

Assessing the Impact of Technology Integration Strategies on Information Literacy Development through Information-Seeking Behavior

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ABSTRACT

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KEYWORDS:

Technology integration strategies

Information literacy development

Information-seeking behavior

Medical students

Social cognitive theory

CITATION:

Wang, H., & Norhayati, H. (2026). Assessing the Impact of Technology Integration Strategies on Information Literacy Development through Information-Seeking Behavior. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, 11(2), e003707.

<https://doi.org/10.47405/mjssh.v11i2.3707>

Information literacy is a critical competency for medical students to evaluate clinical evidence and support professional development in technology-integrated educational settings. Grounded in social cognitive theory, this study developed a model examining how technology integration teaching strategies (environmental factor) influence medical students' information literacy (personal factor) through information-seeking behavior (behavioral factor). A cross-sectional survey was administered to 280 undergraduates from a medical university in western China, all of whom had completed clinical internships and evidence-based medicine training. The proposed model was tested using partial least squares structural equation modeling. Technology integration teaching strategies significantly predicted information-seeking behavior ($\beta = 0.438$, $p < 0.001$) and directly predicted information literacy ($\beta = 0.212$, $p = 0.001$). Information-seeking behavior significantly enhanced information literacy ($\beta = 0.387$, $p < 0.001$) and fully mediated the relationship between technology integration teaching strategies and information literacy (indirect effect: $\beta = 0.169$, $p < 0.001$). These findings support the applicability of social cognitive theory in medical education and clarify the behavioral mechanisms through which technology integration contributes to students' information literacy development. The study provides empirical evidence and practical implications for optimizing curriculum design.

Contribution/Originality: This study contributes to the existing literature by examining the mediating mechanism of information-seeking behavior between technology integration strategies and information literacy development within medical education. This study provides empirical evidence from resource-constrained settings in western China, advancing understanding of social cognitive theory's application in medical education contexts.

1. Introduction

The growing integration of technology in healthcare has fundamentally transformed the educational landscape, creating unprecedented demands for enhanced information literacy among medical students in the era of digital healthcare (Reddi & Javidi, 2025). Consequently, in response to the evolving demands of digital healthcare on medical students, medical educators have increasingly adopted systematic pedagogical strategies that strategically develop students' information literacy competencies to prepare them for the complexities of contemporary digital medical practice. The post-pandemic era has intensified demand for technology-enhanced medical education, prompting resource-limited medical institutions to adopt innovative teaching methodologies that develop students' information literacy through systematic technology integration (Ferdig et al., 2020; Kulaksız et al., 2023). Given the growing need for medical students to develop information literacy and digital skills, technology integration strategies (TIS) is a systematic pedagogical approach that incorporates digital tools and platforms into medical education curricula to enhance learning outcomes and professional competencies. Technology-integrated strategies refer to purposeful pedagogical approaches that systematically combine digital technologies with content knowledge and instructional methods to enhance learning outcomes. Technology adds value to the curriculum by supporting differentiated learning, promoting higher-order thinking, and facilitating authentic learning experiences that bridge school learning with students' everyday lives (Li et al., 2024). TIS is primarily grounded in the TPACK (Technological Pedagogical Content Knowledge) framework, which emphasizes the interactive integration of three domains: technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK), forming the foundation for effective technology integration (Ning et al., 2024).

In clinical learning contexts, information-seeking behavior (ISB) refers to medical students' strategic use of digital technologies and online databases to acquire clinical evidence and enhance their academic and professional competencies (Wilson, 1999). Information literacy (IL) represents medical students' ability to systematically navigate the information landscape in clinical contexts. This includes identifying information needs, accessing relevant digital resources, critically evaluating evidence, and synthesizing findings for clinical practice, it represents a multifaceted competency involving digital navigation, critical evaluation, and information synthesis skills crucial for evidence-based medical practice (ACRL, 2016; ALA, 2000; Bruce, 2002). Technology-integrated teaching strategies in medical education enhance students' motivation and ability to develop systematic information-seeking behaviors and strengthen their overall information literacy skills (Onoue et al., 2024). TIS employs structured technology-enhanced learning environments to develop students' digital literacy and information management competencies. Through systematic exploration of digital databases and evidence-based information practices, students acquire professional-level digital thinking skills (Aydınlar et al., 2024). Information-seeking behavior (ISB) patterns serve as critical mediators between pedagogical strategies and information literacy outcomes in medical education (Barr, 2023). Technology-enhanced teaching methods motivate medical students to engage systematically with digital information resources, consequently enhancing their information literacy. Such engagement develops students' competencies in resource evaluation, evidence synthesis, and technology application for clinical decision-making. Information literacy advancement relies on structured interaction with digital systems and systematic exposure to evaluation methodologies (Zhao, 2024). Technology-enhanced medical education facilitates students' information

literacy development through structured digital engagement (Choi-Lundberg, 2023). Students demonstrate enhanced competencies in information navigation, resource evaluation, and evidence synthesis when exposed to systematic technology-based instruction (Sailer et al., 2024). The integration of teaching strategies, information-seeking behaviors, and literacy outcomes creates a dynamic framework linking pedagogical approaches to student competencies in medical education. Such understanding enables educators to design effective curricula and optimize student preparation strategies (Liu et al., 2023). Research in resource-limited contexts can improve digital education quality while addressing technology-related training challenges. Although the relationships between technology integration, information-seeking behavior, and information literacy are increasingly recognized, significant empirical gaps persist in medical education research (Le et al., 2022). Current literature exhibits several critical limitations. First, mediating mechanisms remain insufficiently explored. Although research has established links between technology-enhanced teaching and information literacy development, the underlying pathways, particularly the mediating role of information-seeking behavior, require further empirical investigation. Second, contextual factors remain inadequately examined (Blau et al., 2020). Third, integrated theoretical models are scarce, with few studies examining the comprehensive interplay between environmental, behavioral and personal factors within a unified theoretical framework. Fourth, medical education contexts require specialized investigation, as the unique demands of medical education, with its emphasis on evidence-based practice and clinical decision-making, create distinct educational requirements that differ from general educational settings (Le et al., 2022; Trullàs et al., 2022). These gaps are especially pronounced in developing regions such as western China, where medical institutions face unique challenges in implementing technology-enhanced education while developing students' information literacy competencies within resource-constrained environments.

Therefore, this study addresses these critical gaps by investigating the relationships between technology integration teaching strategies, information-seeking behavior and information literacy among medical students in western China. Specifically, this research pursues three objectives: (1) Examine the direct effects of technology integration strategies on medical students' information literacy development in medical education environments; (2) Investigate the mediating role of information-seeking behavior in the relationship between technology integration teaching strategies and information literacy development; (3) Test these relationships within the specific context of medical education in resource-limited settings, particularly in western China. By achieving these objectives, this study contributes essential knowledge for designing effective technology integration programs and information literacy curricula in medical education, particularly in resource-constrained environments.

2. Theoretical Framework

This study investigates the impact of TIS on medical students' information literacy development through social cognitive theory (SCT). The SCT framework has been extensively applied across various medical education contexts to examine teaching methodology effectiveness, learning behavior development, professional competency acquisition (Kim, 2024).

