ASEAN Journal of Open and Distance Learning (AJODL)
https://ajodl.oum.edu.my/
Vol. 17, No. 2, 2025, pp. 97 – 108

# Harnessing Educational Technology to Achieve SDG 4 in Malaysia: Insights from a Literature Review

Jusrizul Azeem Jamaludin, and Nurulhasanah Abdul Rahman*

Political Science Section, School of Distance Education, Universiti Sains Malaysia, Penang, Malaysia.

*Corresponding author**:** hasanahrahman@usm.my

Paper Info:
Received: 14 Oct 2025 | Revised: 04 Dec 2025
| Accepted: 31 Dec 2025 | Available Online: 31 Dec 2025

DOI: https://doi.org/10.64233/CUTS1792

Citation:
Jamaludin, J. A., & Rahman, N. A. (2025). Harnessing educational technology to achieve SDG 4 in Malaysia: Insights from a literature review. *ASEAN Journal of Open and Distance Learning, 17*(2), 97-108, https://doi.org/10.64233/CUTS1792

**Abstract**

*This study examines the role of educational technology in advancing the United Nations' fourth Sustainable Development Goal (SDG4: "Quality Education") in Malaysia, with particular attention given to its impact on student engagement and learning outcomes. Using a Systematic Literature Review of peer-reviewed studies published between 2015 and 2025, this study synthesises evidence on technological tools such as learning management systems, online platforms, and interactive applications. Four themes emerged from the review: (1) student engagement, (2) learning outcomes, (3) effectiveness of technological tools, and (4) barriers to integration. The findings demonstrate that technology-enhanced learning environments contribute positively to participation, critical thinking, and academic achievement. However, challenges such as the digital divide, limited teacher readiness, and inadequate infrastructure, particularly in rural areas, continue to hinder equitable implementation of educational initiatives. Addressing these barriers is essential to achieving SDG4 targets, for which this study highlights the importance of sustained investment in teacher professional development, infrastructure enhancement, and inclusive policy design. Overall, the findings advocate for a comprehensive and equitable approach that bridges access gaps, promotes digital inclusion, and ensures that all learners benefit from Malaysia's ongoing educational transformation.*

*Keywords:* digital inclusion, educational technology, Malaysia, quality education, student engagement, Sustainable Development Goal 4

## 1. Introduction

In 2015, the United Nations (UN) introduced the Sustainable Development Goals (SDGs) as part of its 2030 Agenda for Sustainable Development, with the aim of addressing some of the world's most pressing issues, including poverty, inequality, climate change, and environmental degradation (Advocates for International Development, 2022). Among the 17 interconnected goals, the fourth goal (i.e., SDG4: "Quality Education") holds particular significance through its focus to ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all (United Nations, 2025). SDG4 plays a central role in enabling individuals to acquire the knowledge and skills needed to thrive in a rapidly changing world, thereby promoting social mobility and reducing global inequalities. Achieving SDG4 targets is not only a fundamental human right but also a key driver of sustainable development, empowering individuals to participate meaningfully in society and the economy (Boeren, 2019). Technology has the capacity to support this mission by expanding access to learning, enhancing educational experiences, and fostering a more inclusive environment for all students, regardless of socio-economic or geographical background (Kalyani, 2024).

Technological advancements have revolutionised the field of education in recent years by reshaping the way students learn and engage with educational content. As technology becomes increasingly integrated into classrooms worldwide, its impact on learning outcomes and student engagement has garnered significant attention in educational research (Jumnaksarn & Kaewkohsaba, 2024; Ibrahim et al., 2025). Kumar (2024) argues that technology serves as a catalyst for educational innovation, paving the way for the adoption of student-centred teaching practices that can accommodate a wide variety of learning preferences, needs, and skill levels. By providing access to digital resources, multimedia content, and interactive platforms, technology has the potential to foster deeper engagement, promote critical thinking, and develop essential problem-solving skills. Furthermore, the continual development of educational technologies offers solutions for bridging educational gaps, particularly for underprivileged students who lack access to quality learning resources (Haleem et al., 2022).

