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Research Article

Enhancing Student Learning Outcomes: The Interplay of Technology Integration, Pedagogical Approaches, Learner Engagement, and Leadership Support

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ABSTRACT

This study investigates how technology integration impacts student learning outcomes (SLO), focusing on the mediating effects of pedagogical approaches and learner engagement. It also examines the moderating role of leadership support in enhancing technology's impact. The study adopted a quantitative technique. The sampling was based on systematic random sampling. A total of 500 questionnaires were distributed, however, only 394 responses were included in the study after screening. Based on the comprehensive literature review and empirical analysis, the research proclaims that technology-enhanced instruction positively affects student engagement, and academic performance, and caters to diverse learning styles. Learner-centered pedagogies aligned with technology create more active and meaningful learning experiences, leading to deeper understanding and retention of knowledge. Additionally, learner engagement significantly amplifies the positive impact of technology integration on SLO. Effective leadership support, by championing technology initiatives and fostering a culture of innovation, further enhances technology's success in improving student learning outcomes. Strategic technology integration, supported by learner-centered approaches and leadership endorsement, has significant potential to enhance educational outcomes. Educational institutions can use these insights to design evidence-based practices for better student learning outcomes.

Keywords: access to technology; Technological pedagogical knowledge, digital literacy, learner engagement, pedagogical approaches

1. Introduction

In recent years, the rapid advancement of technology has significantly transformed the landscape of education, revolutionizing the way students learn and teachers teach. The integration of technology in educational settings has been a subject of extensive research, with a growing focus on its impact on SLO (Akram et al., 2022; AlAjmi, 2022). This study delves into the intricate relationship between technology integration and SLO, exploring the mediating role of pedagogical approaches and learner engagement, as well as the moderating role of leadership support. By investigating these key factors, we seek to gain deeper insights into how technology integration, when combined with effective teaching methods and active student involvement, can shape and improve educational outcomes(Zhan et al., 2022; Aldossari & Altalhab, 2022; Lai et al., 2022; Wu et al., 2022).

In today's digital age, technology has become an integral part of student's lives, and its integration into education has the potential to revolutionize the learning process(Caneva et al., 2023; Chakabwata, 2023; Zhan et al., 2022). By comprehending how technology interacts with pedagogical approaches and learner engagement, educators can design more effective and student-centered learning experiences(Consoli et al., 2023; Hazzam & Wilkins, 2023; Wu et al., 2022). Learner-centered pedagogies, when aligned with technology, can create a dynamic and interactive learning environment that fosters critical thinking, problem-solving skills, and a deep understanding of the subject matter. Furthermore, understanding the mediating effect of learner engagement sheds light on the importance of keeping students actively involved and motivated in their learning journey, as it positively influences their overall academic performance and achievement(Martin & Borup, 2022; (Caneva et al., 2023; Zhan et al., 2022) Pandita & Kiran, 2023; Hazzam & Wilkins, 2023).

Moreover, the study of the moderating role of leadership support in the technology-SLO relationship is of utmost significance for educational institutions and policymakers. Effective leadership plays a pivotal role in driving successful technology integration initiatives(Sa'ad Al Hyari, 2023; Dereso et al., 2023). When leaders actively champion technology integration, provide necessary resources, and foster a culture of innovation and professional development, it creates an environment conducive to leveraging technology's full potential(Ahlf & McNeil, 2023; Chakabwata, 2023; Zhan et al., 2022)). By recognizing the importance of leadership support, educational institutions can develop strategies to empower educators to use technology effectively, leading to improved student learning outcomes(Chen et al., 2023; Shaheen et al., 2023; Chou et al., 2023) The insights gained from this research will assist in shaping evidence-based practices, guiding educational institutions towards successful technology integration, and ultimately, a better tool for preparing students for success in a technologically-driven world.

The integration of technology in education has become increasingly prevalent, with educational institutions adopting digital tools and platforms to enhance teaching and learning experiences. However, while the potential benefits of technology integration on SLO are widely acknowledged, the underlying mechanisms that drive this relationship remain understudied(Daradkeh, 2023; Aliyu et al., 2023). Specifically, the mediating role of pedagogical approaches and learner engagement, as well as the moderating role of leadership support, in the impact of technology integration on SLO, warrants further investigation. Despite the growing interest in technology integration, there is a gap in understanding how specific pedagogical strategies aligned with technology can influence student engagement and, consequently, learning outcomes(Namboodiri, 2022; Gupta & Mathur, 2023). Additionally, limited research explores the influence of leadership support in optimizing technology integration efforts to maximize its impact on student learning. To address this gap, this study aims to investigate the complex interplay between technology integration, pedagogical approaches, learner engagement, and leadership support, and how they collectively shape student learning outcomes in the digital age (Akram et al., 2022; Kabilan et al., 2023; Caneva et al., 2023; Chakabwata, 2023; Zhan et al., 2022). Based on the above-mentioned gaps and recommendations, the study probes the "What is the interplay between technology integration, pedagogical approaches, learner engagement, and leadership support in shaping student learning outcomes? So, the study aims to investigate the impact of technology integration on student learning outcomes while examining the mediating role of pedagogical approaches and learner engagement, and the moderating role of leadership support. The paper is structured as follows. Section 1 provides operations definitions of the constructs used in the study, followed by hypotheses, theories, methodology, empirical analysis, discussion, and conclusion.

2. Operational Definitions

a. Access to Technology

Access to Technology (AT) is crucial for individuals to use digital devices and online resources. It has a significant impact on various aspects of life, especially in education where it enhances learning experiences, promotes digital literacy, and improves SLO. AT ensures equitable access for all learners and avoids widening existing disparities. It empowers individuals to thrive in the digital age and shapes modern societies(Al-rahmi et al., 2015; Ferns & Comfort, 2014; Kearsley & Shneiderman, 1998).

b. Technological Pedagogical Knowledge

Technological Pedagogical Knowledge (TPK) is a term that describes the integration of technology and pedagogy in educational practices. It refers to teachers' understanding of how to use technology effectively to support and enhance teaching and learning experiences(Kearsley & Shneiderman, 1998). Research has shown that TPK is a critical component of successful technology integration in the classroom. When teachers possess strong TPK, they can design technology-enhanced lessons, create engaging learning environments, and tailor instructional strategies to meet the diverse needs of students(Demmers et al., 2020). TPK enables educators to select appropriate digital tools, implement effective teaching methods, and address potential challenges in using technology for educational purposes(Lowyck & Pöysä, 2001; Xing et al., 2022a)

c. Digital Literacy

Digital Literacy (DL) refers to the ability to navigate, evaluate, and utilize digital technologies effectively and responsibly. It encompasses a range of skills, including accessing and interpreting information online, using digital tools for communication and collaboration, and critically evaluating digital content for accuracy and credibility(Kearsley & Shneiderman, 1998). Research has consistently shown that DL is crucial in the digital age, as it empowers individuals to participate fully in the modern world and make informed decisions in a technology-driven society. People with strong DL skills are better equipped to succeed in education, employment, and various aspects of life that require proficiency in using digital devices and online platforms(Myller et al., 2009). Moreover, DL plays a significant role in promoting online safety and privacy, reducing the risk of falling victim to digital threats and misinformation. As technology continues to shape our daily lives, developing DL skills is essential for individuals of all ages to thrive and engage meaningfully in the digital era(Nokes-Malach et al., 2015; Xing et al., 2022b).

d. Curriculum Integration

Curriculum integration (CI) refers to the intentional and purposeful blending of different subject areas and concepts within the educational curriculum(Al-rahmi et al., 2015). It aims to create a more cohesive and interconnected learning experience for students, allowing them to see the relevance and connections between various disciplines. Research has consistently supported the benefits of curriculum integration, showing that it leads to increased student engagement, a deeper understanding of complex topics, and improved critical thinking skills(Ng et al., 2022). By integrating subjects, students can apply knowledge across different domains, fostering a more holistic approach to learning. Curriculum integration also helps students develop essential skills, such as problem-solving, creativity, and interdisciplinary thinking, which are crucial for success in the modern world. Additionally, research has indicated that integrated curriculum models promote a positive learning environment, where students are more motivated, curious, and active in their learning process(Palincsar & Herrenkohl, 2002). Overall, curriculum integration offers a research-backed approach to enhance educational experiences, making learning more meaningful and preparing students for a diverse and interconnected world(Kearsley & Shneiderman, 1998; W. M. Al-Rahmi et al., 2015; Zhang et al., 2019)

e. Pedagogical Approaches

Pedagogical approaches refer to the methods and strategies employed by educators to facilitate learning and promote student engagement in the classroom. Research has shown that different pedagogical approaches can have a significant impact on student learning outcomes and overall academic performance(Lock & Redmond, 2021). Effective pedagogical approaches focus on student-centered learning, encouraging active participation, critical thinking, and problem-solving skills(Zhang et al., 2019). Research-based evidence supports the benefits of interactive teaching methods, such as collaborative learning, project-based learning, and inquiry-based approaches, which promote deeper understanding and knowledge retention(Eaton et al., 2021). Furthermore, research has demonstrated that flexible and adaptable pedagogical approaches that cater to individual learning styles and preferences can lead to improved student motivation and academic achievement. By implementing evidence-based pedagogical strategies, educators can create dynamic and effective learning environments, empowering students to become active and lifelong learners(Brodie et al., 2019; Ferns & Comfort, 2014).

f. Learner Engagement

Learner engagement refers to the active involvement, interest, and enthusiasm that students demonstrate in their learning experiences. Research has consistently shown that learner engagement is a crucial factor in academic success and positive learning outcomes(Nivedhitha, 2022). Engaged learners are more motivated to explore and understand the subject matter deeply, leading to better retention of knowledge and improved critical thinking skills(Demmers et al., 2020). Studies have also highlighted that learner engagement positively correlates with higher academic achievement, as actively engaged students are more likely to participate in class discussions, ask questions, and seek additional learning opportunities. Furthermore, research has indicated that learner engagement is not only essential for academic performance but also for fostering a positive learning environment and promoting a love for learning. Researchers like Kearsley & Shneiderman (1998) and Iqbal & Masroor (2023) When educators employ strategies to enhance learner engagement, such as interactive activities, real-world connections, and personalized learning experiences, they can create a more dynamic and enriching educational journey for their students.