The social cognitive model describes how educational environmental factors, student behavioral patterns, and personal competencies interact reciprocally through reciprocal

determinism to shape learning outcomes and professional development (Chai & Ye, 2024). When medical students encounter technology integration teaching methodologies, this environmental factor creates structured technology-enhanced learning experiences that influence behavioral patterns (information-seeking) and personal competencies (information literacy), which in turn affect subsequent learning behaviors and competency development through continuous reciprocal interactions (Sheremeta, 2025; Uygur et al., 2019).

According to established SCT principles, this framework operates on several fundamental assumptions within educational contexts (Schunk & DiBenedetto, 2020). First, human behavior and learning result from dynamic interactions between personal factors (cognitive abilities, self-efficacy beliefs, knowledge), environmental factors (teaching strategies, institutional support, educational resources), and behavioral factors (learning activities, information-seeking patterns, skill practice) through triadic reciprocal determinism (Dignath & Veenman, 2021). Second, individuals possess self-regulatory capabilities that enable them to monitor, evaluate, and modify their learning behaviors based on environmental feedback and personal goal attainment (Wu et al., 2025). Third, observational learning and modeling play crucial roles in developing professional competencies, as students learn technology integration skills through observing expert demonstrations and structured educational experiences (Hennessy et al., 2022). Fourth, self-efficacy beliefs significantly influence students' motivation to engage in challenging learning activities and their persistence in developing complex professional competencies (Chen C. et al., 2025).

In the context of SCT applied to medical education, TIS represents the environmental factor that structures technology-enhanced learning experiences, provides systematic frameworks for digital information evaluation, and establishes educational expectations for technology utilization in clinical practice (Zainal et al., 2025). Technology integration teaching strategies create supportive digital learning environments that encourage systematic information evaluation, provide scaffolding for technology-enhanced clinical decision-making, and offer structured opportunities for students to develop evidence-based thinking patterns through digital platforms (Zou et al., 2025). These environmental factors influence both behavioral patterns (information-seeking activities) and personal factors (cognitive competencies and self-efficacy beliefs) through systematic exposure to technology-enhanced methodologies and structured digital learning experiences.

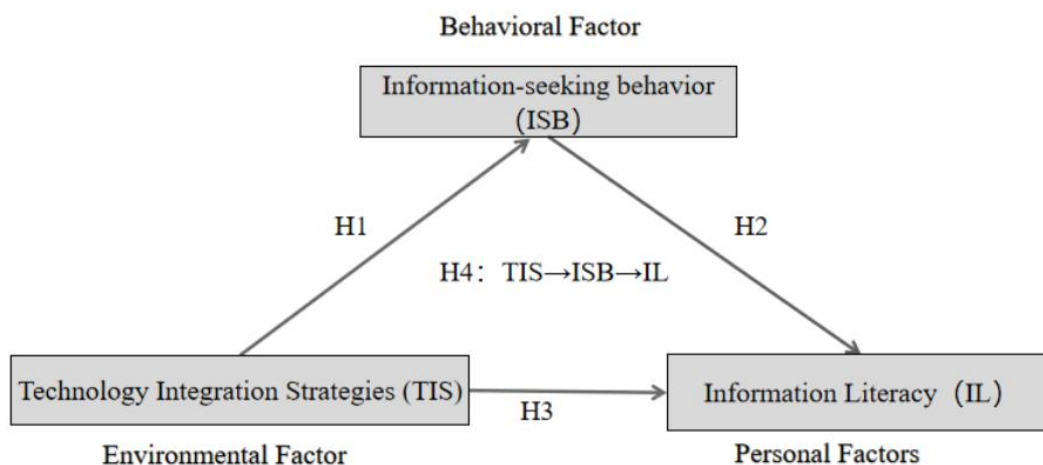
Information-seeking behavior in medical education represents the behavioral factor encompassing students' active engagement in digital information acquisition, online database navigation activities, technology-enhanced literature search behaviors, and digital resource utilization practices (Marasinghe et al., 2025). Medical students' information-seeking behaviors serve as observable learning activities that mediate the relationship between environmental factors (teaching strategies) and personal competencies (information literacy) (Khani et al., 2023). Through systematic engagement in technology-enhanced information-seeking behaviors, students develop enhanced cognitive abilities, strengthen self-efficacy beliefs about digital resource evaluation, and acquire practical skills necessary for evidence-based clinical practice (Brennan et al., 2020).

Information literacy in medical education encompasses personal factors including cognitive abilities (critical thinking, digital navigation skills, online resource evaluation

competencies), knowledge structures (digital information organization, technology-enhanced research comprehension), and self-efficacy beliefs (confidence in digital information evaluation, perceived competence in technology-enhanced evidence synthesis) (Cutrer et al., 2021). Medical students with higher IL possess enhanced cognitive frameworks for processing digital information, demonstrate stronger self-efficacy beliefs about their capability to evaluate online resources, and exhibit greater confidence in applying technology-enhanced resources for clinical decision-making and professional development (Rehman et al., 2024).

SCT emphasizes the reciprocal and dynamic nature of relationships between environmental factors, behavioral patterns, and personal competencies in learning contexts (Guo et al., 2023; Usher, 2018). Environmental factors such as technology integration teaching strategies influence behavioral patterns (information-seeking) and personal factors (information literacy) simultaneously, while behavioral engagement provides feedback that shapes both environmental factors (teaching strategies refinement) and personal competencies (skill development) (Gould et al., 2019). Therefore, based on SCT principles, this study assumes that ISB functions as a mediating behavioral factor that facilitates the transmission of environmental influences (TIS) into personal competency development (IL) by providing systematic opportunities for students to engage with digital information systems and develop technology-enhanced thinking patterns essential for professional practice. As illustrated in Figure 1, the hypothesized model depicts four main pathways: direct effects from technology integration strategies to information-seeking behavior (H1), from information-seeking behavior to information literacy (H2), from technology integration strategies to information literacy (H3), and an indirect effect mediated by information-seeking behavior (H4).

Figure 1: The hypothesized model of this study



3. Hypotheses Development

Technology Integration Strategies creates structured technology-enhanced learning environments that motivate and guide medical students to engage systematically in digital information acquisition and technology-enhanced evidence evaluation activities (Ha et al., 2023; Sulashvili et al., 2024). Technology integration teaching methodologies provide explicit frameworks for digital information searching, offer structured opportunities for online database navigation, and establish clear expectations for systematic technology-enhanced literature review and evidence evaluation (Naseer et al.,

2025). Medical students exposed to technology integration teaching strategies demonstrate increased likelihood of engaging in systematic information-seeking behaviors such as conducting comprehensive digital literature searches, utilizing online clinical databases effectively, participating in technology-enhanced evidence evaluation exercises, and developing systematic approaches to digital information acquisition through structured learning activities (Barr, 2023). These teaching strategies provide scaffolding that supports students' development of effective technology-enhanced information-seeking patterns and digital research methodology understanding (Wang & Zhang, 2024). Therefore, the study postulates the following hypothesis:

H1: Technology integration strategies significantly impact Information-Seeking Behavior among medical students in western China.