In Malaysia, the integration of technology within the education system has become increasingly vital as the nation works to meet the demands of a globalised digital economy. Recognising this potential, the Malaysian government has introduced initiatives such as the 2013–2025 Malaysian Education Blueprint to promote digital innovation in schools (Ministry of Education Malaysia [MOE], 2013). The expansion of educational technologies has facilitated more interactive and engaging learning experiences, as well as improved student motivation and participation (Kamaruddin, 2015). In addition, digital tools have helped address challenges related to learning materials, personalised instruction, and resource accessibility (Ebrahimi & Jiar, 2018). Despite these advancements, the integration of technology into Malaysian classrooms continues to face obstacles, including digital inequities, inadequate teacher preparedness, and limited infrastructure in rural regions. These persistent challenges prevent many students from benefiting equally from technological developments.

The role of technology in advancing SDG4 in Malaysia is especially crucial given the country's diverse population and the need to provide equitable education opportunities for all students (Ibrahim et al., 2025). While the government has made significant strides to integrate technology into the education system, these efforts have not produced equitable or universal impact, particularly for students in remote or underserved areas. For example, students in rural regions often face challenges related to unreliable internet access, outdated hardware, and a lack of teachers who are trained and can effectively utilise digital tools. This disparity in access to technology is a significant barrier to SDG4's core focus of achieving inclusive and equitable quality education.

This study contributes to the growing body of research on educational technology by examining its impact on student engagement and learning outcomes in Malaysia. By focusing on how technology shapes the learning experience, the study provides insights relevant to educators, policymakers, and stakeholders working to enhance educational quality. The review also identifies barriers to effective technology adoption, including limited professional development, insufficient resources, and the digital divide. Addressing these barriers is essential to ensuring that all students regardless of socio-economic status or location have access to the benefits of educational technology.

To support Malaysia's efforts towards achieving SDG4, this study examines how educational technology can enhance access, quality, and equity in education. The primary objectives of this review are twofold. First, it aims to assess the impact of educational technology on student engagement and learning outcomes to provide a comprehensive understanding of how digital tools can enhance learning experiences in Malaysian schools. Second, it examines the effectiveness of various technological platforms and applications used in educational institutions to identify best practices as well as areas requiring further improvement. Although the Malaysian government continues to promote technological integration, challenges such as digital inequities, insufficient teacher readiness, and inconsistent infrastructure still hinder its widespread adoption. By identifying these challenges and proposing evidence-based solutions, this study contributes to addressing the barriers to effective technology integration.

To address these issues and better understand the role of educational technology in achieving SDG4 targets in Malaysia, this review is guided by the following research questions (RQs):

RQ1: How does educational technology influence student engagement in the Malaysian education system?
RQ2: How does educational technology influence learning outcomes in Malaysia?
RQ3: What barriers affect the effective integration of educational technology towards achieving SDG4?

Although numerous studies have examined the use and adoption of educational technology, there remains limited synthesis of how these technologies specifically influence student engagement and learning outcomes within the Malaysian context. Existing reviews tend to focus broadly on information and communication technology (ICT) adoption without directly linking findings to SDG4 targets. Therefore, this study addresses a clear gap by narrowing its focus to the impact of educational technology on engagement and learning outcomes, as well as by synthesising Malaysia-based evidence to understand national progress toward SDG4.

## 2. Literature Review

### 2.1. History of Educational Technology Integration in Malaysia

Malaysia has been at the forefront of integrating technology into education and leveraging advancements in digital infrastructure to transform learning experiences. Over the last four decades, the Malaysian government has made continuous efforts to effect changes to the education system to meet the evolving needs of national development and respond to global technological trends. This movement began in the 1980s when the Malaysian government recognised the need to equip students with basic computing skills to prepare them for an increasingly digital world. This subsequently led to the launch of computer-assisted learning programmes, which was the country's first significant foray into educational technology. The Ministry of Education then initiated several efforts to integrate technology into learning with

the aim of improving the quality of education through digital tools and resources (Hashim & Gapor, 2010).

