

# Technology-based learning and its impact on cognitive and behavioral outcomes

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## Abstract

*This study examines how digital learning modalities influence cognitive and behavioral outcomes across educational levels, including kindergarten, primary, secondary, and higher education. It draws on Constructivist Learning Theory, the Community of Inquiry (CoI) framework, and Engagement Theory to explain the pedagogical foundations of digital learning. Using a library research approach, the study reviews peer-reviewed articles, books, and reports published between 2014 and 2023 to synthesize evidence on digital learning tools, cognitive development, learner engagement, and educational technology. The findings indicate that digital learning can enhance higher-order thinking, problem-solving, and collaboration, particularly among older learners. However, its effects on behavioral engagement vary depending on learners' age, digital literacy, and access to technology. Hybrid learning emerges as the most effective approach when supported by appropriate instructional design, although challenges remain in sustaining younger learners' motivation and reducing inequalities in digital access. Despite its reliance on context-specific studies, primarily from developed countries, this review provides a comprehensive synthesis of current evidence and highlights the potential of flexible hybrid learning to support future-ready education.*

**Keywords:** behavioral engagement; cognitive outcomes; digital learning; educational technology; hybrid learning.

## Abstrak

Penelitian ini mengkaji bagaimana model pembelajaran digital memengaruhi hasil kognitif dan perilaku di berbagai jenjang pendidikan, termasuk taman kanak-kanak, sekolah dasar, sekolah menengah, dan pendidikan tinggi. Penelitian ini mengacu pada Teori Pembelajaran Konstruktivis, kerangka kerja Komunitas Penyelidikan (*Community of Inquiry/CoI*), dan Teori Keterlibatan untuk menjelaskan landasan pedagogis pembelajaran digital. Dengan menggunakan pendekatan penelitian pustaka, studi ini meninjau artikel yang telah ditelaah sejawat, buku, dan laporan yang diterbitkan antara tahun 2014 dan 2023 untuk mensintesis bukti mengenai alat pembelajaran digital, perkembangan kognitif, keterlibatan peserta didik, dan teknologi pendidikan. Temuan menunjukkan bahwa pembelajaran digital dapat meningkatkan pemikiran tingkat tinggi, pemecahan masalah, dan kolaborasi, terutama di kalangan peserta didik yang lebih tua. Namun, dampaknya terhadap keterlibatan perilaku bervariasi

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tergantung pada usia peserta didik, literasi digital, dan akses terhadap teknologi. Pembelajaran hibrida muncul sebagai pendekatan paling efektif jika didukung oleh desain instruksional yang tepat, meskipun masih ada tantangan dalam mempertahankan motivasi peserta didik yang lebih muda dan mengurangi ketimpangan dalam akses digital. Meskipun bergantung pada studi-studi yang spesifik konteks, terutama dari negara-negara maju, tinjauan ini memberikan sintesis komprehensif atas bukti terkini dan menyoroti potensi pembelajaran hibrida yang fleksibel untuk mendukung pendidikan yang siap menghadapi masa depan.

**Kata kunci:** keterlibatan perilaku; hasil kognitif; pembelajaran digital; teknologi pendidikan; pembelajaran hibrida.

## **Introduction**

Technological advances and evolving pedagogical paradigms have changed, altered and transformed education. It sparked an increasing attention to the ongoing debates on the comparative efficacy of online and traditional methods of learning and questions the effectiveness of the hybrid learning environment. These advances trace back to the past where technological innovation has started evolving. Between 1920 to 1980, the advancement of technology started with film and radio, then televisions and early computers. They integrated the use of these technologies into their traditional method of teaching as it was revolutionary. However, the usage of these technologies impacted the transformation of the teaching methods because of the structural constraints and classroom culture (Cuban, 1986). This historical trajectory enhances the need to compare the cognitive and behavioral impacts of online and traditional education.

In this paper, the term “online education” refers to a digital instructional method of teaching whilst “traditional education” refers to a face-to-face, in-person instruction approach, and “hybrid learning” refers to the blending of both modalities. A ground breaking disruption of the global pandemic that occurred in 2019—Covid-19—had impeded education affecting 1.6 billion learners globally with its prolonged school closures, accelerating the shift to remote learning (UNICEF, 2021). This reforms and nurtures the cognitive and behavioral outcomes of education as it forces a replacement of the customary traditional face-to-face instruction of instantaneous response and interactions in class with digital platforms of insufficient pedagogical structural groundwork (Reuge et al., 2021). According to Reuge et al. (2021), the shift in the educational system helps unveil the possibility to adapt with the technological changes and its bias of inequity in educational technology.