Information-seeking behavior serves as a crucial mechanism through which medical students develop and enhance their information literacy competencies in technology-enhanced clinical contexts (Barr, 2023). Systematic engagement in technology-enhanced information-seeking activities provides students with practical experience in digital database navigation, online evidence evaluation, and technology-enhanced research methodology application, which directly contributes to the development of information literacy skills (Setyoko et al., 2023). Medical students who actively engage in technology-enhanced information-seeking behaviors develop enhanced capabilities in identifying reliable digital information sources, critically evaluating online research quality, synthesizing evidence from multiple digital sources, and applying technology-enhanced information effectively for clinical decision-making purposes (Yu, 2022). Through repeated exposure to technology-enhanced information-seeking activities, students strengthen their cognitive frameworks for processing digital clinical information, develop confidence in online evidence evaluation processes, and acquire practical skills essential for information literacy competency in technology-rich environments (Sailer et al., 2024). The behavioral engagement with digital information systems provides experiential learning opportunities that facilitate the development of both technical skills and cognitive competencies necessary for effective information literacy in technology-enhanced medical practice (Kuek & Hakkennes, 2020). Based on this theoretical foundation, the following hypothesis was developed:

H2: Information-seeking behavior significantly and positively enhances Information Literacy skills among medical students in western China.

Technology integration teaching strategies directly influence medical students' information literacy development through structured educational experiences that enhance cognitive competencies and self-efficacy beliefs related to digital information management (Wu et al., 2022). TIS provides systematic frameworks for online evidence evaluation, offers guided instruction in technology-enhanced research methodology understanding, and creates learning opportunities that strengthen students' analytical and critical thinking capabilities in digital environment (Choi-Lundberg et al., 2023; Swart, 2017). These pedagogical strategies directly contribute to information literacy development by providing explicit instruction in digital information evaluation techniques, offering practice opportunities for applying technology-enhanced evidence-based reasoning, and establishing cognitive frameworks that support effective digital clinical information utilization (Sanchez et al., 2022). Therefore, the study postulates the following hypothesis:

H3: Technology integration teaching strategies significantly and positively impacts Information Literacy among medical students in western China.

Information-seeking behavior functions as a mediating mechanism that facilitates the transmission of environmental influences (technology integration teaching strategies) into personal competency development (information literacy) through systematic behavioral engagement with digital information systems (Ikupraja et al., 2025; Usher & Schunk, 2017). According to SCT principles, environmental factors influence personal competencies both directly and indirectly through behavioral pathways. TIS creates technology-enhanced learning environments that encourage information-seeking behaviors, which subsequently provide experiential learning opportunities that enhance information literacy competencies (Chen L. et al., 2025). This mediation process occurs as students engage in systematic technology-enhanced information-seeking activities stimulated by technology integration teaching methodologies, gain practical experience in digital information navigation and evaluation, and develop enhanced cognitive competencies through repeated behavioral engagement with technology-enhanced resources (Phan et al., 2024). The mediating role of information-seeking behavior ensures that environmental factors (teaching strategies) are translated into meaningful digital learning experiences that contribute to personal competency development (information literacy) through active behavioral participation in technology-enhanced information acquisition and evaluation processes. Therefore, based on SCT theoretical framework and mediation principles, the following hypothesis is postulated:

H4: Information-seeking behavior mediates the relationship between technology integration teaching strategies and Information Literacy among medical students in western China.

4. Materials and methods

4.1. Research Design

A cross-sectional design was deemed appropriate for this research as it allows for efficient data collection at a single time point while examining the associations between multiple variables simultaneously. This study was conducted at Ningxia Medical University in the Ningxia Hui Autonomous Region, a representative underdeveloped area in western China. This location was selected to investigate technology-enhanced information-seeking behaviors in medical education within an underserved region. The target population comprised undergraduate students in their advanced stage of medical education, specifically fourth-year clinical medicine students who had completed clinical internships and evidence-based medicine training. The sample size was calculated using Cochran's formula, yielding a base sample size of 267 participants. Accounting for approximately 5% response rate loss, the final sample size was determined to be 280 participants. A purposive sampling technique was employed to recruit participants from the fourth-year clinical medicine program. Purposive sampling was selected as the most appropriate method because the study required participants with specific characteristics—completion of clinical internships and evidence-based medicine training—which cannot be guaranteed through probability sampling alone. Data were collected in August 2025 through a professional web-based survey software in China (<https://wj.qq.com/>), targeting students who had online learning experiences after the outbreak of the COVID-19 pandemic. A structured questionnaire comprising validated multi-item scales was employed to measure the study's core constructs (detailed in

Section 4.2). Prior to full-scale data collection, a pilot study was conducted with 30 third-year clinical medicine students who were not included in the main study. Cronbach's alpha values from the pilot data ranged from 0.72 to 0.88, indicating acceptable internal consistency reliability. A total of 300 questionnaires were returned, with 20 excluded due to ineligibility, resulting in 280 valid samples for data analysis. This study received ethical approval from the Research Ethics Committee of Universiti Teknologi MARA. Informed consent was obtained from all participants prior to data collection. Participants were assured of confidentiality and anonymity, and informed of their voluntary participation and right to withdraw at any time without penalty.

4.2. Measurement Instruments

The comprehensive questionnaire included validated multi-item scales designed to measure the study's core constructs within technology-enhanced medical education contexts. The primary variables, include TIS, ISB, and IL were assessed using established multi-item instruments adapted for technology-enhanced medical education settings and measured through 5-point Likert-type scales ranging from Strongly Disagree (1) to Strongly Agree (5) (Croasmun & Ostrom, 2011). The TIS scale was adapted from established technology integration teaching methodology assessment instruments and digital education effectiveness literature, focusing on students' perceptions of teaching strategies effectiveness, technology integration quality, and systematic digital learning experiences (Wang, 2022). The ISB scale was developed based on existing information-seeking behavior frameworks specifically modified for technology-enhanced information contexts and digital learning environments, measuring systematic digital information acquisition behaviors and online resource utilization patterns (Wilson, 1999). The IL scale was adapted from digital literacy instruments and technology-enhanced information competency assessment tools specifically designed for medical education contexts, assessing cognitive capabilities and self-efficacy beliefs related to digital information evaluation and technology-enhanced information synthesis. Data analysis was conducted using SPSS (29.0) and Smart PLS 4.0 software packages. Structural Equation Modeling (SEM) was employed to examine the proposed hypothetical relationships among the study variables, with particular attention to mediation analysis procedures within the context of technology-enhanced medical education in western China (Cai et al., 2022).

5. Results

5.1. Demographic Profile

This study included 280 fourth-year clinical medicine students who have completed clinical internships and received systematic evidence-based medicine training through technology-enhanced learning environments at a medical university in Ningxia, western China. The sample comprised 53.8% female and 46.2% male participants, reflecting the gender distribution typical of clinical medicine programs in the region. All participants were enrolled in the same academic level (fourth-year clinical medicine program), which eliminated potential confounding effects of academic progression and specialty differences. Regarding clinical internship experience, all students had completed a minimum of 6 months of clinical rotations across various medical departments, including internal medicine, surgery, pediatrics, and emergency medicine. In terms of technology-enhanced learning experience, 100% of participants had completed the mandatory evidence-based medicine curriculum delivered through digital platforms,

including courses on technology-enhanced clinical research methodology, online systematic literature review, and digital critical appraisal of medical literature. Additionally, 82.5% of participants reported using digital learning platforms and online clinical databases regularly during their clinical internship experiences for technology-enhanced case-based learning and clinical decision-making exercises.