Launched in the late 1990s, the Smart School initiative marked a crucial milestone in Malaysia's educational technology integration. It aimed to convert traditional classrooms into cutting-edge learning environments that are equipped with the latest technological tools to foster interactive and dynamic learning experiences. Malaysia was one of the first countries to implement such a nationwide programme, positioning itself as a leader in integrating ICT in education. As part of Vision 2020 (i.e., the national blueprint focused on transforming Malaysia into a fully developed, self-sufficient, and industrialised country by 2020), the Multimedia Super Corridor (i.e., Malaysia's first digital economy initiative) and the push for a digital metropolis further underscored the government's commitment to preparing the nation for the digital age (Bajunid, 2008). Despite its ambitious goals, the Smart School initiative faced several challenges; research indicated that disparities in internet connectivity, infrastructure, and teacher readiness impeded the successful implementation of the programme in many schools. Teachers' resistance to using technology and a lack of professional development also limited the initiative's success (Thang et al., 2010).

In the 21st century, the 2013–2025 Malaysian Education Blueprint (MOE, 2013) further affirmed the government's commitment to leveraging educational technology. This policy framework outlined strategies to enhance students' digital literacy, promote innovative teaching methods, and use technology to support personalised learning experiences. The Blueprint emphasised the importance of creating an ecosystem in which technology could foster deeper engagement and improve educational outcomes. Yet, the progress of its implementation has been uneven, as challenges in teacher training, resource allocation, and ensuring equitable access to technology remained prevalent.

### 2.2. The Impact of Covid-19 on Educational Technology Integration

The Covid-19 pandemic radically altered the Malaysian educational landscape by accelerating the adoption of digital tools and online platforms across the country. When schools were forced to close and transition to remote learning, the government implemented the Pengajaran dan Pembelajaran di Rumah (PdPR, or Teaching and Learning at Home) initiative, which necessitated the use of e-learning applications and platforms to ensure students could continue learning at home (Thang et al., 2022). This transition to online learning marked a significant shift from traditional face-to-face instruction to digital classrooms, using tools like Google Classroom, Microsoft Teams, and Zoom.

However, while the pandemic hastened the adoption of technology, it also revealed the challenges of large-scale online education. Many students faced difficulties adapting to the new learning environment, citing issues such as a lack of familiarity with online learning tools, unreliable internet connections, and limited access to devices (Shirish et al., 2021). These challenges were particularly pronounced in rural areas, where students were often forced to learn without the necessary technology or internet connectivity. On the other hand, some students adapted more quickly to online learning, utilising the flexibility of digital platforms to study independently. This contrast in experiences highlighted the need for continued efforts to bridge the digital divide and provide students with the support they need to succeed in an increasingly digital world.

Driven by the pandemic, the shift to online and hybrid learning models has had a lasting impact on Malaysian education. Moving forward, it is likely that hybrid learning, which combines in-person and online instruction, will continue to play a significant role in the educational experience. Hybrid learning offers the potential for greater flexibility and personalised learning, allowing students to engage with content at their own pace while also benefiting from direct teacher-student interactions (Jumnaksarn & Kaewkohsaba, 2024;

Ibrahim et al., 2025). However, for hybrid learning to be effective, it is crucial to address the remaining barriers to digital access, such as the lack of devices and stable internet connections, and ensure that teachers are adequately trained to use digital tools in their pedagogy.

### 2.3. Student Engagement and Learning Outcomes

The role of student engagement in shaping learning outcomes has garnered increasing recognition within the educational community. Engagement, as defined by Fredricks et al. (2004), encompasses three distinct dimensions: behavioural, emotional, and cognitive. Behavioural engagement refers to active participation in learning activities, emotional engagement involves students' affective reactions to their learning environment, and cognitive engagement pertains to the investment in learning and critical thinking. Research consistently highlights that students who actively engage with their educational experiences are more likely to achieve better academic outcomes and exhibit enhanced overall educational satisfaction (Christenson et al., 2019). This positive correlation between engagement and learning outcomes has been supported by a wealth of recent studies, reaffirming the critical importance of fostering student engagement to achieve educational objectives.

The adoption of instructional technology has been shown to play a significant role in enhancing student engagement. Ali (2024), for instance, demonstrated that the use of interactive learning tools, such as virtual simulations and gamified applications, significantly boosted student motivation and participation. These technologies not only encourage active involvement but also foster a sense of connection among students, which is essential for sustained engagement (Dunn & Kennedy, 2019). Ali et al. (2023) further substantiated this claim within the Malaysian context, showing that the incorporation of technology in classrooms significantly increased student interest and participation in the learning process, leading to higher engagement rates.

