regulated learning; LM: Learning motivation; OLR: Online learning readiness; DL: Deep learning approaches; IS: Instruction interaction and support; CLE: Collaborative learning environment; ID: Instructional design; OPA: Online platform accessibility; AP: Academic performance; PE: Positive academic emotion; NE: Negative academic emotion.

4.4. Publication Bias

We analyzed publication bias through three approaches: (1) funnel plots, (2) Egger's test, and (3) fail-safe N analysis for the three level-one analyses. All three funnel plots for the level-one categories are symmetrically distributed around the mean effect size, suggesting no publication bias. Moreover, publication bias is not evident in Egger's test or fail-safe N analysis, as shown in Table 3. The fail-safe N analysis indicated that 36,587 and 52,980 null-effect studies would be required to reduce the p-values of the three mean effect sizes to non-significant levels. Overall, these tests provide strong evidence that publication bias is unlikely to have influenced the results of this meta-analysis.

Table 3. Publication Bias Tests

	Egger's test				Fail-safe N
	B	*SE*	95% CI	*p*	*N*
Personal learning factor	0.45	0.05	[0.35, 0.55]	0.33	48865
Contextual learning factor	0.61	0.06	[0.50, 0.72]	0.05	52980
Educational outcomes	0.41	0.04	[0.32, 0.49]	0.34	36587

5. Discussion

The current meta-analysis synthesized research findings from 124 studies to examine the associations between student engagement and multiple learning factors and outcomes in online learning contexts within higher education. The results are consistent with the contextual model proposed by Lam et al. (2012). This meta-analysis extends the contextual framework to the online learning context by identifying additional factors critical to the online learning environment, as indicated in Figure 3.