g. Leadership Support

Leadership support refers to the backing, encouragement, and facilitation provided by organizational leaders to promote and sustain positive initiatives and changes within an institution or a team(Demmers et al., 2020). Research has consistently demonstrated the significance of leadership support in driving successful outcomes in various domains, including education, business, and healthcare. In the educational context, studies have shown that effective leadership support positively influences teacher motivation, job satisfaction, and overall school climate(Iliopoulos, 2019). Principals and administrators who actively support and value their teachers' efforts create a positive and nurturing environment, leading to increased teacher commitment and dedication to their profession(Kearsley & Shneiderman, 1998). According to Lowyck & Pöysä (2001) and Eaton et al., (2021), leadership support plays a pivotal role in implementing and sustaining innovative practices and initiatives, such as technology integration, curriculum changes, and professional development programs. Similarly, Ke et al., (2016) leaders champion these initiatives, provide necessary resources, and encourage collaboration, they significantly impact the success and positive outcomes of such endeavors.

h. Student Learning Outcomes

SLO refer to the knowledge, skills, and competencies that students are expected to acquire as a result of their educational experiences(Brodie et al., 2019). These outcomes serve as measurable indicators of students' academic progress and achievement. Research has consistently shown that well-defined and measurable SLO are essential for assessing the effectiveness of educational programs and informing instructional practices(Brodie et al., 2019). It plays a central role in guiding educational practices, evaluating student progress, and shaping students' overall educational experiences. When SLO are well-defined, measurable, and aligned with instructional practices, they can significantly impact student motivation, engagement, and achievement(Demmers et al., 2020). Moreover, by continuously assessing and evaluating SLO, educators can make data-driven decisions to enhance the effectiveness of their teaching and better prepare students for future success(Al-rahmi et al., 2015; Turner & Turner, 2020; Al-rahmi et al., 2015)

3. Theoretical Support

a. Engagement-Driven Technology Integration Theory

The Engagement-Driven Technology Integration Theory (EDTIT) posits that the successful integration of technology in educational settings is dependent on learner engagement, leading to enhanced SLO (Demmers et al., 2020; Zhang et al., 2019). This theory suggests that technology when effectively integrated with pedagogical approaches that promote active participation and motivation, can create a dynamic learning environment that fosters learner engagement. As a result, students become active participants in their education, leading to deeper learning experiences and improved academic achievement(Eaton et al., 2021; Al-Rahmi et al., 2015).

EDTIT focuses broadly on technology integration to positively influence student learning outcomes. When technology is effectively utilized to support and enhance instructional practices, it can provide students with access to a vast array of resources, interactive learning experiences, and personalized learning pathways, leading to improved academic performance and achievement(Lam, 2015; Ahn et al., 2022). The theory suggests active learner engagement, so that they immerse in their studies, explore diverse perspectives, and critically reflect on the content, resulting in deeper learning and better retention of knowledge. Additionally, when technology is coupled with appropriate pedagogical approaches, it can foster learner engagement and create a conducive learning environment, leading to improved learning outcomes(Lowyck & Pöysä, 2001; Nokes-Malach et al., 2015; Park et al., 2014).

Furthermore, the theory posits that when students are engaged in technology-enhanced learning experiences, they are more likely to achieve deeper learning(Kearsley & Shneiderman, 1998; Al-Rahmi et al., 2015). Deeper learning involves the acquisition of higher-order thinking skills, such as analysis, synthesis, and evaluation, as well as the ability to transfer knowledge to real-world situations. Technology integration, when coupled with learner engagement, supports students in developing these essential skills. In short, EDTIT emphasizes the interplay between technology integration, learner engagement, and effective pedagogical approaches in achieving improved student learning outcomes(Myller et al., 2009; Demmers et al., 2020). By strategically incorporating technology to foster active engagement and support deeper learning experiences, educators can create a more dynamic and effective learning environment that prepares students for success in the ever-evolving digital age(Lock & Redmond, 2021; Ferns & Comfort, 2014; Lu et al., 2022)

b. Collaborative Learning Engagement Theory

The Collaborative Learning Engagement Theory (CLET) postulates that collaborative learning significantly influences learner engagement and ultimately enhances SLO. This theory emphasizes the role of social interaction, cooperation, and active participation in the learning process, leading to deeper understanding and increased retention of knowledge(Lowyck & Pöysä, 2001). CLET promotes social interaction. The theory highlights that collaborative learning provides opportunities for students to engage in meaningful social interactions with their peers(W. Al-Rahmi et al., 2015). Through active collaboration, learners share ideas, ask questions, provide feedback, and engage in discussions, which fosters a sense of belonging and connection to the learning community. The social nature of collaborative learning enhances motivation and stimulates a positive learning environment(Ahn et al., 2022; Nokes-Malach et al., 2015; Rohm et al., 2013).

Similarly, collaborative learning encourages active participation from all students in the group. When students are actively engaged in the learning process, they take ownership of their learning and become more motivated to succeed(Xing et al., 2022b). Active participation in collaborative learning activities promotes higher-order thinking skills, critical analysis, and problem-solving, as students collaborate to find solutions collectively. This process leads to knowledge construction(Roberts, 2004). The theory suggests that collaborative learning supports the construction of knowledge through dialogue and interaction. Engaging in discussions, debates, and peer teaching allows students to clarify their ideas and challenge their thinking, contributing to a more comprehensive and integrated understanding of the content(Zhu et al., 2022; Ferns & Comfort, 2014; Demmers et al., 2020)

Furthermore, it supports social and cognitive development. These social skills are transferable to various real-life situations and are essential for success in personal and professional settings. Last but not least, CLET gave positive learning outcomes(Ke et al., 2016). The ultimate goal of CLET is to achieve positive learning outcomes for students. Research-based evidence indicates that collaborative learning leads to improved academic performance, increased knowledge retention, and higher levels of student satisfaction. Moreover, collaborative learning experiences positively influence students' attitudes toward learning, contributing to their lifelong learning journey(Radinger-Peer, 2019). In short, CLET emphasizes the significance of social interaction, active participation, and knowledge construction in collaborative learning experiences. By encouraging collaborative learning in educational settings, educators can create engaging and dynamic learning environments that promote learner engagement and foster deeper understanding. Through the collaborative process, students develop not only academic knowledge but also vital social and cognitive skills that are crucial for their overall development and future success(Iliopoulos, 2019; ; Nivedhitha, 2022).

4. Hypothesis and Research Framework for the Study

5.

a. Access to Technology and its Impacts on Student Outcome

The hypothesis suggests that the availability and utilization of technology have a beneficial effect on student's academic achievements and overall success. It implies that students who have access to technology, such as computers, the internet, and educational software, are more likely to perform better academically compared to those who lack such access(Annetta et al., 2009). There are several ways, through which students' performance can be increased. First and foremost, the availability of information and resource technology integration provides students with easy access to a vast amount of information and resources(McKnight et al., 2016). With internet connectivity, students can conduct research, access digital libraries, and explore educational content beyond the limitations of traditional textbooks. This increased access to information empowers students to deepen their understanding of subjects and enhances their ability to grasp complex concepts(Yang & Wu, 2012). Similarly, technology integration offers various interactive tools and platforms that facilitate engaging and interactive learning experiences. Educational software, multimedia presentations, simulations, and virtual reality applications can captivate students' attention and promote active participation in the learning process(Oncu & Cakir, 2011). These interactive learning opportunities can enhance comprehension, critical thinking, and problem-solving skills, leading to improved academic performance. Technology integration helps in personalized learning, adaptive learning, and providing customized content and targeted interventions. Likewise, collaboration and communication are the hallmark of technology integration in bringing positive impacts on the student's performance(Deng et al., 2019). Last but not least, access to technology develops digital skills among students and boosts their performance. Therefore, it is important to note that while access to technology is an essential component, other factors such as quality of instruction, educational support systems, socioeconomic status, and individual motivation also contribute to student success(Liao et al., 2021). On the basis of the above findings, the study proposes that

H1: Access to technology positively impacts student outcomes.

b. Technological Pedagogical Knowledge (TPK) impacts student outcomes

Studies suggest that teachers' TPK has a positive influence on student outcomes. It posits that teachers who possess strong TPK are better equipped to leverage technology in ways that enhance students' learning experiences and ultimately improve their academic achievements(Oncu & Cakir, 2011). Effective integration of the technology helps in selecting appropriate digital tools, resources, and platforms that align with the curriculum and learning objectives. By seamlessly integrating technology, these teachers can create engaging and interactive learning experiences that cater to diverse student needs and learning styles(Han & Finkelstein, 2013; Moreira et al., 2013).

TPK also helps in enhancing instructional strategies, empowers teachers to employ innovative instructional strategies, incorporates multimedia presentations, simulations, virtual labs, and online collaboration tools to enhance instruction and promote active student engagement, and fosters critical thinking, problem-solving skills, and creativity, leading to improved student outcomes(Baylor & Ritchie, 2002). Similarly, TPK provides personalized learning opportunities, which improve the weak areas of the students(Heflin et al., 2017). It improves the digital literacy skills of the learners. Teachers can guide students in using digital tools, evaluating online information, practising responsible digital citizenship, supportive and collaborative environment, and utilizing technology for research and presentation purposes. Strong digital literacy skills are essential for success in the digital age, and teachers with TPK can effectively prepare students for the demands of the modern world(Wang, 2015; Zainuddin et al., 2020). Therefore, the study proclaims that

H2: Technological Pedagogical Knowledge (TPK) positively impacts student outcomes

c. Impact of Digital Literacy (DL) on Students' Performance

The digital literacy of the instructor has a positive impact on student outcomes. It proposes that instructors who possess strong digital literacy skills and effectively integrate technology into their teaching practices can enhance student learning experiences, and engagement, and ultimately improve their academic achievements(Oncu & Cakir, 2011). With DL support, instructors can design and implement technology-enhanced instructional strategies that align with learning objectives. They can leverage various digital tools, multimedia resources, and online platforms to create interactive and engaging learning experiences. Effective instructional design facilitated by digital literacy can promote active learning, critical thinking, and problem-solving skills, leading to improved student performance(Eteokleous, 2008). It helps in the selection of required digital resources, enhances communication, interaction, and collaboration among students and teachers, provides personalized learning opportunities, and makes the Teaching-Learning Process (TLP) smoother, and congenial(Garrison & Vaughan, 2013; Chang & Hwang, 2018). On the basis of the above-cited literature, the study proposes that