Research on learning outcomes has continuously highlighted that critical thinking, knowledge retention and problem-solving skills in cognitive outcomes are the fundamental key aspects of educational success. Persistence and self-

regulated learning in behavioral outcomes, are as important in education in the long-term and lifelong academic achievement (Martin et al., 2021). These outcomes remains debatable with its ongoing research of inconclusive findings as some findings shows no significant differences while others decipher its advantages and disadvantages of different environments depending on the circumstances and students characteristics, like how online learning can strengthen rapid interaction and social presence, it may not necessarily help with deep learning or behavioral engagement that develops in traditional classroom environment (Martin et al., 2021). The differences in results emphasized the absence of agreement in research and the importance of detailed, situation-specific studies.

The surge in technological advances of online digital platforms changes the ways of traditional methods—in-person, teacher-centered instructions and limitations in access to education for the underprivileged, to the approach of student-centered methods along with its flexibility that allow access to education globally has impacted the population in education (Ally & Tsinakos, 2014). However, according to Cuban (1986), technological revolution brought upon eagerness to integrate them into education that it shadowed the need for deeper theoretical grounding and plannings to change the method of instruction to adapt well with the changes. Hence, the need to incorporate frameworks like constructivists learning theories and Community of Inquiry (CoI) model would shape a better quality and effectiveness in an online and hybrid learning setting (Akpen et. al., 2024). The gap between digital literacy and pedagogical competency highlights a significant area for the what the study aims to contribute.

The existing literature on online versus traditional education lacks a comprehensive systematic comparison across all educational levels and in hybrid models, but instead focusing on specific stages or general fulfilment. This limitation and the tendency to treat online and traditional learning as opposing options, prevents a full understanding of how different modalities, student factors and teaching approach interact and correspond with each other. The contribution of this research relies on its holistic and comprehensive method. It considers how cognitive and behavioral outcomes vary across different educational stages—kindergarten, primary to pre-university, and tertiary, acknowledges both technological tools and theoretical frameworks, and explores hybrid learning as the ultimate balanced approach, as a result offering more thorough and nuanced analysis of the educational landscape.

The significance of this study incorporates many different aspects. Academically, it bridges gap in comparative research by synthesizing insights

from various educational settings. Pedagogically, it provides a theoretical framework-based approach for educators to effectively integrate digital technology. From a policy perspective, it offers a corroboration to support the decision on resourcing allocation, curriculum development, and training for an equitable and effective learning.

Correspondingly, this study aims to explore how integrating digital technology in learning modalities—online, traditional, and hybrid—influence the cognitive and behavioral outcomes across different educational levels. Its purpose is to identify patterns, differences, and collaboration in modalities grounded by theories, as the ultimate goal is to foster an understanding of how technology and pedagogy can be aligned and integrated together to optimize learning outcomes, ensuring that educational innovations are inclusive and effective for a future-ready approach. By addressing existing gaps and clarifying the best application for each modality to excel, the findings are expected to offer both theoretical contributions and practical recommendations for the future of education.

## Methodology

This research study uses a library-based research approach method in reviewing and putting together peer-reviewed scholarly articles, books and reports to explore and investigate the cognitive and behavioral outcomes in online, traditional and hybrid learning environments. The key databases used to maintain academic rigor are Google Scholar, Google Book, Springer, and ScienceDirect. Keywords contains: *online learning outcomes, cognitive impact, behavioral engagement, educational technology, constructivist theory, Community of Inquiry model, blended learning, and COVID-19 pandemic*. This study is limited to only extracting data from existing literature to determine trends and achieve an understanding of research study. Limited comparability, lack of standardization and inconsistent measurements of articles are some limitations that can affect the findings of study.

## Findings and Discussion

### A. Key Findings

#### 1. *Publication distribution and research trends*

The exponential growth of digital advancements, especially after the urgency to adopt remote learning during the COVID-19 pandemic era, sparks debate and rigorous discussions of the cognitive and behavioral outcomes in online, traditional and hybrid learning environments. Insights from peer-reviewed

literature are consolidated and examined to analyze how different educational modalities affect learners' engagement, motivation, interaction, and its development of higher-order thinking skills across various age groups and contexts thereby providing useful knowledge in guiding educators to improve the methods and pedagogy approaches. The reviewed studies ranged from kindergarten to tertiary education that includes international context such as Indonesia, Singapore and China.

**Table 1.** Summary of Research Distribution and Contexts

| Year | Country     | Educational Level          | Context and Focus                                                                 |
|------|-------------|----------------------------|-----------------------------------------------------------------------------------|
| 2017 | USA         | Early Childhood            | ICT access and impact on memory and metacognition (Troseth & Strouse, 2017)       |
| 2020 | USA         | Kindergarten               | Home-school digital engagement (Taylor & Boyer, 2020)                             |
| 2016 | Philippines | Kindergarten               | Online platforms and community building (Thai & Ponciano, 2016)                   |
| 2022 | Indonesia   | Kindergarten               | Blended and hybrid learning impacts (Hayati et al., 2022)                         |
| 2021 | Singapore   | Primary to Pre-University  | National digital learning platforms (Bacher-Hicks et al., 2021)                   |
| 2019 | Singapore   | System-wide Implementation | Active learning design via technology (MOE Educational Technology Division, 2017) |
| 2023 | Singapore   | National Policy            | Transforming Education through Technology Masterplan 2030 (MOE, 2023)             |
| 2014 | China       | Tertiary Education         | Traditional vs online engagement (Li et al., 2014)                                |
| 2009 | UK          | Tertiary Education         | Online learning confidence and retention (Heaton-Shrestha et al., 2009)           |

Source: Results of the research study

Technology has continuously developed over the years escalating the need to incorporate it into educational practices and modalities which raises the importance of digital collaboration and emphasis on increased attention and focus on critical thinking and independent learning.