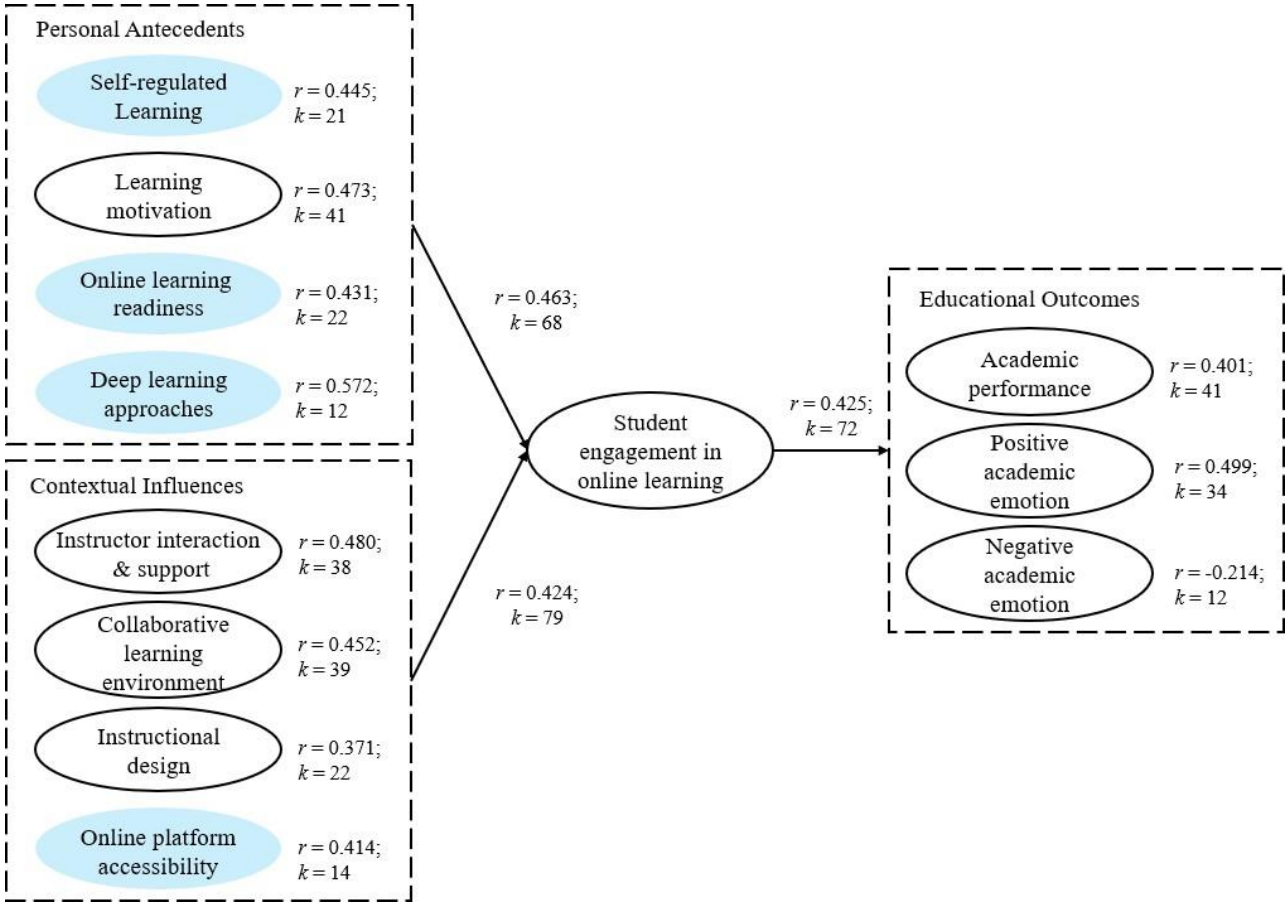

Figure 3. Summary Model of Meta-Analysis Results.

Notes. The blue-highlighted factors represent additional predictors not originally included in the contextual model of student engagement but identified through this meta-analysis.

5.1. Effect of Personal Antecedents on Student Engagement

Results in the current analysis supported the original contextual model of student engagement (Lam et al., 2012) in which motivational beliefs play a key role in sustaining student engagement.

Motivation was also the most frequently studied factor, with 41 studies reporting effect sizes. This finding suggests that motivation remains the foundation of engagement in both face-to-face and online learning contexts. Students who consider themselves competent and perceive value in the learning tasks are more inclined to expend effort and persevere through difficulties. The findings are consistent with previous research on self-efficacy and intrinsic motivation (Bandura, 1997; Deci & Ryan, 2000; Lu et al., 2022) and confirm that motivation remains a core psychological factor that promotes student engagement, even as learning occurs in digital environments.

Apart from motivation, self-regulated learning and online readiness were found to have modest, positively significant relationships with students' engagement. The significance of both factors is more pronounced in online-based learning. Although online learning offers greater flexibility in time and place than traditional offline learning, it is generally less structured and supervised (Song & Hill, 2002). Moreover, flexibility in online learning can sometimes provide students with more opportunities to encounter distractions, which, in turn, require self-regulation skills to stay focused (Garrison & Vaughan, 2008). The findings in the current study align with the literature, which identifies that students who adeptly plan, monitor, and reflect on their learning process tend to be more intrinsically engaged in both online and offline contexts (Sun et al., 2023; Xie et al., 2019).

Similarly, online learning readiness was identified as a critical contributor to students' active and effective engagement in online learning (Aguilera-Hermida et al., 2021; Baloran et al., 2021). The roles of both factors, self-regulated learning skills and online learning readiness, may together form a new type of "digital self-control" that plays a key role in shaping students' online experiences. Biedermann et al. (2024) examined how college students' ability to regulate their own behavior and attention in online settings influences their learning experiences. Results suggest that students who can resist temptation, remain focused on their learning tasks, and use different types of digital self-control software or apps tend to be more engaged and satisfied with their learning. The finding is consistent with the results in the current meta-analysis.

Deep learning approaches showed the largest summary effect size among all individual antecedents. The result is consistent with the existing literature, which suggests that students who consistently apply critical thinking, elaboration, and organizational learning strategies demonstrate higher engagement (Beauchamp & Monk, 2022; Chen et al., 2023). This strong correlation highlights the importance of encouraging students to use deep learning strategies. However, there is a substantial conceptual overlap between deep learning strategies and the cognition aspect of student engagement. For example, in Zhang et al. (2022), deep learning strategies were conceptualized as a three-dimensional construct encompassing higher-level learning strategies and reflective learning. The definition is nearly identical to the cognitive engagement dimension in a widely used instrument that measures student engagement in online learning (Dixson, 2015). The substantial conceptual overlap between deep learning strategies and cognitive engagement suggests that it is likely that this effect size may have been inflated.