H3: Digital Literacy (DL) Positively Impact on Students' Performance

d. Curriculum integration with technology and its impacts on students' outcomes

This research study proclaims that integrating technology into the curriculum has a positive influence on students' academic outcomes(Liao et al., 2021). It proposes that when technology is purposefully and effectively integrated into the curriculum, it can enhance student engagement, motivation, and learning, leading to improved academic performance and outcomes(Shin et al., 2019). There can be a number of benefits. It increases student engagement, and enhances TLP, making the learning process more simulated, prototype and persona-based, interactive, live feedback(Chang & Hwang, 2018). These processes make the learner get engaged in real-world problems, therefore, they obtain both abstract and practical reasoning and skills. It also brings independence among the learner, making them more confident and comfortable moving forward to accept the challenges of the real world(Annetta et al., 2009; Wang, 2015; Oncu & Cakir, 2011). The above-cited literature admits that

H4: Curriculum integration with technology positively impacts students' outcomes

e. The mediating role of the pedagogical approach between access to technology and student outcomes

The mediating role of the pedagogical approach between access to technology and student outcomes suggests that the effect of access to technology on student outcomes is partially or fully mediated by the pedagogical approach employed in the educational setting(Liao et al., 2021). In other words, the pedagogical approach acts as an intermediate factor that influences how access to technology ultimately impacts student outcomes. When considering the relationship between access to technology and student outcomes, it is important to recognize that simply having access to technology does not guarantee positive educational outcomes(Shieh, 2012). The pedagogical approach, which encompasses the instructional strategies, teaching methods, and learning activities employed by educators, plays a crucial role in leveraging the potential of technology to enhance student learning and achievement(Posey & Pintz, 2017; Gikandi et al., 2011)

The pedagogical approach influences how students interact with and utilize technology for learning purposes, shaping the impact of technology on their academic performance, engagement, critical thinking skills, and overall learning outcomes(Joseph, 2012;Han & Finkelstein, 2013). It determines how technology is effectively incorporated into the learning process, impacting the extent to which students benefit from the opportunities provided by technology for enhanced learning experiences and improved educational outcomes(Bereczki & Kárpáti, 2021; Okaz, 2015). On the basis of the findings, the study proposes that

H5: Pedagogical approach positively mediates between access to technology and student outcomes.

f. The mediating role of the pedagogical approach between technological pedagogical knowledge impact students' outcomes

TPK encompasses teachers' knowledge and skills in utilizing technology tools, selecting appropriate digital resources, designing technology-infused learning activities, and assessing students' technological competencies(Kim et al., 2013). When considering the mediating role of the pedagogical approach, TPK can influence student outcomes by shaping how teachers integrate technology into their instructional practices. According to previous studies, the pedagogical approach acts as a mediator between TPK and student outcomes(Zainuddin et al., 2020). Teachers' TPK influences their decision-making process and instructional practices, including how they incorporate technology into their teaching. This, in turn, impacts how students interact with technology, engage in learning activities, and acquire knowledge and skills(Posey & Pintz, 2017). The Pedagogical approach suggests that teachers' TPK influences their instructional decisions, which then impact student outcomes. When teachers possess strong TPK, they are more likely to effectively integrate technology into their pedagogical approach, leading to improved student outcomes(Ladyshewsky, 2006). Conversely, a lack of TPK may result in ineffective technology integration and, subsequently, reduced impact on student outcomes(Okaz, 2015). Overall, the mediating role of the pedagogical approach emphasizes the importance of teachers' TPK in leveraging technology to enhance student learning outcomes. It highlights the need for teachers to possess the knowledge and skills to effectively integrate technology into their pedagogical practices, thereby maximizing the potential benefits of technology for students' academic achievement, engagement, and overall learning success(Liao et al., 2021). On the basis of the above-mentioned literature, the study proposes that

H6. The pedagogical approach positively mediates between TPK and student outcomes.

g. The mediating role of the pedagogical approach between digital literacy impact students' outcomes

The mediating role of the pedagogical approach between digital literacy and students' outcomes suggests that the impact of digital literacy on student outcomes is partially or fully mediated by the pedagogical approach used in the educational setting. In other words, the pedagogical approach acts as an intermediate factor that influences how digital literacy ultimately affects student outcomes(Caneva et al., 2023). PA influences how students engage with and apply their digital literacy skills within the educational context, shaping the impact

of digital literacy on their academic performance, critical thinking skills, information literacy, and overall learning outcomes(Gupta & Mathur, 2023). It determines how digital literacy skills are effectively incorporated into the learning process, impacting the extent to which students can utilize their digital skills for enhanced learning experiences and improved educational outcomes(Ahlf & McNeil, 2023). Through the pedagogical approach, teachers can provide instructional support, guidance, and meaningful learning experiences that enable students to apply their digital literacy skills effectively in their academic pursuits(Han & Finkelstein, 2013). On the basis of the above-cited literature, the study proposes that
H7: The pedagogical approach positively mediates between DL and student outcomes.

h. The pedagogical approach positively mediates between CI and SO.

The pedagogical approach positively mediates between curriculum technological integration and student outcomes by shaping how technology is effectively incorporated into the teaching and learning process, ultimately impacting student achievement, engagement, and other learning outcomes(Eteokleous, 2008). It is important to recognize that the mere presence of technology in the curriculum does not guarantee positive educational outcomes(Joseph, 2012). The pedagogical approach, which encompasses instructional strategies, teaching methods, and learning activities, plays a crucial role in leveraging the potential of technology to enhance student learning and achievement(Kearsley & Shneiderman, 1998).
The pedagogical approach plays a critical role in mediating the relationship between curriculum technological integration and student outcomes. Teachers' instructional decisions, their ability to effectively integrate technology into their teaching practices, and their utilization of appropriate pedagogical strategies all influence how technology is utilized within the curriculum and how it impacts student learning(Qureshi et al., 2023). A well-designed pedagogical approach ensures that technology is effectively integrated, enhancing student engagement, understanding, and achievement. In summary, the pedagogical approach acts as a positive mediator between curriculum technological integration and student outcomes(Radinger-Peer, 2019). It highlights the importance of effective instructional practices that leverage technology to support and enhance student learning, leading to improved academic achievement, engagement, and other desired learning outcomes(Ferns & Comfort, 2014). On the basis of the above-mentioned literature, the study proposes that
H8: The pedagogical approach positively mediates between CI and SO.

6. Learner Engagement positively mediates between Access to Technology and SLO

Research has shown that access to technology in educational settings has a significant impact on SLO (Eteokleous, 2008). Numerous studies have demonstrated that students who have access to digital devices, online resources, and educational software exhibit improved academic performance and higher levels of achievement. For instance, a meta-analysis conducted by Hattie (2015) found a strong positive for technology use in education. Additionally, a study McDuff (2012)revealed that students with access to technology demonstrated better problem-solving skills and critical thinking abilities. These findings highlight the importance of providing students with ample opportunities to leverage technology for learning. However, the extent to which access to technology positively influences SLO can be further enhanced by an important mediating factor learner engagement(Deng et al., 2019).
Research admits that when students actively engage with technology during their learning experiences, they are more likely to acquire a deeper understanding of the subject matter and retain information effectively. A study by Anderson, Boyles, and Rainie (2018) explored the mediating role of learner engagement in the context of technology-enhanced learning environments. The researchers found that when learners actively engaged with technology tools and resources, their academic performance and learning outcomes significantly improved(Baylor & Ritchie, 2002). Further, the findings reinforce the notion that technology alone is not sufficient; rather, it is the active participation and engagement of students that catalyze the positive impact of technology on learning outcomes(Eteokleous, 2008). The arguments lead the study to hypothesis

H9: Learner Engagement positively mediates between Access to Technology and SLO

Learner Engagement positively mediates between TPK and SLO

It is widely acknowledged that teachers' proficiency in TPK can significantly influence SLO. When teachers effectively leverage technology to enhance their teaching methods and adapt them to the specific subject matter, students are more likely to experience improved learning outcomes(Liao et al., 2021). However, the role of learner engagement becomes pivotal in mediating the relationship between TPK and SLO. Learner engagement refers to the active participation and involvement of students in their learning process, and it can serve as a bridge that connects the teacher's technological pedagogical knowledge with student achievement(Y.-C. J. Wu et al., 2019).
Research has provided compelling evidence for the mediating role of learner engagement between TPK and SLO. A study by Koehler and Mishra (2009) explored the impact of teachers' TPK on student outcomes in technology-enhanced classrooms. The researchers found that when teachers possessed high levels of TPK, students' engagement in the learning activities increased significantly. Furthermore, the study revealed a positive association between learner engagement and academic achievement(Baylor & Ritchie, 2002). This suggests that when teachers effectively integrate technology into their pedagogy (TPK), students become more engaged in the learning process, which, in turn, leads to improved learning outcomes. The findings of this study

highlight the importance of focusing not only on teachers' technological knowledge but also on how that knowledge translates into engaging learning experiences for students(Deng et al., 2019).
Another study by Sang et al. (2021) explored the relationship between TPK, learner engagement, and student learning outcomes in the context of online learning environments. The researchers found that teachers who demonstrated strong TPK were more likely to create interactive and technology-rich learning experiences, fostering higher levels of learner engagement among students. Notably, the study revealed that learner engagement acted as a significant mediator, linking teachers' TPK with student learning outcomes. When students were actively engaged in the learning process, they demonstrated better understanding of the content and performed more effectively in assessments(Garrison & Vaughan, 2013). This study provides further support for the notion that learner engagement plays a vital mediating role in the relationship between TPK and SLO, particularly in technology-driven learning environments(Posey & Pintz, 2017). On the basis of these findings the study postulates that

H10: Learner Engagement positively mediates between TPK and SLO.