5.2. Measurement Model Assessment

5.2.1. Convergent Validity

Data analysis commenced with reliability assessment using SPSS 29, followed by Partial Least Squares Structural Equation Modeling (PLS-SEM) procedures to examine interrelationships between latent variables using Smart-PLS 4.0 software. All measurement constructs were reflective in nature, and construct reliability was evaluated using Composite Reliability (CR) and Cronbach's Alpha (α) coefficients. CR and α values exceeding 0.7 are considered satisfactory for research purposes (Hair et al., 2019; Holmbeck & Devine, 2009).

As presented in Table 1, CR values for all constructs ranged from 0.842 to 0.919, exceeding the recommended threshold of 0.7. Cronbach's Alpha values demonstrated similar patterns, with values ranging from 0.764 to 0.895. Table 1 presents the complete reliability and validity indicators for all measurement constructs in this study. Notably, the IL construct exhibited a Cronbach's Alpha of 0.764, which, while marginally lower than other constructs, remains above the acceptable threshold. Since Cronbach's Alpha assumes equal outer loadings across construct indicators whereas CR accommodates varying outer loadings, the consistently high CR values (all > 0.80) provide robust evidence of internal consistency reliability across all constructs in this technology-enhanced medical education context.

Convergent validity was assessed through Average Variance Extracted (AVE), with a minimum acceptable threshold of 0.50 (Nasution et al., 2020). As shown in Table 1, Results indicated that AVE values for all constructs ranged from 0.515 to 0.695, surpassing the recommended threshold and thereby confirming adequate convergent validity. Additionally, item loadings for all indicators exceeded 0.70 (ranging from 0.738 to 0.957), further substantiating the convergent validity of the measurement model.

Table 1: Composite reliability, Cronbach's α and AVE

Construct	items loading	Cronbach's α	rho_a	CR	AVE
IL		0.764	0.766	0.842	0.515
ILA	0.949	0.819	0.825	0.881	0.649
ILC	0.950	0.872	0.878	0.907	0.661
ILE	0.957	0.840	0.843	0.886	0.610
ILN	0.908	0.855	0.859	0.896	0.633
ILT	0.946	0.840	0.841	0.887	0.610
ISB		0.872	0.877	0.904	0.610
ISB1	0.792				
ISB2	0.817				
ISB3	0.751				
ISB4	0.794				
ISB5	0.738				

ISB6	0.790				
TIS		0.890		0.895	0.919
TIS1	0.824				
TIS2	0.859				
TIS3	0.855				
TIS4	0.801				
TIS5	0.828				

5.2.2. Discriminant Validity

The discriminant validity of the scales was assessed using the Heterotrait-Monotrait (HTMT) ratio criterion. Following the guidelines established by Tudor Car et al. (2022), HTMT values should remain below 0.85 to demonstrate adequate discriminant validity in technology-enhanced medical education contexts. As presented in Table 2, the diagonal values represent the square root of the Average Variance Extracted (AVE) for each construct: Intention to Learn (IL = 0.719), Information Literacy Awareness (ILA = 0.805), Information Literacy Competence (ILC = 0.813), Information Literacy Efficacy (ILE = 0.781), Information Literacy Need (ILN = 0.795), Information Literacy Trust (ILT = 0.781), Information Seeking Behavior (ISB = 0.781), and Technology Integration Strategies (TIS = 0.834). Table 2 illustrates that the off-diagonal elements represent inter-construct correlations, with all values ranging from 0.189 to 0.750, remaining substantially below the 0.85 threshold. These results confirm that all constructs demonstrate satisfactory discriminant validity, indicating that the measurement model successfully differentiates between conceptually distinct constructs within the technology integration teaching strategies and information behavior framework.

Table 2: The discriminant validity of the scales

	IL	ILA	ILC	ILE	ILN	ILT	ISB	TIS
IL	0.719							
ILA	0.718	0.805						
ILC	0.703	0.386	0.813					
ILE	0.740	0.423	0.378	0.781				
ILN	0.682	0.339	0.356	0.396	0.795			
ILT	0.750	0.431	0.413	0.435	0.401	0.781		
ISB	0.477	0.371	0.323	0.393	0.296	0.328	0.781	
TIS	0.378	0.288	0.334	0.288	0.189	0.255	0.438	0.834

5.2.3. Structural Model and Hypothesis Testing

Following reliability and validity confirmation, the study proceeded to hypothesis testing through structural model assessment using PLS-SEM. As shown in Table 3, path analysis results confirm that TIS significantly enhances information-seeking behavior among fourth-year clinical medicine students, with this impact being statistically significant ($\beta = 0.438, t = 8.017, p < 0.001$), thus supporting H1.

Furthermore, Table 3 demonstrates that ISB shows a significantly positive impact on IL ($\beta = 0.387, t = 5.993, p < 0.001$), confirming H2. Additionally, TIS shows a significantly positive direct effect on IL ($\beta = 0.212, t = 3.316, p = 0.001$), which supports H3. Path analysis revealed that technology integration teaching strategies not only directly enhance information-seeking behaviors among fourth-year clinical medicine students in

the western China context, but also exert a significant direct effect on information literacy competencies.

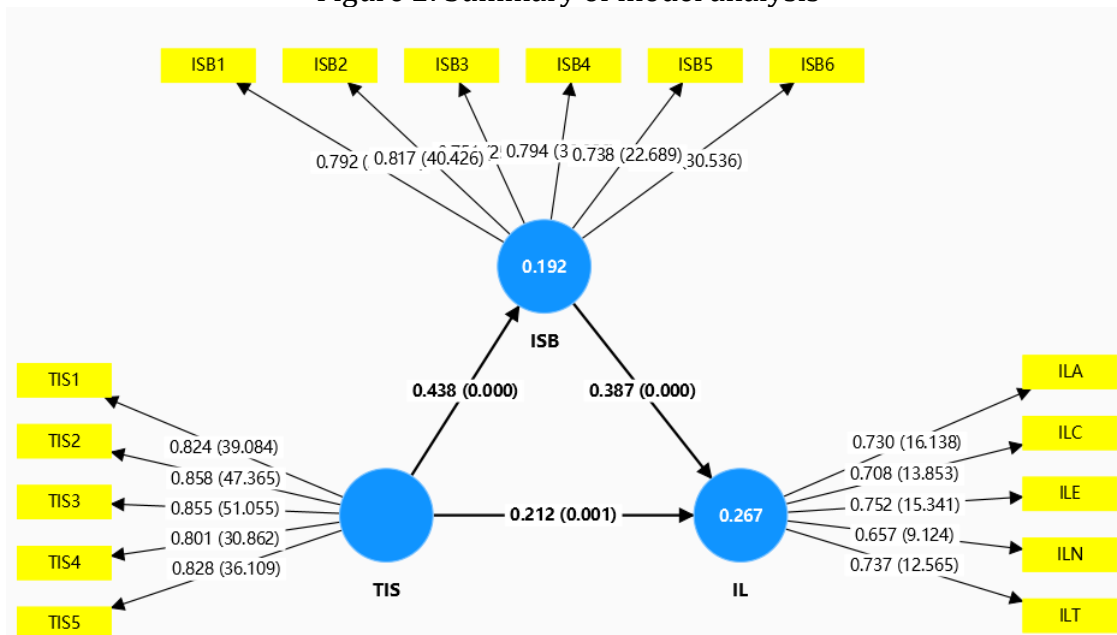
Mediation analysis confirms that ISB partially mediates the relationship between TIS and IL. As indicated in Table 3, the indirect effect through information-seeking behavior is statistically significant ($\beta = 0.169$, $t = 4.763$, $p < 0.001$), and the direct effect is also significant ($\beta = 0.212$, $p = 0.001$), indicating partial mediation. Both direct and indirect pathways contribute to the overall effect of technology integration teaching strategies on information literacy, supporting H4.