5.2. Effect of Contextual Influences on Student Engagement

The four major contextual influence factors highlighted in the present meta-analysis are overall consistent with the contextual model: (1) instructor interaction and the collaborative learning environment aligned with the social relatedness factor, and (2) instructional design aligned with the instructional context factor, plus one additional online learning context-specific factor: online platform accessibility. A comparison of the effect sizes revealed that social connectedness had the strongest correlation with student engagement. Findings are consistent with the Community of Inquiry framework and self-determination theory (Deci & Ryan, 2000; Garrison & Arbaugh, 2007), which emphasize the crucial role of social relatedness in maintaining student engagement. The effect size indicated the importance of providing a supportive and collaborative learning environment. The

importance of social connectedness is especially salient in online education, where physical separation can lead to feelings of isolation and disengagement (Dahleez et al., 2021).

Instructional design demonstrated the lowest correlation with engagement, with notable variability across studies. The variation in how effective different instructional designs are can be attributed to teachers' varying degrees of readiness to teach online. Some instructors might have had more experience with the online platform. Thus, they are better positioned to apply innovative approaches to teaching. Such approaches can include gamification and interactive question-and-answer sessions (Baran et al., 2011). On the other hand, some instructors might have a harder time adapting to teaching students on the online platform. Thus, applying teaching strategies and approaches suitable for an online platform may also require teachers to be ready for online teaching. The mixed results suggest that innovative teaching designs may not guarantee engagement. Future studies should investigate when and how teaching strategies can more effectively contribute to engagement.

5.3. Effect of Student Engagement on Educational Outcomes

The significant correlation between student engagement and educational outcomes further supports the effect of engagement on school-related outcomes as suggested in the contextual model, not only in face-to-face classroom settings but also in online education. A previous meta-analysis synthesized the relationship between student engagement and academic performance with a summary effect size of 0.33 (Wong et al., 2024), which is slightly lower than the summary effect size in the current meta-analysis (r = 0.401). The positive and moderate correlation is consistent with the previous meta-analysis, indicating the important role of fostering student engagement in supporting their academic success. In addition, results show a stronger correlation between student engagement and satisfaction and enjoyment in online learning than with negative emotions, such as boredom and anxiety. One possible interpretation is that while positive emotion can be reinforced in highly engaging learning experiences, the feeling of immersive, active engagement can directly lead to positive feelings. However, low engagement in online settings may not be the only reason behind students' negative emotions. Other factors specific to the online learning contexts, such as technical challenges, may also contribute to the prevalence of negative emotions.

5.4. Limitations and Future Research

There were still several limitations in the current study. First, since the present study mainly focused on analyzing the association between student engagement and a series of learning-related factors under the guidance of the contextual model, we did not investigate the potential moderating effects of demographic variables. Future studies should investigate the moderating effects of demographic and other contextual variables, such as cultural background, age, and prior experience with online learning. Second, as studies included in this meta-analysis measured student engagement using different scales, it is difficult for the current meta-analysis to explore and compare how these three aspects of student engagement relate to the learning factors and outcomes. The multidimensional structure of students' engagement level can and should be considered in future studies. The heterogeneity that is evident in this study suggests that a more homogeneous scale for measuring students' engagement level and learning factors is needed

6. Conclusion

This meta-analysis synthesized the results of 124 studies to provide robust evidence on how the personal and contextual factors influence student engagement in digital higher education. Results validated the contextual model of engagement in online education settings. They identified additional factors that are especially important in the online learning process: self-regulated learning and online learning readiness. Among the contextual antecedents, the social presence-related factors, such as

perceived support from instructors and opportunities for collaborative learning, are strong predictors of student engagement. However, research that examined the effectiveness of different instructional strategies has reported mixed results.

7. Suggestion

Given the findings in the current study, the following practical implications for digital higher education are discussed. First, online learning contexts have higher requirements for students' self-regulated skills than face-to-face classroom settings, where teachers can directly monitor students' participation and learning progress. Therefore, institutions need to consider introducing explicit training in self-regulated skills to help students learn time management, goal-setting, and self-reflection during online learning. Second, the results show that online readiness significantly impacts student engagement in digital settings. Institutions should establish a technical support system, such as platform tutorial sessions and responsive help services, to ensure students receive sufficient support when facing technical issues and to minimize barriers to engagement. Third, social presence plays a key role in students' online learning experiences. Instructional practices that focus on increasing social connectedness in digital settings, such as providing timely and encouraging feedback, creating collaborative learning groups, and developing interactive tasks, would be beneficial for sustaining student engagement.

Declarations

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