Learner Engagement positively mediates between DL and SLO

Digital literacy is a crucial skill in the 21st century, enabling individuals to effectively navigate, evaluate, and utilize digital technologies for various purposes, including education(Garrison & Vaughan, 2013). As DL becomes increasingly important in educational settings, researchers have explored its impact on SLO. Studies have shown that students with higher levels of DL skills tend to exhibit improved academic performance, information-processing skills, and critical-thinking abilities(Daradkeh, 2023). The mediating role of learner engagement has positive effects on digital literacy on SLO are further enhanced when students actively engage with digital learning materials and technology-enhanced educational resources(Chen et al., 2023).
Numerous research studies have investigated the mediating role of learner engagement between digital literacy and student learning outcomes. For example, a study by Hew and Brush (2007) examined the impact of digital literacy on student performance in online learning environments. The researchers found that students with higher levels of digital literacy were more likely to engage actively with the online learning materials and demonstrate better learning outcomes. The study also revealed that learner engagement served as a significant mediator, explaining part of the relationship between digital literacy and academic achievement(Shaheen et al., 2023). These findings suggest that students' digital literacy skills alone are not sufficient to ensure improved learning outcomes; learner engagement plays a critical role in translating digital literacy into academic success(Gupta & Mathur, 2023).
Additionally, research has highlighted the importance of learner engagement in fostering positive attitudes toward digital technologies, which, in turn, can influence student learning outcomes. A study by Chu and Law (2011) examined the relationship between digital literacy, learner engagement, and student perceptions of technology in the classroom(Chou et al., 2023). The results indicated that students who were more digitally literate and engaged with technology had more positive attitudes toward using digital tools for learning. Furthermore, students with positive perceptions of technology were more likely to embrace digital learning opportunities and, consequently, achieve better learning outcomes. This study underscores the significance of learner engagement in shaping students' attitudes toward digital literacy and its impact on academic achievement(Ahlf & McNeil, 2023; Nassir & Benoliel, 2023). These finding proclaims that

H11: Learner Engagement positively mediates between DL and SLO

Learner Engagement positively mediates between CI and SLO

The adoption of integrated curriculum approaches has gained attention in educational research for its potential to enhance SLO. Studies have shown that integrated curriculum models can lead to improved critical thinking skills, problem-solving abilities, and a deeper understanding of complex topics. Previous studies support the mediating role of learner engagement between curriculum integration and student learning outcomes(Caneva et al., 2023). A study by Drake and Reid (2012) examined the impact of an integrated curriculum model on student achievement in science and mathematics. The researchers found that students who experienced the integrated curriculum approach demonstrated higher levels of engagement in the learning process compared to those following traditional, subject-based instruction(Pandita & Kiran, 2023). Furthermore, the study revealed that learner engagement significantly mediated the relationship between curriculum integration and academic achievement. This suggests that when students actively engage with the integrated curriculum materials and experiences, they are more likely to achieve better learning outcomes(L. Wu et al., 2022).
Additionally, learner engagement has been associated with increased intrinsic motivation and a positive attitude toward learning, both of which contribute to improved student learning outcomes. A meta-analysis by Fredricks, Blumenfeld, and Paris (2004) explored the link between learner engagement and academic achievement across various educational contexts. The results indicated that higher levels of learner engagement were consistently associated with better academic performance. Moreover, engaged learners exhibited greater persistence, effort, and enthusiasm in their studies. In the context of integrated curriculum approaches, students are more likely to be engaged when they see the relevance and interconnectedness of different subject

areas, leading to a more comprehensive understanding of complex concepts and a deeper appreciation for the learning process(Consoli et al., 2023). Consequently, the study hypothesis that

H12: Learner Engagement positively mediates between CI and SLO

i. Moderating role of leadership support between access to technology and student outcomes

The moderating role of leadership support between access to technology and student outcomes suggests that the impact of access to technology on student outcomes is influenced by the level of support provided by school leaders or administrators. In other words, leadership support acts as a moderator that can enhance or diminish the relationship between access to technology and student outcomes(Namboodiri, 2022). The level of leadership support can influence how access to technology is effectively utilized by teachers and students. Strong leadership support can provide the necessary resources, guidance, and encouragement for teachers to effectively integrate technology into their instructional practices, leading to enhanced student outcomes. Conversely, limited or inadequate leadership support may hinder the effective use of technology and limit its impact on student outcomes. It is a contingent relationship(Ogunyemi et al., 2022). When leadership support is strong, it creates an environment that fosters effective technology integration, promotes teacher professional development, provides necessary resources, and supports teachers in implementing innovative instructional practices(Aliyu et al., 2023). This, in turn, enhances the impact of access to technology on student outcomes. It emphasizes the need for school leaders or administrators to provide the necessary support, resources, and guidance to ensure effective technology integration, which can lead to improved student outcomes in terms of academic achievement, engagement, and other desired learning outcomes(Zhan et al., 2022). This reasoning leads us to the conclusion that

H13: Leadership support positively moderates the relationship between access to technology and student outcomes

I. Moderating role of leadership support between TPK and student outcomes

The moderating role of leadership support between TPK and student outcomes suggests that the impact of teachers' TPK on student outcomes is influenced by the level of support provided by school leaders or administrators. In other words, leadership support acts as a moderator that can enhance or diminish the relationship between TPK and student outcomes(Martin & Borup, 2022). The level of leadership support can influence how effectively teachers apply their TPK in the classroom. Strong leadership support can provide the necessary resources, guidance, and encouragement for teachers to effectively integrate technology into their pedagogical practices, leading to enhanced student outcomes(Ogunyemi et al., 2022). Conversely, limited or inadequate leadership support may hinder the effective use of TPK and limit its impact on student outcomes(Akram et al., 2022).

When leadership support is strong, it creates an environment that fosters the development and application of TPK, provides necessary resources and professional development opportunities, and supports teachers in implementing effective technology integration strategies(Ogunyemi et al., 2022). This, in turn, enhances the impact of TPK on student outcomes. It emphasizes the need for school leaders to provide the necessary support, resources, and guidance to ensure effective TPK development and implementation, which can lead to improved student outcomes in terms of academic achievement, engagement, and other desired learning outcomes(Consoli et al., 2023). So, the study came-up with proclaims that

H14: Leadership support positively moderates the relationship between TPK and student outcomes

j.Moderating role of leadership support between DL and student outcomes

The moderating role of leadership support between Digital Literacy (DL) and student outcomes suggests that the impact of students' digital literacy on their outcomes is influenced by the level of support provided by school leaders. In other words, leadership support acts as a moderator that can enhance or diminish the relationship between digital literacy and student outcomes(Aliyu et al., 2023). The moderating role of leadership support suggests that the impact of students' digital literacy on their outcomes is contingent on the level of support provided by school leaders. When leadership support is strong, it creates an environment that fosters the development and application of digital literacy, provides necessary resources and guidance, and supports students in applying their digital literacy skills effectively. This, in turn, enhances the impact of digital literacy on student outcomes(Chou et al., 2023).

In summary, the moderating role of leadership support highlights the importance of supportive leadership in maximizing the impact of students' digital literacy on their outcomes. It emphasizes the need for school leaders or administrators to provide the necessary support, resources, and guidance to ensure effective digital literacy development and implementation, which can lead to improved student outcomes in terms of academic achievement, information literacy, problem-solving abilities, and other desired learning outcomes(Chen et al., 2023; Nassir & Benoliel, 2023). The study concludes that

H15: Leadership support positively moderates the relationship between DL and student outcomes

k. Moderating role of leadership support between CI and student outcomes

The moderating role of leadership support between Curriculum Integration (CI) and student outcomes suggests that the impact of curriculum integration on student outcomes is influenced by the level of support provided by school leaders or administrators. In other words, leadership support acts as a moderator that can enhance or diminish the relationship between curriculum integration and student outcomes(Borokhovski et al., 2016). When leadership support is strong, it creates an environment that fosters curriculum integration,

provides necessary resources and professional development opportunities, and supports teachers in implementing integrated approaches to teaching and learning. This, in turn, enhances the impact of curriculum integration on student outcomes(Liao et al., 2021). It emphasizes the need for school leaders or administrators to provide the necessary support, resources, and guidance to ensure effective curriculum integration, which can lead to improved student outcomes in terms of academic achievement, critical thinking skills, problem-solving abilities, collaboration, and other desired learning outcomes(Chang & Hwang, 2018). So, the study proposes that
H16: Leadership support positively moderates the relationship between CI and student outcomes

On the basis of the comprehensive review, findings, suppositions, and recommendations, the study proposes the following model for the study

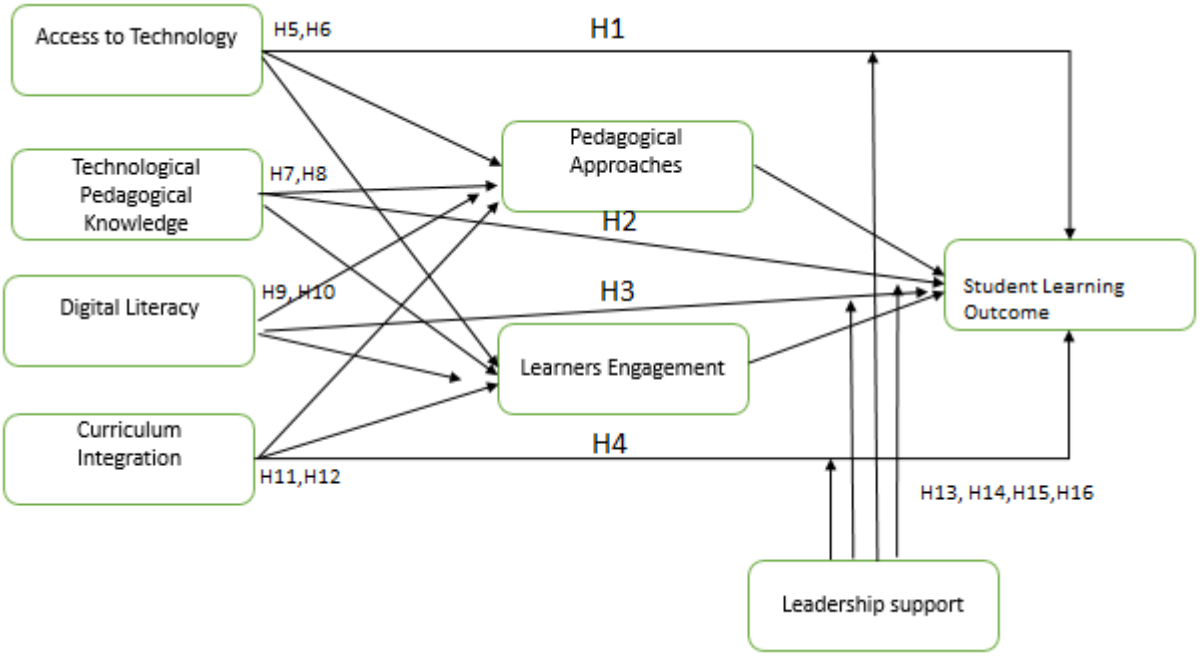

Figure 1: Research Model for the Study

7. Methodology

a. Research Design

The study adopted quantitative methods for data analysis. Data were collected using a cross-sectional approach. The quantitative technique was adopted due to its generalizability, objectivity, replicability, measurement, and precision. Moreover, the study was supposed to large scale data besides testing causal relationships, therefore, a quantitative approach was adopted in the study.