As illustrated in Table 3 and Figure 2, the structural model demonstrates the results of hypothesis testing.

Table 3: Results of path analysis

Hypotheses	Path	Beta	STD	T values	P values	Decision
H1	TIS -> ISB	0.438	0.055	8.017	0	Supported
H2	ISB -> IL	0.387	0.065	5.993	0	Supported
H3	TIS -> IL	0.212	0.064	3.316	0.001	Supported
H4	TIS -> ISB -> IL	0.169	0.036	4.763	0	Supported

Figure 2: Summary of model analysis



6. Discussion

The study presents compelling evidence demonstrating that technology integration teaching strategies significantly enhance fourth-year clinical medicine students' information literacy competencies through the mediating mechanism of information-seeking behavior in the western China regional context. Thus, it is evident from this study that systematic implementation of technology integration teaching methodologies leads senior clinical medicine students to engage more actively in digital information-seeking activities, which subsequently contributes to enhanced information literacy development (Consoli et al., 2025; Shannaq, 2025). Therefore, technology integration teaching strategies create optimal technological environments wherein fourth-year

clinical medicine students, building upon their clinical internship experiences and evidence-based medicine training, experience structured opportunities to engage meaningfully with digital information systems and develop technology-enhanced competencies through systematic behavioral engagement, ultimately facilitating the development of comprehensive information literacy skills essential for contemporary professional practice. As medical education technology literature supports, information-seeking behavior serves as a crucial mediating mechanism through which environmental factors (teaching strategies) influence personal competencies (information literacy) in healthcare education contexts (Shamsaei et al., 2021). Technology integration teaching strategies provide structured digital learning experiences that enhance information literacy through behavioral pathways, and the findings confirm that when fourth-year clinical medicine students engage actively in information-seeking behaviors stimulated by these teaching methodologies, they develop significantly enhanced information literacy competencies. Considering these relationships, this study demonstrated that ISB functions as a mediator between TIS and information literacy development among senior clinical medicine students in western China. The mediation analysis reveals that technology integration teaching strategies influence information literacy both directly and indirectly through information-seeking behavior pathways (Ishimura & Fitzgibbons, 2023).

This finding indicates that teaching strategies enhance information literacy not only through direct instructional effects but also by encouraging behavioral engagement with digital information systems that provides experiential learning opportunities essential for competency development in technology-enhanced environments. Social cognitive theory postulates that environmental factors, behavioral patterns, and personal competencies interact reciprocally through triadic determinism (Bandura, 2001; Usher, 2018). Maintaining consistency with this theoretical framework, the study findings demonstrate how environmental factors (technology integration teaching strategies) influence behavioral patterns (information-seeking behavior), which subsequently affect personal competencies (information literacy). The mediation mechanism reveals that teaching strategies create technology-enhanced learning environments that stimulate information-seeking behaviors, which provide practical experience essential for developing information literacy competencies (Ashraf et al., 2022). This triadic interaction demonstrates how systematic teaching methodologies can optimize learning outcomes through structured behavioral engagement and competency development processes in resource-constrained educational contexts.

7. Conclusion

The purpose of this study was to gain initial insights into how technology integration teaching strategies influence fourth-year clinical medicine students' information literacy development through information-seeking behavior mechanisms within the western China regional context, specifically in Ningxia. The study empirically validated social cognitive theory principles by examining the triadic interactions between environmental factors (teaching strategies), behavioral patterns (information-seeking), and personal competencies (information literacy) among senior clinical medicine students who had completed clinical internships and technology-enhanced evidence-based medicine training. Consistent with SCT principles that environmental factors, behavioral patterns, and personal competencies interact through reciprocal relationships, this study confirms that information-seeking behavior functions as a crucial mediating mechanism facilitating the transmission of environmental influences (teaching strategies) into

personal competency development (information literacy) (Ishimura & Fitzgibbons, 2023). Technology integration teaching strategies demonstrate significantly positive effects on both information-seeking behavior and information literacy (Ikapraja et al., 2025), while information-seeking behavior emerges as both a direct predictor and a significant mediator in the relationship between teaching strategies and competency development among senior clinical medicine students.

The study findings reveal that in medical education environments within western China's underdeveloped regions, where standardized technological support systems may be inadequate due to regional economic constraints, technology integration teaching strategies can serve as effective environmental interventions when systematically implemented among students who possess foundational clinical experience and technology-enhanced learning background (Sulashvili et al., 2024). Teaching strategies optimization can be executed through faculty development programs and curricular integration initiatives specific to the needs of senior clinical medicine students (Zhang et al., 2025). Medical education institutions in similar regional contexts may implement technology integration teaching methodologies more systematically to create structured digital learning environments that stimulate information-seeking behaviors and facilitate information literacy development, ultimately enhancing clinical competency preparation and technology-enhanced learning readiness among fourth-year clinical medicine students in resource-constrained contexts (Sulashvili et al., 2024).

Based on study findings, it can be argued that technology integration teaching strategies may be effectively implemented to enhance senior clinical medicine students' information literacy competencies through systematic information-seeking behavior development in western China's underdeveloped regions. With appropriate TIS implementation, medical education institutions in similar regional contexts can create structured technology-enhanced learning environments that motivate fourth-year clinical medicine students to engage systematically with digital information resources, ultimately facilitating information literacy development essential for technology-enhanced clinical practice (Dhar et al., 2021). This approach helps optimize educational resource utilization while addressing information literacy gaps common in resource-constrained educational environments, particularly for students who have completed clinical internships and technology-enhanced evidence-based medicine training (Chen et al., 2024). Additionally, medical education administrators and faculty members in western China and similar regional contexts can benefit significantly from understanding how teaching strategies influence senior clinical medicine students' learning behaviors and competency development patterns (Lan et al., 2025). Technology integration teaching strategies can be enhanced through systematic faculty development, curricular integration initiatives, and improved access to digital educational resources (Akram et al., 2022). Therefore, several strategic actions are required to optimize teaching methodology implementation in western China's underdeveloped regions (Reddi & Javidi, 2025). For example, faculty development programs should be promoted extensively to ensure systematic implementation of technology integration teaching methodologies. Medical education faculty should receive comprehensive training in technology-enhanced teaching techniques and systematic approaches to integrating digital information literacy development into curricula across various medical education contexts and specialty areas (Sadiq et al., 2024). Furthermore, medical education institutions should actively implement technology integration teaching strategies through curricular redesign initiatives that

emphasize systematic information-seeking skill development and digital evidence evaluation competencies.