Moreover, numerous studies have confirmed the considerable link between engagement and academic achievement; for example, Fredricks and McColskey’s (2012) meta-analysis highlighted the positive impact of increased student engagement on academic success across various educational settings. This relationship is equally evident in Malaysia, where research has shown that students who are motivated and engaged in their learning tend to perform better academically and demonstrate enhanced critical thinking skills (Liu et al., 2023). These findings underscore the importance of fostering a learning environment that encourages active participation and intellectual investment.

However, it is crucial to acknowledge the challenges that educators face in promoting engagement, particularly in contexts where access to technology is limited. A study by Balalle (2024) pointed out that disparities in access to educational technology can significantly hinder student engagement, particularly in under-resourced schools. The unequal distribution of digital tools and resources can create barriers for students, limiting their ability to fully participate in technology-enhanced learning experiences. Schools must thus prioritise equitable access to digital resources to ensure that all students benefit from the integration of technology in education. Addressing these disparities is key to ensuring that technology becomes an inclusive tool that fosters engagement across diverse student populations.

### 2.4. Effectiveness of Educational Technology

Recent research has increasingly focused on the effectiveness of educational technology in enhancing teaching and learning outcomes. Numerous studies have shown that when

used appropriately, educational technologies can improve student achievement, promote active learning, and transform traditional learning environments.

A meta-analysis by Hattie and Clarke (2018) revealed that educational technology has a moderate yet significant impact on learning outcomes, particularly when used to support interactive and collaborative learning. This substantiates the concept of blended learning, which integrates online and in-person instruction to offer a more personalised learning experience. According to Cao (2023), blended learning environments improve students' academic performance by increasing motivation and engagement, thus creating a more dynamic learning atmosphere.

Further research by Xu and Jaggars (2013) examined the impact of online learning platforms on student learning outcomes in higher education. They found that students using digital resources outperformed peers studying in traditional settings in comprehension and information retention. Online learning platforms enable students to access instructional materials at their own pace and from any location, thus providing greater flexibility in balancing academic and personal commitments (Kamraju et al., 2024).

There is also considerable evidence supporting the efficacy of the use of learning management systems (LMS). An LMS is a digital platform that facilitates the sharing of resources, communication, and assessment between students and instructors, while also enabling educational institutions to manage administrative tasks. According to Ajijola et al. (2021), an LMS provides a comprehensive learning environment, in which both students and instructors can engage in educational activities. In remote learning contexts, LMS platforms have become indispensable, enabling teachers to connect with students and deliver content effectively even in the absence of in-person interactions. The integration of such technologies represents a significant advancement in the democratisation of knowledge and expansion of educational opportunities (Furqon et al., 2023).

However, the integration of educational technology is not without its challenges. Research by Salehi and Salehi (2012) highlighted that unequal access to technological resources can create disparities among students, limiting the overall effectiveness of technology in the classroom. For technology to truly enhance learning for all students, educational institutions must address inequities by ensuring that all students have equal access to the tools and resources necessary for a technology-enhanced learning experience.

In summary, research has consistently supported the positive impact of educational technology on learning outcomes, particularly in terms of promoting engagement, collaboration, and personalised learning. To maximise the potential of these technologies, continuous research and development is essential, as are efforts to address the challenges associated with their integration. Educational institutions must ensure equitable access to digital resources and provide adequate training for educators to effectively implement these technologies in diverse learning environments. As Malaysia continues to adopt new educational technologies, ongoing efforts to resolve issues such as infrastructure gaps and teacher preparedness will be crucial to optimising the benefits of educational technology for all students.

### 2.5. Research Gap

Despite the extensive research conducted on the topic of educational technology in Malaysia, several gaps remain evident in the existing literature.

First, while numerous studies examine the evolution of educational technology initiatives and the general effectiveness of digital tools, few synthesise findings in ways that connect them directly to the targets and indicators of SDG4. Much of the existing work focuses on

ICT adoption, digital literacy, or classroom implementation, without explicitly linking these outcomes to equitable and quality education.