b. The target population

The target population were the students of the K12 schools and colleges, where technology has been integrated comprehensively in the classrooms. The data was collected using a structured questionnaire, which was sent to the target population. A total of 600 questionnaires were distributed, however, only 529 were collected back from the respondent. During the screening process, 13 questionnaires were found incomplete, therefore, they were discarded. Moreover, 17 questionnaires were found redundant, so, the study left with 499 responses, which were included in the study processes and analysis.

c. Sampling Technique

A systematic random sampling technique was adopted for the data collection. This technique ensures that every element of the population was given its due weightage and it decreases the chances of biases and achieves a representative sample from the population. The sample size was determined using a G-Power reference (Scientific Calculator) and also, there is a general rule that for the larger population the minimum sample size should be at least 384. However, the study was fortunate enough to get a larger sample size than its threshold. Moreover, a sample frame was defined and a randomized starting point was decided to avoid all kinds of possible biases

d. Data Collection Methods and Research Instruments

The data was collected using a structured questionnaire adapted from the previous studies, given in Appendix-A. The target population was the educated respondents, at least holding a bachelor's degree. Moreover, the survey was self-administrated, therefore, the response ratio was high.

e. Ethical Considerations

Informed consent was taken from the respondent via a detailed letter, which explained the purpose of the study. Moreover, confidentiality, and privacy protection for participants were also observed.

f. Data Analysis

Data analysis was done using SPSS and Smart-PLS. The collected data was first given input in SPSS v23 to check the initial screening of the data based on the missing values, data normality, and outliers' check. A descriptive statistic is used to test the demographic profile of the respondents using SPSS software. Smart-PLS 4.0 was deployed for analysis due to its versatility, and capacity to absorb and handle abnormal data. It also has the capability to handle complex and non-linear data. Moreover, small size and unequally populated data can also be handled by Smart-PLS. additionally, Smart-PLS uses the two-staged technique, in which, the first measurement model is tested for reliability and the later structural model for the hypothesized relationship.

8. Findings of the Study

7.1 Measurement Model Assessment

After initial screening and descriptive statistics, Smart-PLS was deployed to assess the consturcts validity, reliability, and other initial constructs formalities. For the internal consistency and relaibility, PLS-algorithm observe Cronbach's Alpha (CA), and Composite Relaibility (CR). The study found both the values reliable, as both of the falled in the acceptance threshold and limits. All values for the CA were obtained more then 0.70, and for CR, the limites were 0.906 to 0.943. (Reference) . For the convergent validity, the PLS-algorithm uses Factor Loading (FLs) of all the items and the Average Variance Extracted (AVE). The values for the FLs should be more than 0.70 to confirm the convergent validity. Similarly, for the EVAs, the obtained values were in the defined limits, i.e. (AVEs > 0.5). These constructs assured adequate convergent validity. The values for the above-mentioned constructs have been mentioned in Table 2.

Table 2: Constructs validity and reliability

Constructs/Items	F.L	CA	CR	AVE
AT1	0.893	**0.887**	**0.921**	**0.587**
AT2	0.893			
AT3	0.856			
AT4	0.846			
CI1	0.726	**0.881**	**0.917**	**0.539**
CI2	0.655			
CI3	0.797			
CI4	0.833			
DL1	0.787	**0.927**	**0.941**	**0.671**
DL2	0.784			
DL3	0.817			
DL4	0.649			
LE1	0.768	**0.818**	**0.722**	**0.582**
LE2	0.668			
LE3	0.801			
LE4	0.782			
LS1	0.738	**0.926**	**0.933**	**0.632**
LS2	0.778			
LS3	0.765			
LS4	0.798			
LS5	0.776			
PA1	0.776	**0.941**	**0.942**	**0.670**
PA2	0.852			

PA3	0.865			
PA4	0.829			
SLO1	0.794	**0.929**	**0.942**	**0.665**
SLO2	0.788			
SLO3	0.765			
SLO4	0.729			
SLO5	0.794			
TPK2	0.889	**0.911**	**0.924**	**0.618**
TPK3	0.857			
TPK4	0.889			
TPK5	0.927			

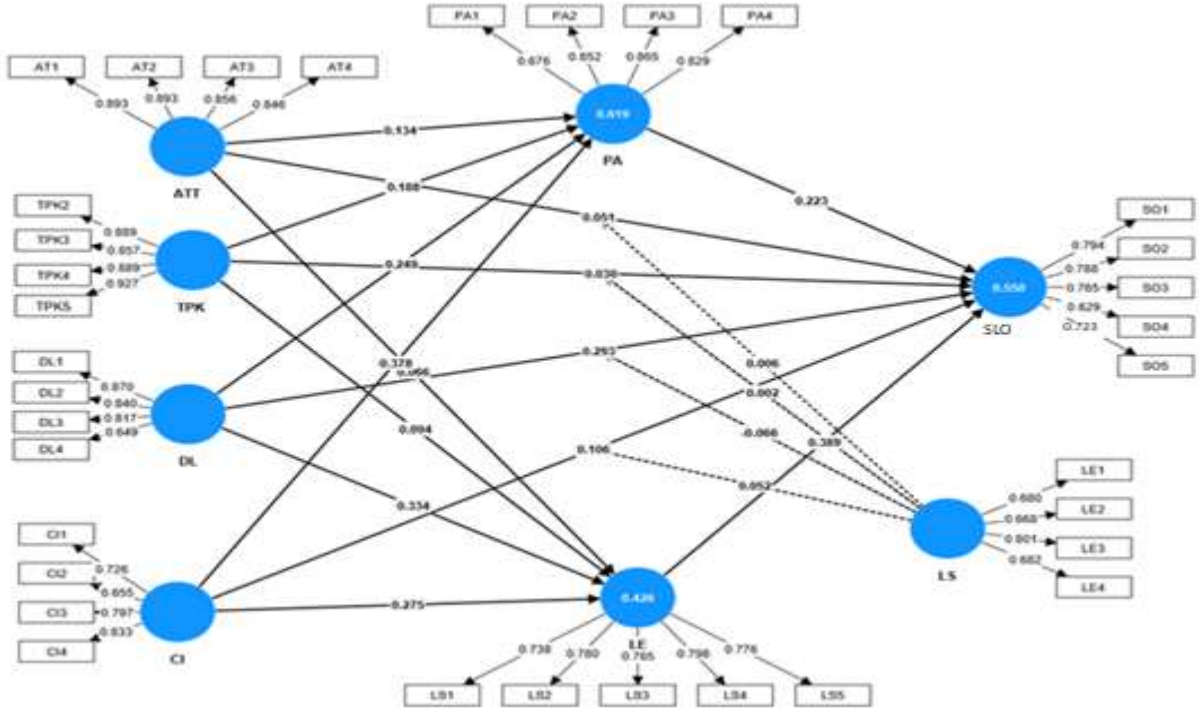

Figure 3: Outer loadings and AVE values of measurement model from PLS-Algorithm

The study checked the discriminant validity through Fornell Lacker and also thorugh Heterotrait and Monotrait Ratio (HTMT). Fronell Lacker assess and calculate that the square root of AVEs of one construct should must be greater than the constructs' inter correlation with the values of the other constucts. The attained results have been presented in Table 3, which indicates and affirm the construct validity of the instrument and the constructs.

Table 3: Discriminant validity- Fornell Larcker

Constructs	**AT**	**CI**	**DL**	**LE**	**LS**	**PA**	**SLO**	**TPK**
AT	0.773							
CI	0.614	0.741						
DL	0.608	0.694	0.820					
LE	0.640	0.779	0.724	0.816				
LS	0.423	0.425	0.511	0.528	0.780			
PA	0.685	0.675	0.725	0.817	0.499	0.791		
SLO	0.372	0.468	0.374	0.462	0.473	0.674	0.783	

TPK	0.637	0.593	0.738	0.637	0.634	0.674	0.637	0.748

After Fronell Larcker's test, the study deployed HTMT method to assess and confirm the discriminant validity among the set of constructs of the study. This method was introduced by Henseler et al. (2015). It holds the threshold value to be 0.9. The results of the study confirm that for all the constructs, the value attained were greater enough to qualify the test. The HTMT values are presented in Table 4.

Table 4: Discriminant validity- HTMT

Constructs	**AT**	**CI**	**DL**	**LE**	**LS**	**PA**	**SLO**	**TPK**
AT								
CI	0.682							
DL	0.654	0.766						
LE	0.699	0.859	0.778					
LS	0.460	0.439	0.525	0.532				
PA	0.752	0.762	0.793	0.895	0.516			
SLO	0.738	0.738	0.738	0.839	0.388	0.738		
TPK	0.684	0.738	0.637	0.637	0.737	0.738	0.683	

7.2 Assessment of the Structural Model

After confirming the measurement model, the study assessed the structural model of the study, as the study design and recommendations. In the structural model, first of all, the Variance Inflation Factor (VIF) was assessed to affirm the multicollinearity issues. Multicollinearity proclaims that the independent variables are highly correlated and they can affect the performance of the model. Therefore, according to research, its vale should be less than 3 or (2.975). The other structural model criteria are coefficient of determination (R^2), the effect size level (f^2), and the predictive relevance (Q^2). There values and threshold levels are given in Table 4.