Ethics Approval and Consent to Participate

This study received ethical approval from the Research Ethics Committee of Universiti Teknologi MARA (approval reference: REC/08/2025(PG/MR/434)). All procedures performed in this study involving human participants were conducted in accordance with the ethical standards of the institutional research committee and with the Declaration of Helsinki. electronic informed consent was obtained from all participants prior to data collection.

Acknowledgement

Part of this article was extracted from a doctoral thesis to be submitted to Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia.

Funding

This study received no funding.

Conflict of Interest

The authors declare no conflict of interest.

References

- ACRL. (2016). *Framework for information literacy for higher education*. Association of College & Research Libraries. <https://www.ala.org/acrl/standards/ilframework>
- Akram, H., Abdelrady, A. H., Al-Adwan, A. S., & Ramzan, M. (2022). Teachers' perceptions of technology integration in teaching-learning practices: A systematic review. *Frontiers in Psychology*, 13, Article 920317. <https://doi.org/10.3389/fpsyg.2022.920317>
- ALA. (2000). *Information literacy competency standards for higher education*. American Library Association. <http://www.ala.org/acrl/standards/informationliteracycompetency>
- Ashraf, M. A., Iqbal, J., Arif, M. I., & Asghar, M. Z. (2022). Fostering ICT competencies in blended learning: Role of curriculum content, material, and teaching strategies. *Frontiers in Psychology*, 13, Article 758016. <https://doi.org/10.3389/fpsyg.2022.758016>
- Aydınlar, A., Mavi, A., Kütükçü, E., Kırımlı, E. E., Alış, D., Akın, A., & Altıntaş, L. (2024). Awareness and level of digital literacy among students receiving health-based education. *BMC Medical Education*, 24(1), Article 38. <https://doi.org/10.1186/s12909-024-05025-w>
- Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology*, 52(1), 1–26. <https://doi.org/10.1146/annurev.psych.52.1.1>
- Barr, A. (2023). Initial efforts to improve medical student information-seeking behavior with embedded library instruction. *Journal of the Medical Library Association: JMLA*, 111(4), 823. <https://doi.org/10.5195/jmla.2023.1771>

- Blau, I., Shamir-Inbal, T., & Avdiel, O. (2020). How does the pedagogical design of a technology-enhanced collaborative academic course promote digital literacies, self-regulation, and perceived learning of students? *The Internet and Higher Education*, 45, Article 100722. <https://doi.org/10.1016/j.iheduc.2019.100722>
- Brennan, E. A., Ogawa, R. S., Thormodson, K., & von Isenburg, M. (2020). Introducing a health information literacy competencies map: Connecting the Association of American Medical Colleges Core Entrustable Professional Activities and Accreditation Council for Graduate Medical Education Common Program Requirements to the Association of College & Research Libraries Framework. *Journal of the Medical Library Association: JMLA*, 108(3), 420. <https://doi.org/10.5195/jmla.2020.645>
- Bruce, C. S. (2002). *Information literacy as a catalyst for educational change: A background paper*. (White Paper prepared for UNESCO). <https://eprints.qut.edu.au/4977/>
- Cai, X., Zhu, Y., Huang, Y., & Ghosh, D. (2022). High-dimensional causal mediation analysis based on partial linear structural equation models. *Computational Statistics & Data Analysis*, 174, Article 107501. <https://doi.org/10.1016/j.csda.2022.107501>
- Case, D. O., & Given, L. M. (2016). *Looking for information: A survey of research on information seeking, needs, and behavior* (4th ed.). Emerald Group Publishing. <https://bookstore.emerald.com/looking-for-information.html>
- Celik, I. (2023). Towards Intelligent-TPACK: An empirical study on teachers' professional knowledge to ethically integrate artificial intelligence (AI)-based tools into education. *Computers in Human Behavior*, 138, Article 107468. <https://doi.org/10.1016/j.chb.2022.107468>
- Chai, J., & Ye, J.-H. (2024). A social network analysis of college students' online learning during the epidemic era: A triadic reciprocal determinism perspective. *Heliyon*, 10(6), Article e28768. <https://doi.org/10.1016/j.heliyon.2024.e28107>
- Chen, C., Sun, Y., & Zhu, Y. (2025). The mechanism of academic self-efficacy in the relationship between professional identity and learning engagement among university students. *Scientific Reports*, 15(1), Article 10640. <https://doi.org/10.1038/s41598-025-95556-z>
- Chen, L., He, M., & Hu, Y. (2025). Abstract TP55: Analysis of factors and paths influencing the health information seeking behavior of stroke patients. *Stroke*, 56(Suppl. 1), ATP55–ATP55. https://doi.org/10.1161/str.56.suppl_1.tp55
- Chen, S., Xue, Y., & Cui, X. (2024). Information literacy of college students from library education in smart classrooms: Based on big data exploring data mining patterns using Apriori algorithm. *Soft Computing*, 28(4), 3571–3589. <https://doi.org/10.1007/s00500-023-09621-8>
- Choi-Lundberg, D. (2023). Technology-enhanced learning in medical education collection: Latest developments. *MedEdPublish*, 13, Article 219. <https://doi.org/10.12688/mep.19856.1>
- Choi-Lundberg, D. L., Butler-Henderson, K., Harman, K., & Crawford, J. (2023). A systematic review of digital innovations in technology-enhanced learning designs in higher education. *Australasian Journal of Educational Technology*, 39(3), 133–162. <https://doi.org/10.14742/ajet.7615>
- Consoli, T., Schmitz, M.-L., Antonietti, C., Gonon, P., Cattaneo, A., & Petko, D. (2025). Quality of technology integration matters: Positive associations with students' behavioral engagement and digital competencies for learning. *Education and Information Technologies*, 30(6), 7719–7752. <https://doi.org/10.1007/s10639-024-13118-8>