Second, research on student engagement and learning outcomes tends to be fragmented, often examining isolated technological tools or single institutional contexts. As a result, there is limited consolidated evidence on how technology influences behavioural, emotional, and cognitive engagement and subsequently affects academic performance across different Malaysian educational settings.

Third, although issues such as the digital divide, uneven infrastructure, and teacher readiness have been frequently discussed, integrated reviews that analyse how these barriers collectively hinder progress toward meeting the objectives of SDG4 are lacking. Existing reviews rarely position these challenges within the broader discourse on inclusivity and equity, which are central to SDG4 targets.

Given these gaps, there is a clear need for a systematic review that brings together Malaysia-specific evidence on technology integration, student engagement, learning outcomes, and the structural barriers that influence equitable implementation. This synthesis provides the foundation for understanding Malaysia's progress toward meeting SDG4 targets and guides the formulation of the research questions in this study.

## 3. Research Method

This study adopts a simple Systematic Literature Review (SLR) approach to examine existing research on the role of educational technology in Malaysia, with a particular focus on its relation to the UN's fourth Sustainable Development Goal (SDG4) on quality education. The purpose of the review is to collate, synthesise, and critically evaluate findings on the use and effectiveness of educational technology within the Malaysian education system.

The review process consists of two stages. In the first stage, a structured keyword search was conducted using predefined terms such as "Sustainable Development Goal 4," "educational technology," "Malaysian educational technology," and "impacts of educational technology." These keywords were selected to reflect the core focus of the study, encompassing both global discussions on educational technology and Malaysia-specific applications. Searches were carried out across several reputable academic databases and search engines, including Scopus, ScienceDirect, and Google Scholar, chosen for their broad coverage of peer-reviewed publications in education and technology. This strategy ensured that both general and context-specific studies related to educational technology were systematically identified.

In the second stage, the snowball sampling technique was applied to extend the search. Reference lists of initially selected studies were screened to locate additional relevant articles not captured during the earlier stage. This iterative approach enabled a more inclusive and comprehensive selection of literature. Categories of data extracted from each study included author, year, context, research method, sample characteristics, type of technology used, findings on engagement and/or learning outcomes, and stated limitations.

The inclusion criteria comprised the following:

- Peer-reviewed journal articles, conference proceedings, and policy-related studies.
- Publications in English between 2015 and 2025.
- Studies that explicitly examine educational technology in relation to SDG4 or associated targets (e.g., quality education, student engagement, learning outcomes).

- Research focused on the Malaysian education system or comparative studies involving Malaysia.

The exclusion criteria comprised the following:

- Non-academic sources (e.g., blogs, news articles, non-scholarly reports).
- Studies unavailable in full text.
- Publications discussing only general ICT adoption without reference to educational outcomes or SDG4.
- Studies published outside the 2015–2025 timeframe.

By employing a structured search strategy, reputable databases, and iterative sampling, this SLR approach ensured transparency, replicability, and methodological rigour. The final dataset provided a robust foundation for understanding how educational technology contributes to Malaysia's progress toward meeting SDG4 targets. A thematic analysis was subsequently conducted, resulting in four dominant themes aligned with the study's research questions.

## 4. Findings and Discussion

The findings of this SLR highlight the significant role educational technology plays in supporting Malaysia's progress toward meeting SDG4 targets. Through an iterative coding process, four dominant themes emerged: (1) student engagement, (2) learning outcomes, (3) effectiveness of technological tools, and (4) barriers to integration. These themes were derived by grouping similar findings reported across the included studies, allowing commonalities and divergences to be systematically mapped. Overall, the reviewed evidence shows that digital tools can enhance teaching and learning processes, although their impact varies depending on contextual factors such as access, teacher readiness, and institutional support.

### 4.1. Theme 1: Student Engagement

As the literature affirms, educational technology plays a pivotal role in dismantling barriers to access and providing equitable learning opportunities (Kalyani, 2024). The use of technology to offer diverse, interactive learning experiences has a profound impact on student development, fostering essential skills such as critical thinking, self-directed learning, and engagement. These skills are indispensable for navigating the complexities of a rapidly evolving global landscape, where the ability to learn independently and adapt to change is paramount (Kumar, 2024).