Table 5: Structural model assessment

R-Square	Endogenous Variables	R Square	R Square Adjusted		0.26: Substantial, 0.13: Moderate, 0.02: Weak (Cohen, 1989)
	LE	0.569	0.561		
	PA	0.548	0.552		
	SO	0.584	0.594		
Effect Size (F-Square)	Exogenous Variables	LE	PA	SLO	0.35: Substantial, 0.15: Medium effect, 0.02: Weak effect (Cohen, 1989)
	AT	0.035	0.036	0.021	
	CI	0.027	0.028	0.028	
	DL	0.014	0.015	0.016	
	LS	0.017	0.007	0.012	
	TPK	0.084	0.069	0.082	
Collinearity (Inner VIF)	Exogenous Variables	LE	PA	SLO	VIF <= 5.0 (Hair et al., 2020)
	AT	2.531	2.332	2.121	
	LC	2.841	2.082	2.328	
	OS	2.972	1.631	2.814	
	SI	1.493	2.035	1.212	
	SN	2.101	2.177	2.838	
Predictive Relevance (Q-Square)	Endogenous Variables	CCR	CCC		Value higher than o indicates Predictive Relevance (Stone, 1974; Geisser, 1975)
	SLO	0.324	0.485		

After the measurement and structural testing of the model, the study run the bootstrapping 5000 resampling technique to test the proposed hypothesis. All the attained values have been presented in Table 6. According to

the results, all the direct hypotheses were found significant. ATT, TPK, DL and CI have significant positive impact on the SLO. ATT having the parameter β = 0.051, t=4.295, and p< 0.000, TPK having bootstrapping values β = 0.061, t=5.285, and p< 0.001, DL attained values β = 0.081, t=8.845, and p< 0.041, and CI with β = 0.049, t=6.357, and p< 0.001 affirms that SLO is dependent on ATT, TPK, DL and CI. This means that the integration of the holistic parameters is needed for the significant SLO. So, H1, H2, H3, H4 are accepted. The values are confirmed and supported by Table 6 and Figure 3.
4.295, 5.285, 8.845, 6.357

Table 6: Path coefficient (Direct effect) result

Hypotheses		OS/Beta	SM	SD	T	P Values	Decision
H1	ATT -> SLO	0.051	0.072	0.033	4.295	0.000	Significant
H2	TPK -> SLO	0.061	0.377	0.093	5.285	0.001	Significant
H3	DL-> SLO	0.081	0.185	0.073	8.845	0.041	Significant
H4	CI -> SLO	0.049	0.222	0.095	6.357	0.001	Significant

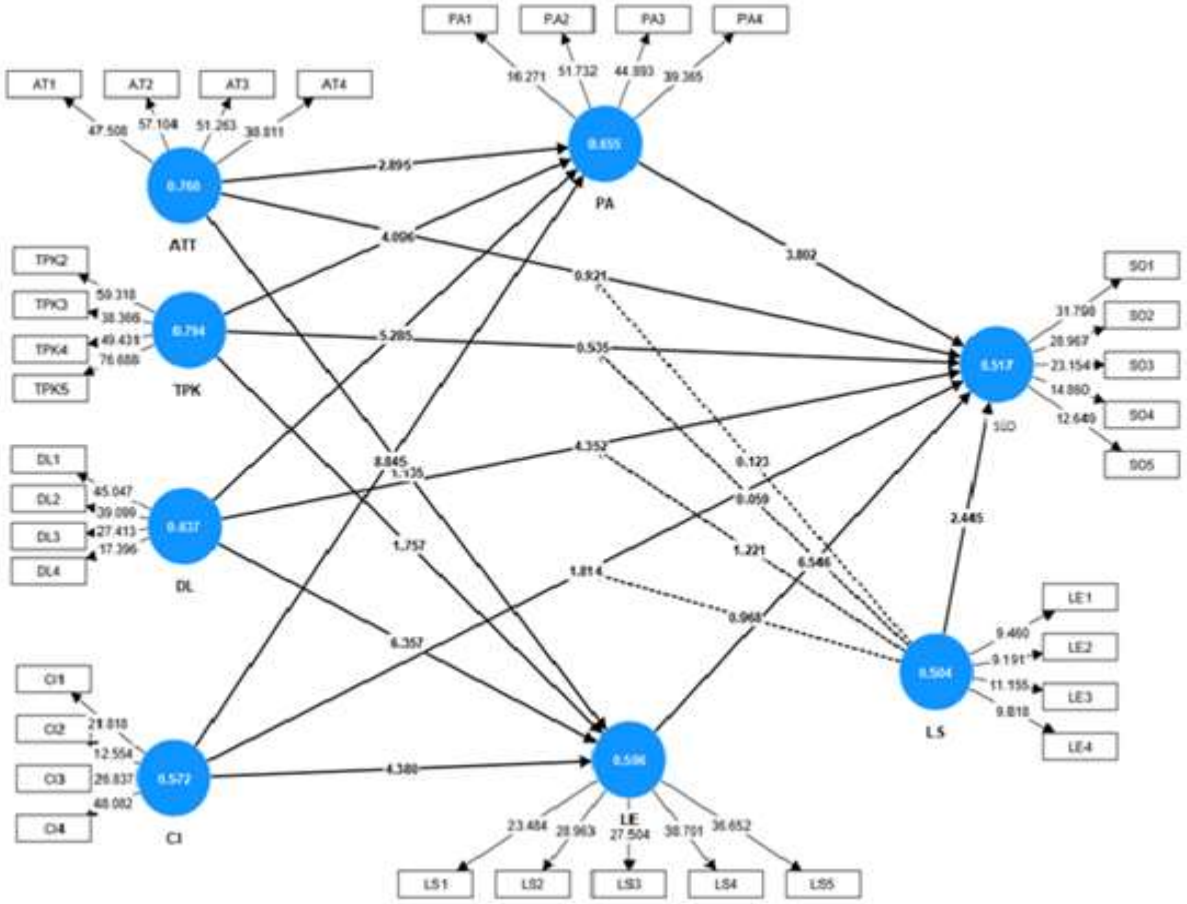

Figure 4: Inner model with t-values in the structural model from Bootstrapping test

PA, LE, SLO
Table 7 contains the values for the indirect hypotheses, which is composed of moderation and mediation hypotheses. There were eight (8) mediating and four (4) moderating hypothesis. Table 7 contains results for both mediation and moderating hypothesis. According to the statistics, all the mediating hypotheses proclaims that PE and LE hold significant positive impact on SLO. There were no negative values in the OS, SM and SD and all the T-values attained were more than 1.96 and also the P-value attained were less than the threshold value, i.e. P<=0.05.
For the moderating hypotheses, only one hypothesis affirmed the significant impact on DLO. According to the statistics, only values for LS*TPK-> SO hypothesized relationship holds true, i.e. the T-value attained i.e. t= 546 was larger than its limit size (1.96), and also the P-Value was 0.000, less than the threshold value i.e. P<=0.005, which indicates that the availability of the LS has a positive moderating (contingent) impact on

SLO. According to the study results, SL does not moderate the relationship between DL, CI, and ATT and the dependent variable SLO, as indicated by their values.

Table 7: Results of Indirect Hypothesis

s.no	Hypotheses	OS	SM	SD	T	P	Decision
1	DL -> PA -> SLO	0.122	0.098	0.058	2.895	0.002	Significant
2	ATT -> PA -> SLO	0.147	0.163	0.044	4.096	0.003	Significant
3	DL -> LE -> SLO	0.218	0.204	0.038	2.372	0.013	Significant
4	ATT -> LE -> SLO	0.079	0.073	0.068	3.948	0.026	Significant
5	CI -> LE -> SLO	0.122	0.100	0.088	4.029	0.001	Significant
6	TPK -> LE -> SLO	0.147	0.137	0.024	5.278	0.000	Significant
7	CI -> PA -> SLO	0.218	0.247	0.048	4.389	0.004	Significant
8	TPK -> PA -> SLO	0.689	0.063	0.058	3.842	0.002	Significant
9	LS* ATT-> SLO	0.212	0.047	0.038	0.123	0.600	Not significant
10	LS * TPK-> SLO	0.657	0.468	0.024	6.546	0.000	Significant
11	LS * DL-> SLO	0.238	0.278	0.078	1.221	0.600	Not significant
12	LS * CI-> SLO	0.037	0.047	0.038	0.968	0.800	Not significant

9. Discussion

Overall, the findings from the measurement model assessment, structural model assessment, and hypothesis testing provide substantial evidence to support the proposed relationships and confirm the research objectives. The results contribute to a better understanding of the factors influencing SLO and highlight the importance of ATT, TPK, DL, and CI in achieving significant SLO.

The impact of technology integration on student learning outcomes through the mediating role of pedagogical approaches and learner engagement and the moderating role of leadership support is a complex and multi-faceted relationship that has garnered significant attention in educational research. This discussion will explore the research-based evidence supporting the interplay between these key factors and their collective influence on student learning outcomes.

Numerous research studies have demonstrated the positive impact of technology integration on student learning outcomes. Technology offers various interactive and multimedia resources that can enhance content delivery, cater to diverse learning styles, and provide personalized learning experiences. A meta-analysis by Tamim et al. (2011) found that technology integration had a moderate effect on improving student learning outcomes across various subjects and grade levels. Moreover, technology-enhanced instruction has been associated with increased student motivation and engagement, leading to better academic performance (Kay, 2012). These findings highlight the potential of technology as a valuable tool to support and enhance student learning outcomes.

Similarly, the effectiveness of technology integration on student learning outcomes is significantly influenced by the mediating roles of pedagogical approaches and learner engagement. When educators employ learner-centered pedagogical strategies that align with technology integration, it can lead to more active and meaningful learning experiences. A study by Alzaghoul and Obeidat (2014) revealed that the use of technology in tandem with constructivist pedagogies positively impacted student learning outcomes in mathematics education. Furthermore, learner engagement plays a crucial role in mediating the relationship between technology integration and student learning outcomes. Engaged learners actively participate in technology-enhanced learning activities, leading to deeper understanding and knowledge retention (Means et al., 2013). When pedagogical approaches and learner engagement are integrated with technology, it amplifies the impact on student learning outcomes. Leadership support plays a vital moderating role in determining the success of technology integration efforts in educational settings. Research has shown that when leaders actively support technology initiatives, provide resources, and foster a positive climate for innovation, the benefits of technology integration on student learning outcomes are magnified. A study by Ertmer et al. (2012) found that strong leadership support positively influenced teacher attitudes and intentions to integrate technology into their instructional practices. Leadership support creates a culture of collaboration, professional development, and risk-taking, which can empower educators to use technology effectively to enhance student learning.

It is obvious, that when educators strategically integrate technology with learner-centered pedagogies and foster learner engagement, it can lead to improved student learning outcomes. Additionally, strong leadership support creates an enabling environment that maximizes the potential of technology integration. To fully harness the benefits of technology in education, schools, and educational institutions should prioritize

pedagogical training, create a supportive leadership structure, and encourage continuous research to inform evidence-based practices that lead to better student learning outcomes. One thing need to be investigated in future research that, as this study found that SL does not have any contingent impact on SLO when integrated with ATT, CI and DL. There may some contextual factors, which limit the contingent effect and can be investigated through qualitative (exploratory) study, and longitudinal study may also help to unveil the factors involved.