- Croasmun, J. T., & Ostrom, L. (2011). Using Likert-type scales in the social sciences. *Journal of Adult Education, 40*(1), 19–22. <https://eric.ed.gov/?id=EJ961998>
- Cutrer, W. B., Spickard III, W. A., Triola, M. M., Allen, B. L., Spell III, N., Herrine, S. K., Dalrymple, J. L., Gorman, P. N., & Lomis, K. D. (2021). Exploiting the power of information in medical education. *Medical Teacher, 43*(Suppl. 2), S17–S24. <https://doi.org/10.1080/0142159X.2021.1925234>
- Dhar, P., Rocks, T., Samarasinghe, R. M., Stephenson, G., & Smith, C. (2021). Augmented reality in medical education: Students' experiences and learning outcomes. *Medical Education Online, 26*(1), Article 1953953. <https://doi.org/10.1080/10872981.2021.1953953>
- Dignath, C., & Veenman, M. V. (2021). The role of direct strategy instruction and indirect activation of self-regulated learning—Evidence from classroom observation studies. *Educational Psychology Review, 33*(2), 489–533. <https://doi.org/10.1007/s10648-020-09534-0>
- Ferdig, R. E., Baumgartner, E., Hartshorne, R., Kaplan-Rakowski, R., & Mouza, C. (2020). *Teaching, technology, and teacher education during the COVID-19 pandemic: Stories from the field*. Association for the Advancement of Computing in Education. <https://www.learntechlib.org/p/216903/>
- Gould, R. K., Ardoin, N. M., Thomsen, J. M., & Wyman Roth, N. (2019). Exploring connections between environmental learning and behavior through four everyday-life case studies. *Environmental Education Research, 25*(3), 314–340. <https://doi.org/10.1080/13504622.2018.1510903>
- Guo, J.-P., Lv, S., Wang, S.-C., Wei, S.-M., Guo, Y.-R., & Yang, L.-Y. (2023). Reciprocal modeling of university students' perceptions of the learning environment, engagement, and learning outcome: A longitudinal study. *Learning and Instruction, 83*, Article 101692. <https://doi.org/10.1016/j.learninstruc.2022.101692>
- Ha, T., Hoang, D., Huynh, C., & Le, L. (2023). Integrated educational technology in teaching anatomy using the ASIC framework: A case study from VinUniversity. *Advances in Medical Education and Practice, 14*, 669–681. <https://doi.org/10.2147/AMEP.S405340>
- Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. *European Business Review, 31*(1), 2–24. <https://doi.org/10.1108/EBR-11-2018-0203>
- Hennessy, S., D'Angelo, S., McIntyre, N., Koomar, S., Kreimeia, A., Cao, L., Brugha, M., & Zubairi, A. (2022). Technology use for teacher professional development in low- and middle-income countries: A systematic review. *Computers and Education Open, 3*, Article 100080. <https://doi.org/10.1016/j.caeo.2022.100080>
- Holmbeck, G. N., & Devine, K. A. (2009). An author's checklist for measure development and validation manuscripts. *Journal of Pediatric Psychology, 34*(7), 691–696. <https://doi.org/10.1093/jpepsy/jsp046>
- Ikapraja, B., Siswanto, J., Ariani, F., & Sugianto, S. (2025). Using Ellis model for the analysis of information seeking behavior about digital literacy. *BIS Information Technology and Computer Science, 2*, V225004–V225004. <https://doi.org/10.31603/bistycs.181>
- Ishimura, Y., & Fitzgibbons, M. (2023). How does web-based collaborative learning impact information literacy development? *The Journal of Academic Librarianship, 49*(1), Article 102614. <https://doi.org/10.1016/j.acalib.2022.102614>
- Khani, H., Ahmady, S., Sabet, B., Namaki, A., Zandi, S., & Niakan, S. (2023). Teaching-learning in clinical education based on epistemological orientations: A multi-method study. *PLOS ONE, 18*(11), Article e0289150. <https://doi.org/10.1371/journal.pone.0289150>

- Kim, H. W. (2024). Social cognitive theory and medical education: How social interactions give rise to learning. *Korean Medical Education Review*, 26(Suppl. 1), S13–S21. <https://doi.org/10.17496/kmer.24.001>
- Kuek, A., & Hakkennes, S. (2020). Healthcare staff digital literacy levels and their attitudes towards information systems. *Health Informatics Journal*, 26(1), 592–612. <https://doi.org/10.1177/1460458219839613>
- Kulaksız, T., Steinbacher, J., & Kalz, M. (2023). Technology-enhanced learning in the education of oncology medical professionals: A systematic literature review. *Journal of Cancer Education*, 38(5), 1743–1751. <https://doi.org/10.1007/s13187-023-02329-1>
- Lan, Y.-Z., Lin, W.-T., Wu, Z., Chen, W.-J., Guo, D., Liu, S.-H., & Liu, J. (2025). Investigation and analysis of clinical medical undergraduate learning behaviors under different teaching models. *Frontiers in Education*, 10, Article 1471616. <https://doi.org/10.3389/educ.2024.1458216>
- Le, B., Lawrie, G. A., & Wang, J. T. (2022). Student self-perception on digital literacy in STEM blended learning environments. *Journal of Science Education and Technology*, 31(3), 303–321. <https://doi.org/10.1007/s10956-022-09956-1>
- Li, N., Lau, K. L., Liang, Y., & Chai, C. S. (2024). Pre-service foreign language teachers' TPACK preparation for technology integration: What are the profiles and key drivers? *Asia Pacific Journal of Education*, 44(2), 414–430. <https://doi.org/10.1080/02188791.2024.2415392>
- Liu, J., Yuan, K., Lin, X., & Zhu, W. (2023). What learning strategies influence higher-order learning behaviours of medical students? *Annals of Medicine*, 55(1), Article 2205166. <https://doi.org/10.1080/07853890.2023.2205166>
- Marasinghe, M., Kasturiratne, K., & Chandratilake, M. (2025). Information seeking behavior of medical students in Sri Lanka. *Information Development*, 41(1), 229–241. <https://doi.org/10.1177/02666669231179398>
- Naseer, M. A., Saeed, S., Afzal, A., Ali, S., & Malik, M. G. R. (2025). Navigating the integration of artificial intelligence in the medical education curriculum: A mixed-methods study exploring the perspectives of medical students and faculty in Pakistan. *BMC Medical Education*, 25(1), Article 273. <https://doi.org/10.1186/s12909-024-06552-2>
- Nasution, M. I., Fahmi, M., & Prayogi, M. A. (2020). The quality of small and medium enterprises performance using the structural equation model-part least square (SEM-PLS). *Journal of Physics: Conference Series*, 1477(5), Article 052052. <https://doi.org/10.1088/1742-6596/1477/5/052052>
- Ning, Y., Zhang, C., Xu, B., Zhou, Y., & Wijaya, T. T. (2024). Teachers' AI-TPACK: Exploring the relationship between knowledge elements. *Sustainability*, 16(3), Article 978. <https://doi.org/10.3390/su16030978>
- Onoue, T., Asada, Y., Imafuku, R., Kou, S., Takami, H., Takahashi, Y., Nomura, O., & Saiki, T. (2024). Developing competencies relating to information science and technology in Japanese undergraduate medical education. *Medical Teacher*, 46(Suppl. 1), S31–S37. <https://doi.org/10.1080/0142159X.2024.2385199>
- Phan, T. C., Van Tran, H., Truong, T. D., Le, H. T., & Phan, D. M. (2024). Developing information technology competence in online education with the TPACK approach. *Vietnam Journal of Education*, 8(3), 166–176. <https://doi.org/10.52296/vje.2024.361>
- Reddi, S., & Javidi, D. (2025). A critical narrative review of medical school curricula: Teaching methods, assessment strategies, and technological integration. *Cureus*, 17(4), Article e80780. <https://doi.org/10.7759/cureus.82015>