Moreover, research consistently demonstrates the positive relationship between technology-enhanced learning environments and key student outcomes, such as motivation and academic performance. Studies by Dunn and Kennedy (2019) and Ali (2024) show that interactive, technology-driven learning environments significantly increase student motivation and engagement, which are crucial for improving educational achievement (Fredricks & McColskey, 2012). These findings are compelling, suggesting that when students are actively engaged with the learning materials through digital means, their enthusiasm and participation in the learning process soar. This is a crucial finding, as student engagement has long been correlated with improved academic outcomes.

### 4.2. Theme 2: Learning Outcomes

Meeting SDG4 targets serves not only as a step towards enhancing the quality of education but also contributes to the broader achievement of the other 16 UN SDGs. In

particular, SDG4 serves as a gateway to poverty alleviation and lifelong learning: two critical objectives in the global agenda for sustainable development (Boeren, 2019). The rapid evolution of digital tools and resources has the capacity to radically transform educational outcomes by broadening access and deepening engagement among students (Kamaruddin, 2015).

The evidence highlights how technology can enhance student engagement and learning outcomes, while also identifying the barriers that prevent its full integration into the educational system. The research demonstrates that, when used effectively, educational technology has the potential to significantly improve the quality and accessibility of education.

### 4.3. Theme 3: Effectiveness of Technological Tools

In the Malaysian context, the integration of educational technology is not just a strategy for enhancement, it is a necessity in addressing the dynamic challenges posed by globalisation and digitalisation. Government-led initiatives such as the 2013–2025 Malaysian Education Blueprint and Smart School programme reflect a strategic commitment to leveraging technology to create innovative, inclusive, and forward-thinking learning environments (Bajunid, 2008; MOE, 2013). These initiatives are emblematic of a national effort to harness technology as a powerful tool for educational reform and the realisation of SDG4.

Furthermore, while technological integration in education holds substantial promise, educational stakeholders must recognise the importance of developing comprehensive, long-term strategies. Rather than simply considered a short-term solution or supplementary tool, technology should be integrated holistically into curricula and teaching methods. This requires a systemic approach to teachers' professional development, through which educators are trained not just to use digital tools but also equipped with the pedagogical expertise needed to incorporate these tools effectively into their teaching practice. Moreover, priority must be given to providing the infrastructure necessary to support such integration, such as stable internet connectivity and sufficient devices.

### 4.4. Theme 4: Barriers to Integration

Despite the significant progress made, challenges that hinder the full realisation of benefits related to educational technology integration persist, particularly in terms of teacher preparedness and resource allocation. Insufficient professional development for educators and uneven distribution of resources remain barriers that, if not addressed, will limit the impact of technological integration in classrooms (Ebrahimi & Jiar, 2018; Salehi & Salehi, 2012).

Disparities in access to devices, internet connectivity, and digital literacy remain persistent issues that can undermine the efficacy of technology-driven educational interventions (Salehi & Salehi, 2012; Balalle, 2024). While technology's potential to enhance education is clear, its success hinges on the ability to bridge these gaps and ensure that all students, irrespective of socio-economic background, have equal access to the tools necessary for success. Thus, policymakers and educators must act decisively to address these access-related issues by providing targeted interventions that can ensure all learners benefit equally from technological advancements.

Failure to strengthen infrastructure and provide requisite professional training risks exacerbating existing inequalities in an environment where only select groups of students benefit from the advantages that educational technology can offer.

The study thus underscores the need for continuous research and adaptive strategies that can provide suitable responses and solutions to the rapidly changing technological landscape. As Malaysia moves forward with its educational reforms, it must focus not only on the tools and technologies themselves but also the policies and practices that will ensure these tools are used effectively, equitably, and sustainably. Only then can the country realise its educational objectives and contribute meaningfully to the global sustainable development agenda.

## 5. Conclusion

This study reinforces the significant potential of educational technology to enhance learning outcomes and strengthen student engagement in Malaysia. When effectively implemented, digital tools contribute to more inclusive and student-centred learning environments that support SDG4 targets. However, persistent issues such as uneven access to devices and insufficient teacher preparedness continue to limit the full impact of technology and reveal a clear gap between policy ambitions and classroom realities. Closing the digital divide and improving teacher readiness remain critical priorities. Equitable access to resources and sustained professional development are essential to ensure that technology supports, rather than widens, educational disparities. These findings are especially relevant for open and distance learning (ODL) institutions in Malaysia and the wider ASEAN region, where digital platforms broadly form the foundation of teaching and learning. Future research should examine the longer-term effects of emerging technologies, including artificial intelligence and immersive tools, on engagement and inclusivity in diverse ODL contexts. Strengthening access and educator capacity will be key to meeting SDG4 objectives and supporting a more equitable digital education ecosystem.