10. Conclusion

This research has shed light on the intricate relationship between technology integration, pedagogical approaches, learner engagement, and leadership support, and their collective impact on student learning outcomes. The findings have highlighted the significance of learner-centered pedagogies aligned with technology in creating engaging and dynamic learning environments that foster deeper understanding and knowledge retention. Learner engagement emerged as a pivotal factor, amplifying the positive effects of technology integration on student learning outcomes. Moreover, the study underscored the crucial role of effective leadership support in driving successful technology integration initiatives, creating a culture of innovation, and empowering educators to harness technology's full potential. By exploring these interwoven factors, this research has contributed valuable insights for educational stakeholders, informing evidence-based practices to optimize technology integration in educational settings. As educational institutions seek to adapt to the ever-evolving digital landscape, understanding the mediating and moderating roles in the technology-SLO relationship becomes paramount. By implementing strategic technology integration, supported by learner-centered pedagogies and leadership endorsement, educators can pave the way for improved student learning outcomes in the digital age.

However, while this research provides significant contributions to the field, there are still areas that warrant further exploration. Future studies could delve deeper into specific pedagogical approaches that synergize best with technology integration, further examining the impact on different subjects and grade levels. Additionally, understanding the role of individual differences in learner engagement and the varying degrees of leadership support across educational contexts would enhance the applicability of the findings.
This research lays the foundation for a more comprehensive understanding of the impact of technology integration on student learning outcomes. It underscores the importance of considering pedagogical approaches, learner engagement, and leadership support as integral elements when harnessing technology's potential to optimize educational outcomes. As technology continues to shape the landscape of education, ongoing research, and evidence-based practices will be essential in preparing students for success in an increasingly digitized and interconnected world.

References

1. Ahlf, M., & McNeil, S. G. (2023). An exploratory review of literature on moderation in asynchronous discussions. *Distance Education*, *44*(1), 137–161.
2. Ahn, S. J., Kim, J., & Kim, J. (2022). The bifold triadic relationships framework: A theoretical primer for advertising research in the metaverse. *Journal of Advertising*, *51*(5), 592–607.
3. 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*, 920317.
4. AlAjmi, M. K. (2022). The impact of digital leadership on teachers' technology integration during the COVID-19 pandemic in Kuwait. *International Journal of Educational Research*, *112*, 101928.
5. Aldossari, S., & Altalhab, S. (2022). Distance Learning during COVID-19: EFL Students' Engagement and Motivation from Teachers' Perspective. *English Language Teaching*, *15*(7), 85–109.
6. Aliyu, J., Osman, S., Kumar, J. A., & Jamil, M. R. M. (2023). The design and development of a learning strategy to enhance students' engagement in simultaneous equations: An evaluation viewpoint. *JOTSE*, *13*(1), 36–52.
7. Al-Rahmi, W. M., Othman, M. S., & Yusuf, L. M. (2015). Effect of engagement and collaborative learning on satisfaction through the use of social media on Malaysian higher education. *Research Journal of Applied Sciences, Engineering and Technology*, *9*(12), 1132–1142.
8. Al-rahmi, W. M., Othman, M. S., & Yusuf, L. M. (2015a). Social media for collaborative learning and engagement: Adoption framework in higher education institutions in Malaysia. *Mediterranean Journal of Social Sciences*, *6*(3 S1), 246.
9. Al-rahmi, W. M., Othman, M. S., & Yusuf, L. M. (2015b). Using social media for research: The role of interactivity, collaborative learning, and engagement on the performance of students in Malaysian post-secondary institutes. *Mediterranean Journal of Social Sciences*, *6*(5), 536.

10. Al-rahmi, W. M., Othman, M. S., & Yusuf, L. M. (2015c). Using social media for research: The role of interactivity, collaborative learning, and engagement on the performance of students in Malaysian post-secondary institutes. *Mediterranean Journal of Social Sciences*, *6*(5), 536.
11. Al-Rahmi, W., Othman, M. S., & Yusuf, L. M. (2015). The role of social media for collaborative learning to improve academic performance of students and researchers in Malaysian higher education. *The International Review of Research in Open and Distributed Learning*, *16*(4).
12. Annetta, L. A., Minogue, J., Holmes, S. Y., & Cheng, M.-T. (2009). Investigating the impact of video games on high school students' engagement and learning about genetics. *Computers & Education*, *53*(1), 74–85.
13. Baylor, A. L., & Ritchie, D. (2002). What factors facilitate teacher skill, teacher morale, and perceived student learning in technology-using classrooms? *Computers & Education*, *39*(4), 395–414.
14. Bereczki, E. O., & Kárpáti, A. (2021). Technology-enhanced creativity: A multiple case study of digital technology-integration expert teachers' beliefs and practices. *Thinking Skills and Creativity*, *39*, 100791.
15. Borokhovski, E., Bernard, R. M., Tamim, R. M., Schmid, R. F., & Sokolovskaya, A. (2016). Technology-supported student interaction in post-secondary education: A meta-analysis of designed versus contextual treatments. *Computers & Education*, *96*, 15–28.
16. Brodie, R. J., Fehrer, J. A., Jaakkola, E., & Conduit, J. (2019). Actor engagement in networks: Defining the conceptual domain. *Journal of Service Research*, *22*(2), 173–188.
17. Caneva, C., Monnier, E., Pulfrey, C., El-Hamamsy, L., Avry, S., & Delher Zufferey, J. (2023). Technology integration needs empowered instructional coaches: Accompanying in-service teachers in school digitalization. *International Journal of Mentoring and Coaching in Education*, *12*(2), 194–215.
18. Chakabwata, W. (2023). Using Technology to Enhance Student Engagement in STEM Subjects in Higher Education. In *Technology Integration and Transformation in STEM Classrooms* (pp. 165–183). IGI Global.
19. Chang, S.-C., & Hwang, G.-J. (2018). Impacts of an augmented reality-based flipped learning guiding approach on students' scientific project performance and perceptions. *Computers & Education*, *125*, 226–239.
20. Chen, S.-L., Su, Y.-S., Diep, G. L., Sivanandan, P., Sadiq, M., & Phan, T. T. H. (2023). The impact of environmental knowledge and green supply chain practices in improving sustainable energy production: The moderating role of green behavior and green leadership. *Environmental Science and Pollution Research*, *30*(19), 57017–57031.
21. Chou, C.-H., Lee, S.-C., & Kuo, Y.-K. (2023). A longitudinal study on international brand perceptions and outcomes among entrepreneurship & EMBA students in Taiwan: Moderating role of students' attitude towards technology. *Current Psychology*, 1–14.
22. Consoli, T., Désiron, J., & Cattaneo, A. (2023). What is "technology integration" and how is it measured in K-12 education? A systematic review of survey instruments from 2010 to 2021. *Computers & Education*, 104742.
23. Daradkeh, M. (2023). Exploring the influence of risk management on the performance of industry–university collaborative projects: The moderating role of knowledge management capabilities. *Journal of Organizational Effectiveness: People and Performance*.
24. Demmers, J., Weltevreden, J. W., & van Dolen, W. M. (2020). Consumer engagement with brand posts on social media in consecutive stages of the customer journey. *International Journal of Electronic Commerce*, *24*(1), 53–77.
25. Deng, R., Benckendorff, P., & Gannaway, D. (2019). Progress and new directions for teaching and learning in MOOCs. *Computers & Education*, *129*, 48–60.
26. Dereso, C. W., Kant, S., Muthuraman, M., & Tufa, G. (2023). Effect of Point of Service on Health Department Student's Creativity in Comprehensive Universities of Ethiopia: Moderating Role of Public-Private Partnership and Mediating Role of Work Place Learning. *Proceedings of the International Health Informatics Conference: IHIC 2022*, 135–147.
27. Eaton, W. M., Brasier, K. J., Burbach, M. E., Whitmer, W., Engle, E. W., Burnham, M., Quimby, B., Kumar Chaudhary, A., Whitley, H., & Delozier, J. (2021). A conceptual framework for social, behavioral, and environmental change through stakeholder engagement in water resource management. *Society & Natural Resources*, *34*(8), 1111–1132.
28. Eteokleous, N. (2008). Evaluating computer technology integration in a centralized school system. *Computers & Education*, *51*(2), 669–686.
29. Ferns, S., & Comfort, J. (2014). Eportfolios as Evidence of Standards and Outcomes in Work-Integrated Learning. *Asia-Pacific Journal of Cooperative Education*, *15*(3), 269–280.
30. Garrison, D. R., & Vaughan, N. D. (2013). Institutional change and leadership associated with blended learning innovation: Two case studies. *The Internet and Higher Education*, *18*, 24–28.
31. Gikandi, J. W., Morrow, D., & Davis, N. E. (2011). Online formative assessment in higher education: A review of the literature. *Computers & Education*, *57*(4), 2333–2351.
32. Gupta, S., & Mathur, N. (2023). Virtual communication adoption by educational leaders: Moderating role of perceived risk and benefits. *The International Journal of Information and Learning Technology*, *40*(3), 242–258.