- Rehman, S., Addas, A., Rehman, E., Khan, M. N., Shahiman, M. A., Rahman, M. A., & Wang, M. (2024). Leveraging digital skills to reduce cognitive strain: Implications for academic self-efficacy in medical education. *Acta Psychologica*, 251, Article 104602. <https://doi.org/10.1016/j.actpsy.2024.104602>
- Sadiq, N., Fatima, S. H., Shabnam, N., & Rauf, A. (2024). Empowering health professions educators: Enhancing curriculum delivery through customized e-tutorial training on fundamental digital tools. *Frontiers in Medicine*, 11, Article 1342654. <https://doi.org/10.3389/fmed.2024.1342654>
- Sailer, M., Maier, R., Berger, S., Kastorff, T., & Stegmann, K. (2024). Learning activities in technology-enhanced learning: A systematic review of meta-analyses and second-order meta-analysis in higher education. *Learning and Individual Differences*, 112, Article 102446. <https://doi.org/10.1016/j.lindif.2024.102446>
- Sanches, T., Lopes, C., & Antunes, M. D. L. (2022). Critical thinking in information literacy pedagogical strategies: New dynamics for higher education throughout librarians' vision. In *8th International Conference on Higher Education Advances (HEAD'22)* (pp. 549–556). Editorial Universitat Politècnica de València. <https://doi.org/10.4995/HEAD22.2022.14476>
- Schunk, D. H., & DiBenedetto, M. K. (2020). Motivation and social cognitive theory. *Contemporary Educational Psychology*, 60, Article 101832. <https://doi.org/10.1016/j.cedpsych.2019.101832>
- Setyoko, S., Yani, A. F. S., Fitria, D., & Suryanti, S. (2023). Analysis of college student technology literacy and information literacy skills: E-learning activities based on online platforms in higher education. *Jurnal Penelitian Pendidikan IPA*, 9(11), 9416–9422. <https://doi.org/10.29303/jppipa.v9i11.5276>
- Shamsaee, M., Mangolian Shahrababaki, P., Ahmadian, L., Farokhzadian, J., & Fatehi, F. (2021). Assessing the effect of virtual education on information literacy competency for evidence-based practice among the undergraduate nursing students. *BMC Medical Informatics and Decision Making*, 21(1), Article 48. <https://doi.org/10.1186/s12911-021-01418-9>
- Shannaq, B. (2025). E-learning integration and teaching strategies to enhance knowledge retention in higher education. *Emerging Science Journal*, 9(2), 829–850. <https://doi.org/10.28991/ESJ-2025-09-02-017>
- Sheremeta, R. (2025). Interactive technologies in teaching pathological anatomy: Impact on the quality of medical student training. *Ukrainian Medical Journal*, 2(160), 16–20. <https://dspace.vnm.edu.ua/123456789/9486>
- Sulashvili, N., Alavidze, N., Buleishvili, M., Kravchenko, V., Sulashvili, M., Seniuk, I., Okropiridze, T., Giorgobiani, M., Grigolia, L., & Robakidze, K. (2024). The manifestation of key issue features of global perspectives on innovative teaching and learning approach strategies in higher medical education: Advancing student-centered practices, technology integration and competency-based frameworks. *Scientific Journal "Spectri"*, 10(2), 42–53. <https://doi.org/10.52340/spectri.2024.10.02.05>
- Swart, R. (2017). Critical thinking instruction and technology enhanced learning from the student perspective: A mixed methods research study. *Nurse Education in Practice*, 23, 30–39. <https://doi.org/10.1016/j.nepr.2017.02.003>
- Trullàs, J. C., Blay, C., Sarri, E., & Pujol, R. (2022). Effectiveness of problem-based learning methodology in undergraduate medical education: A scoping review. *BMC Medical Education*, 22(1), Article 104. <https://doi.org/10.1186/s12909-022-03154-8>
- Tudor Car, L., Kyaw, B. M., Teo, A., Fox, T. E., Vimalasvaran, S., Apfelbacher, C., Kemp, S., & Chavannes, N. (2022). Outcomes, measurement instruments, and their validity evidence in randomized controlled trials on virtual, augmented, and mixed reality

- in undergraduate medical education: Systematic mapping review. *JMIR Serious Games*, 10(2), Article e29594. <https://doi.org/10.2196/29594>
- Usher, E. L. (2018). Acknowledging the whiteness of motivation research: Seeking cultural relevance. *Educational Psychologist*, 53(2), 131–144. <https://doi.org/10.1080/00461520.2018.1442220>
- Usher, E. L., & Schunk, D. H. (2017). Social cognitive theoretical perspective of self-regulation. In D. H. Schunk & J. A. Greene (Eds.), *Handbook of self-regulation of learning and performance* (2nd ed., pp. 19–35). Routledge.
- Uygur, J., Stuart, E., De Paor, M., Wallace, E., Duffy, S., O'Shea, M., Smith, S., & Pawlikowska, T. (2019). A best evidence in medical education systematic review to determine the most effective teaching methods that develop reflection in medical students: BEME Guide No. 51. *Medical Teacher*, 41(1), 3–16. <https://doi.org/10.1080/0142159X.2018.1505037>
- Wang, A. Y. (2022). Understanding levels of technology integration: A TPACK scale for EFL teachers to promote 21st-century learning. *Education and Information Technologies*, 27(7), 9935–9952. <https://doi.org/10.1007/s10639-022-11019-w>
- Wang, Y., & Zhang, Y. (2024). Effects of teaching strategies on students' learning engagement and knowledge construction in asynchronous online learning. *Distance Education*, 45(2), 281–296. <https://doi.org/10.1080/01587919.2024.2333713>
- Wilson, T. D. (1999). Models in information behaviour research. *Journal of Documentation*, 55(3), 249–270. <https://doi.org/10.1108/EUM000000007145>
- Wu, F., Dang, Y., & Li, M. (2025). A systematic review of responses, attitudes, and utilization behaviors on generative AI for teaching and learning in higher education. *Behavioral Sciences*, 15(4), Article 467. <https://doi.org/10.3390/bs15040467>
- Wu, Q., Wang, Y., Lu, L., Chen, Y., Long, H., & Wang, J. (2022). Virtual simulation in undergraduate medical education: A scoping review of recent practice. *Frontiers in Medicine*, 9, Article 855403. <https://doi.org/10.3389/fmed.2022.855403>
- Yu, Z. (2022). Sustaining student roles, digital literacy, learning achievements, and motivation in online learning environments during the COVID-19 pandemic. *Sustainability*, 14(8), Article 4388. <https://doi.org/10.3390/su14084388>
- Zainal, H., Xiao Hui, X., Thumboo, J., & Kok Yong, F. (2025). Organizational leaders' views on digital health competencies in medical education: Qualitative semistructured interview study. *JMIR Medical Education*, 11, Article e64768. <https://doi.org/10.2196/64768>
- Zhang, R.-l., Gan, K., Zuo, H., Han, D., Shi, K., Wang, J., Zhang, K., Jiang, W., Wang, D., & Li, Y. (2025). Unleashing potential: Evaluating the effectiveness of the BOPPPS teaching strategy in Chinese urology education. *Frontiers in Medicine*, 12, Article 1452165. <https://doi.org/10.3389/fmed.2025.1452165>
- Zhao, J. (2024). The relationship between information literacy and online learning engagement: A moderated mediating model. *BMC Psychology*, 12(1), Article 791. <https://doi.org/10.1186/s40359-024-02282-6>
- Zou, Y., Kuek, F., Feng, W., & Cheng, X. (2025). Digital learning in the 21st century: Trends, challenges, and innovations in technology integration. *Frontiers in Education*, 10, Article 1469734. <https://doi.org/10.3389/feduc.2025.1469734>