***Funding:*** This research was supported by the Universiti Sains Malaysia Short Term Grant (304/PJJAUH/6315695).

***Acknowledgement:*** The authors would like to express their sincere appreciation to Universiti Sains Malaysia for the financial assistance and technical support that made this study possible.

***Conflict of Interest Statement:*** The authors declare no conflict of interest.

***Ethics Statement:*** Ethical approval was not required for this study.

### References

Advocates for International Development. (2022). *SDG legal guide: SDG 4 - Quality education*. Right to Education. https://www.right-to-education.org/sites/right-to-education.org/files/resource-attachments/A4ID_SDG%20Legal%20Guide_SDG4_Quality%20education_February2022_EN.pdf

Ali, F. U. (2024). Gamification in higher education: Enhancing student engagement and learning outcomes. *Research Invention Journal of Research in Education, 3*(2), 49-58. https://www.researchgate.net/publication/380928997_Gamification_in_Higher_Education_Enhancing_Student_Engagement_and_Learning_Outcomes

Ali, M. S. B., Yasmeen, R., & Munawar, Z. (2023). The impact of technology integration on student engagement and achievement in mathematics education: A systematic review. *International Journal of Computer Integrated Manufacturing, 6*(3), 222-232. https://www.researchgate.net/publication/370446167_The_Impact_of_Technology_Integration_on_Student_Engagement_and_Achievement_in_Mathematics_Education_A_Systematic_Review_httpsjournalsresearchparksorgindexphpIJIE

Bajunid, I. A. (2008). *Malaysia: From traditional to smart schools: The Malaysian educational odyssey*. Oxford Fajar.

Balalle, H. (2024). Exploring student engagement in technology-based education in relation to gamification, online/distance learning, and other factors: A systematic literature review. *Social Sciences & Humanities Open, 9*, 100870. https://doi.org/10.1016/j.ssaho.2024.100870

Boeren, E. (2019). Understanding Sustainable Development Goal (SDG) 4 on "quality education" from micro, meso and macro perspectives. *International Review of Education, 65*, 277–294. https://doi.org/10.1007/s11159-019-09772-7

Cao, W. (2023). A meta-analysis of effects of blended learning on performance, attitude, achievement, and engagement across different countries. *Frontiers in Psychology, 14*, Article 1212056. https://doi.org/10.3389/fpsyg.2023.1212056

Christenson, S. L., Reschly, A. L., & Wylie, C. (2019). *Handbook of research on student engagement*. Springer.

Dunn, T. J., & Kennedy, M. (2019). Technology enhanced learning in higher education: Motivations, engagement, and academic achievement. *Computers & Education, 137*, 104-113. https://doi.org/10.1016/j.compedu.2019.04.004

Ebrahimi, S. S., & Jiar, Y. K. (2018). The use of technology at Malaysian public high schools. *Merit Research Journal of Education and Review*, *6*(3). https://meritresearchjournals.org/articles/pdf/344529062023

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59-109. https://doi.org/10.3102/00346543074001059

Fredricks, J. A., McColskey, W. (2012). The measurement of student engagement: A comparative analysis of various methods and student self-report instruments. In S. Christenson, A. Reschly, & C. Wylie. (Eds). *Handbook of research on student engagement*. Springer. https://doi.org/10.1007/978-1-4614-2018-7_37

Furqon, M., Sinaga, P., Liliasari, L., & Riza, L. S. (2023). The impact of learning management system (LMS) usage on students. *TEM Journal, 12*(2), 1082–1089. https://doi.org/10.18421/TEM122-54

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers, 3*, 275-285. https://doi.org/10.1016/j.susoc.2022.05.004