33. Han, J. H., & Finkelstein, A. (2013). Understanding the effects of professors' pedagogical development with Clicker Assessment and Feedback technologies and the impact on students' engagement and learning in higher education. *Computers & Education*, *65*, 64–76.
34. Hazzam, J., & Wilkins, S. (2023). The influences of lecturer charismatic leadership and technology use on student online engagement, learning performance, and satisfaction. *Computers & Education*, *200*, 104809.
35. Heflin, H., Shewmaker, J., & Nguyen, J. (2017). Impact of mobile technology on student attitudes, engagement, and learning. *Computers & Education*, *107*, 91–99.
36. Iliopoulos, A. (2019). Material Engagement Theory and its philosophical ties to pragmatism. *Phenomenology and the Cognitive Sciences*, *18*(1), 39–63.
37. Iqbal, J., & Masroor, F. (2023). Projecting the Chinese language as a power tool in the discourse on the China-Pakistan Economic Corridor (CPEC). *International Journal of Strategic Communication*, 1–18.
38. Joseph, J. (2012). The barriers of using education technology for optimizing the educational experience of learners. *Procedia-Social and Behavioral Sciences*, *64*, 427–436.
39. Kabilan, M. K., Annamalai, N., & Chuah, K.-M. (2023). Practices, purposes and challenges in integrating gamification using technology: A mixed-methods study on university academics. *Education and Information Technologies*, 1–33.
40. Ke, F., Xie, K., & Xie, Y. (2016). Game-based learning engagement: A theory-and data-driven exploration. *British Journal of Educational Technology*, *47*(6), 1183–1201.
41. Kearsley, G., & Shneiderman, B. (1998). Engagement theory: A framework for technology-based teaching and learning. *Educational Technology*, *38*(5), 20–23.
42. Kim, C., Kim, M. K., Lee, C., Spector, J. M., & DeMeester, K. (2013). Teacher beliefs and technology integration. *Teaching and Teacher Education*, *29*, 76–85.
43. Ladyshewsky, R. K. (2006). Building cooperation in peer coaching relationships: Understanding the relationships between reward structure, learner preparedness, coaching skill and learner engagement. *Physiotherapy*, *92*(1), 4–10.
44. Lai, C., Wang, Q., & Huang, X. (2022). The differential interplay of TPACK, teacher beliefs, school culture and professional development with the nature of in-service EFL teachers' technology adoption. *British Journal of Educational Technology*, *53*(5), 1389–1411.
45. Lam, J. (2015). Collaborative learning using social media tools in a blended learning course. *Hybrid Learning: Innovation in Educational Practices: 8th International Conference, ICHL 2015, Wuhan, China, July 27-29, 2015, Proceedings 8*, 187–198.
46. Liao, Y.-C., Ottenbreit-Leftwich, A., Glazewski, K., & Karlin, M. (2021). Coaching to support teacher technology integration in elementary classrooms: A multiple case study. *Teaching and Teacher Education*, *104*, 103384.
47. Lock, J., & Redmond, P. (2021). Embedded experts in online collaborative learning: A case study. *The Internet and Higher Education*, *48*, 100773.
48. Lowyck, J., & Pöysä, J. (2001a). Design of collaborative learning environments. *Computers in Human Behavior*, *17*(5–6), 507–516.
49. Lowyck, J., & Pöysä, J. (2001b). Design of collaborative learning environments. *Computers in Human Behavior*, *17*(5–6), 507–516.
50. Lu, G., Xie, K., & Liu, Q. (2022). What influences student situational engagement in smart classrooms: Perception of the learning environment and students' motivation. *British Journal of Educational Technology*, *53*(6), 1665–1687.
51. Martin, F., & Borup, J. (2022). Online learner engagement: Conceptual definitions, research themes, and supportive practices. *Educational Psychologist*, *57*(3), 162–177.
52. McDuff, E. (2012). Collaborative learning in an undergraduate theory course: An assessment of goals and outcomes. *Teaching Sociology*, *40*(2), 166–176.
53. McKnight, K., O'Malley, K., Ruzic, R., Horsley, M. K., Franey, J. J., & Bassett, K. (2016). Teaching in a digital age: How educators use technology to improve student learning. *Journal of Research on Technology in Education*, *48*(3), 194–211.
54. Moreira, P. A., Dias, P., Vaz, F. M., & Vaz, J. M. (2013). Predictors of academic performance and school engagement—Integrating persistence, motivation and study skills perspectives using person-centered and variable-centered approaches. *Learning and Individual Differences*, *24*, 117–125.
55. Myller, N., Bednarik, R., Sutinen, E., & Ben-Ari, M. (2009a). Extending the engagement taxonomy: Software visualization and collaborative learning. *ACM Transactions on Computing Education (TOCE)*, *9*(1), 1–27.
56. Myller, N., Bednarik, R., Sutinen, E., & Ben-Ari, M. (2009b). Extending the engagement taxonomy: Software visualization and collaborative learning. *ACM Transactions on Computing Education (TOCE)*, *9*(1), 1–27.

57. Namboodiri, S. (2022). Zoom-ing past "the new normal"? Understanding students' engagement with online learning in higher education during the covid-19 pandemic. In *Re-imagining Educational Futures in Developing Countries: Lessons from Global Health Crises* (pp. 139–158). Springer.
58. Nassir, M., & Benoliel, P. (2023). Promoting school effectiveness: Examining the mediating role of teachers' organisational commitment and the moderating role of school cultural attributes. *Educational Management Administration & Leadership*, 17411432231167716.
59. Ng, P. M., Chan, J. K., & Lit, K. K. (2022). Student learning performance in online collaborative learning. *Education and Information Technologies*, *27*(6), 8129–8145.
60. Nivedhitha, K. S. (2022). Key in socially driven game dynamics, open the doors of agility-an empirical study on gamification and employee agility. *Behaviour & Information Technology*, 1–27.
61. Nokes-Malach, T. J., Richey, J. E., & Gadgil, S. (2015). When is it better to learn together? Insights from research on collaborative learning. *Educational Psychology Review*, *27*, 645–656.
62. Ogunyemi, A. A., Quaicoe, J. S., & Bauters, M. (2022). Indicators for enhancing learners' engagement in massive open online courses: A systematic review. *Computers and Education Open*, *3*, 100088.
63. Okaz, A. A. (2015). Integrating blended learning in higher education. *Procedia-Social and Behavioral Sciences*, *186*, 600–603.
64. Oncu, S., & Cakir, H. (2011). Research in online learning environments: Priorities and methodologies. *Computers & Education*, *57*(1), 1098–1108.
65. Palincsar, A. S., & Herrenkohl, L. R. (2002). Designing collaborative learning contexts. *Theory into Practice*, *41*(1), 26–32.
66. Pandita, A., & Kiran, R. (2023). The Technology Interface and Student Engagement Are Significant Stimuli in Sustainable Student Satisfaction. *Sustainability*, *15*(10), 7923.
67. Park, Y. K., Song, J. H., Yoon, S. W., & Kim, J. (2014). Learning organization and innovative behavior: The mediating effect of work engagement. *European Journal of Training and Development*, *38*(1/2), 75–94.
68. Posey, L., & Pintz, C. (2017). Transitioning a bachelor of science in nursing program to blended learning: Successes, challenges & outcomes. *Nurse Education in Practice*, *26*, 126–133.
69. Qureshi, M. A., Khaskheli, A., Qureshi, J. A., Raza, S. A., & Yousufi, S. Q. (2023). Factors affecting students' learning performance through collaborative learning and engagement. *Interactive Learning Environments*, *31*(4), 2371–2391.
70. Radinger-Peer, V. (2019). What influences universities' regional engagement? A multi-stakeholder perspective applying a Q-methodological approach. *Regional Studies, Regional Science*, *6*(1), 170–185.
71. Roberts, T. S. (2004). *Online collaborative learning: Theory and practice*. IGI Global.
72. Rohm, A., D. Kaltcheva, V., & R. Milne, G. (2013). A mixed-method approach to examining brand-consumer interactions driven by social media. *Journal of Research in Interactive Marketing*, *7*(4), 295–311.
73. Sa'ad Al Hyari, H. (2023). Change Resistance Management And The Transition To Distamce Learning During COVID-19: Moderating Role Of Education Technology. *International Journal of Professional Business Review: Int. J. Prof. Bus. Rev.*, *8*(3), 4.
74. Shaheen, N., Al-Haddad, S., Marei, A., & Daoud, L. (2023). The Effect of Creativity on Entrepreneurial Behavior: The Moderating Role of Demographics. *Information Sciences Letters*, *12*(3), 1365–1372.
75. Shieh, R. S. (2012). The impact of Technology-Enabled Active Learning (TEAL) implementation on student learning and teachers' teaching in a high school context. *Computers & Education*, *59*(2), 206–214.
76. Shin, H., Rim, D., Kim, H., Park, S., & Shon, S. (2019). Educational characteristics of virtual simulation in nursing: An integrative review. *Clinical Simulation in Nursing*, *37*, 18–28.
77. Turner, P., & Turner, P. (2020). Engagement driven strategic HRM. *Employee Engagement in Contemporary Organizations: Maintaining High Productivity and Sustained Competitiveness*, 223–256.
78. Wang, A. I. (2015). The wear out effect of a game-based student response system. *Computers & Education*, *82*, 217–227.
79. Wu, L., Hsieh, P.-J., & Wu, S.-M. (2022). Developing effective e-learning environments through e-learning use mediating technology affordance and constructivist learning aspects for performance impacts: Moderator of learner involvement. *The Internet and Higher Education*, *55*, 100871.
80. Wu, Y.-C. J., Wu, T., & Li, Y. (2019). Impact of using classroom response systems on students' entrepreneurship learning experience. *Computers in Human Behavior*, *92*, 634–645.
81. Xie, K., & Hawk, N. (2017). Technology's role and place in student learning: What we have learned from research and theories. *Technology in School Classrooms: How It Can Transform Teaching and Student Learning Today*, 1–17.
82. Xing, W., Zhu, G., Arslan, O., Shim, J., & Popov, V. (2022a). Using learning analytics to explore the multifaceted engagement in collaborative learning. *Journal of Computing in Higher Education*, 1–30.
83. Xing, W., Zhu, G., Arslan, O., Shim, J., & Popov, V. (2022b). Using learning analytics to explore the multifaceted engagement in collaborative learning. *Journal of Computing in Higher Education*, 1–30.

84. Yang, Y.-T. C., & Wu, W.-C. I. (2012). Digital storytelling for enhancing student academic achievement, critical thinking, and learning motivation: A year-long experimental study. *Computers & Education*, *59*(2), 339–352.
85. Zainuddin, Z., Chu, S. K. W., Shujahat, M., & Perera, C. J. (2020). The impact of gamification on learning and instruction: A systematic review of empirical evidence. *Educational Research Review*, *30*, 100326.
86. Zhan, X., Sun, D., Wen, Y., Yang, Y., & Zhan, Y. (2022). Investigating students' engagement in mobile technology-supported science learning through video-based classroom observation. *Journal of Science Education and Technology*, *31*(4), 514–527.
87. Zhang, X., Meng, Y., de Pablos, P. O., & Sun, Y. (2019). Learning analytics in collaborative learning supported by Slack: From the perspective of engagement. *Computers in Human Behavior*, *92*, 625–633.
88. Zhu, W., Yan, R., & Song, Y. (2022). Analysing the impact of smart city service quality on citizen engagement in a public emergency. *Cities*, *120*, 103439.