Hashim, Y., & Gapor, A. L. (2010). The evolution of instructional technology in Malaysia. *International Journal of Instructional Media, 37*(3), 229-238. https://www.researchgate.net/publication/315644560_The_Evolution_of_Instructional_Technology_In_Malaysia

Hattie, J., & Clarke, S. (2018). *Visible learning: Feedback* (1st ed.). Routledge. https://doi.org/10.4324/9780429485480

Ibrahim, S. E., Ismail, M. R., & Subramaniam, T. T. (2024). Information literacy self-efficacy of open, digital and distance education of new learners. *ASEAN Journal of Open and Distance Learning, 16*(2), 42-54. https://doi.org/10.64233/NOMA2568

Jumnaksarn, S., & Kaewkohsaba, S. (2024). The development of assessment as a learning model by applying digital technology for undergraduate students in distance education at Sukhothai Thammathirat Open University Thailand. *ASEAN Journal of Open and Distance Learning, 16*(2), 15-29. https://doi.org/10.64233/GSSQ3780

Kalyani, L. K. (2024). The role of technology in education: Enhancing learning outcomes and 21st-century skills. *International Journal of Scientific Research in Modern Science and Technology, 3*(4), 5-10. https://doi.org/10.59828/ijsrmst.v3i4.199

Kamaruddin, N. (2015). Understanding patterns of interactive courseware use within Malaysian primary smart schools. *Malaysian Online Journal of Educational Technology, 3*(1), 49-56. https://files.eric.ed.gov/fulltext/EJ1085951.pdf

Kamraju, M., Krishnaiah, J., Durgesham, G., Shaba, N., Begum, S. B. U., Fatima, N., & Madhuri, Y. (2024). Exploring the impact of online education on higher education. *ASEAN Journal on Science and Technology for Development, 3*(1), 27–36. https://www.researchgate.net/publication/370766475_Exploring_the_Impact_of_Online_Education_on_Higher_Education

Kumar, S. (2024). The impact of technology on student engagement and learning outcomes. *International Journal of Research Publication and Reviews, 5*(4), 9383-9387. https://doi.org/10.55248/gengpi.5.0424.1121

Liu, M., Noordin, N., Lilliati, I., & Abdrahim, N. A. (2023). Relationship between student engagement and academic achievement in college English education for non-English majors in China. *International Journal of Learning Teaching and Educational Research, 22*(8), 203-232. https://doi.org/10.26803/ijlter.22.8.12

Ministry of Education Malaysia. (2013). *Malaysia education blueprint 2013-2025*. Ministry of Education Malaysia.

Salehi, H., & Salehi, Z. (2012). Challenges for using ICT in education: Teachers' insights. *International Journal of e-Education, e-Business, e-Management and e-Learning, 2*(1), 40–43. https://ijeeee.org/Papers/078-Z00061F10037.pdf

Shirish, A., Chandra, S., & Srivastava, S. C. (2021). Switching to online learning during COVID-19: Theorizing the role of IT mindfulness and techno-eustress for facilitating productivity and creativity in student learning. *International Journal of Information Management, 61*(1), Article 102394. https://doi.org/10.1016/j.ijinfomgt.2021.102394

Thang, S. M., Mahmud, N., Mohd Jaafar, N., Ng, L. L., & Abdul Aziz, N. B. (2022). Online learning engagement among Malaysian primary school students during the COVID-19 pandemic. *International Journal of Innovation, Creativity and Change, 16*(2), 302-326. https://www.researchgate.net/publication/362916389_Online_Learning_Engagement_Among_Malaysian_Primary_School_Students_During_the_Covid-19_Pandemic

Thang, S. M., Murugaiah, P., Lee, K. W., Azman, H., Tan, L. Y., & Lee, Y. S. (2010). Grappling with technology: A case of supporting Malaysian smart school teachers' professional development. *Australasian Journal of Educational Technology, 26*(3), 400-416. https://doi.org/10.14742/ajet.1083

United Nations. (2025). *Sustainable Development Goal 4: Quality education*. The Global Goals. https://www.globalgoals.org/goals/4-quality-education/

Xu, D., & Jaggars, S. S. (2013). The impact of online learning on students' course outcomes: Evidence from a large community and technical college system. *Economics of Education Review, 37*, 46–57. https://doi.org/10.1016/j.econedurev.2013.08.001