## 2. *Types of learning technologies studied*

With the advancement of technology, even before the Covid-19 phenomena, children are already able to learn through devices which tap on the internet just like how they can learn through reading physical books and watching television (Troseth & Strouse, 2017). A wide range of technology tools for education were used across the studies like screen-based learning tools, interactive digital tools, blended learning platforms and data-driven resources.

Screen-based learning tools such as PowerPoint, Student Learning Space (SLS) which is Singapore's Ministry of Education's core platform where teaching and learning can happen online for primary school to pre-university students, and Google Apps for Education (<http://apps.google.com/>) where its utilization suite of applications aids collaboration and presentation for both teachers and students at all levels. This includes Google Suite, Google Docs, Google Scholar and Google Forms. These tools and platforms have helped in aiding with a collaborative and interactive learning environment (*MTS Blended Learning - Useful ICT Tools for T&L*, 2021; Overview of Student Learning Space, n.d.). Interactive digital tools including VoiceThread (<http://voicethread.com/>) can be used to help students efficiently create slideshows where they are able to comment on each photo by text, audio or video. Such annotation helps students to share their train of thoughts on multimedia artefacts helping all of the students to be heard and valued. Such detailed recording of their thought process enables an effective assessment of their understanding as their thinking is made visible. This can be used in conjunction with other digital mind mapping tools to provide more platforms for them to share ideas and connections. For example, Mindomo (<http://www.mindomo.com/>) or MindMeister (<http://www.mindmeister.com/>) (*MTS Blended Learning - Useful ICT Tools for T&L*, 2021).

Blended learning platforms like Zoom meetings, WhatsApp voice notes, video calls and YouTube videos are used to ease and enable asynchronous and real-time interaction (Hayati, et al., (2022). Data-driven resources such as analytics and feedback that are embedded within systems like SLS, a platform that keeps evolving from the shared feedback by educators and students alike leading to new tools to better support teaching and learning. This would help in tracking learning progress and adjusting learning designs better (*MTS Blended Learning - Useful ICT Tools for T&L*, 2021; Overview of Student Learning Space, n.d.).

### **3. Influenced cognitive aspects**

Pedagogical techniques in using technologies have shown an improvement in cognitive development. The usage of the above ICT tools, like Google Docs, allows students to be able to work together on assignments and give instant feedback without being in the same physical location automatically creates the tendency for them to approach learning more collaboratively. Cognitively, such coloration promotes and develops skills like co-construction of knowledge, brainstorming, and active reflection (*MTS Blended Learning - Useful ICT Tools for T&L*, 2021). In early childhood education, cognitive development in integrating digital technologies into education are also evident. In Indonesia, technology has also made an impact on students and teachers cognitively. In Masjid Syuhada

Kindergarten, educators use PowerPoint through Zoom meetings, WhatsApp voice notes, video calls and also YouTube videos. The findings have surfaced benefits in using such models. Parents were able to join in on lessons and assist their children. Students managed to learn counting, recognize even and odd numbers and even use the pen feature to correctly identify and circle different types of numbers on the Zoom whiteboard interface (Hayati et al., (2022).

From the above findings, we can deduce that most children are able to handle the cognitive aspect of online learning. This is crucial as cognitive abilities such as recognizing different shapes, counting and thought process facilitates and sets the stage for success in academics and their future (Schoon et al., 2021). To elaborate further, there are other possible impacts on children's cognitive processes such as memory, metacognition and exploration. Due to the ease of access to abundance of information, children could have less opportunities to develop strategies to help them remember information such as clustering or rehearsal. On the other hand, the lack of the need to actually remember all information could help free up cognitive resources so they are able to instead focus on much more complex content of higher order thinking skills such as conceptual relationships and procedures (Troseth & Strouse, 2017).

Technology can also accelerate the growth of metacognition and reflective thinking. Taylor and Boyer (2020) showed how educators leverage on digital tools and platforms. These teachers created and designed multimedia resources and uploaded them on their chosen online platforms for both parents and children to access. The children were shown to be able to access the learning content online followed by sharing and commenting on them through the platforms by asking questions and stating their own justifications for their ideas. Here, we can see how the platforms and digital content clearly help build and foster home-school connections. This is corroborated by Thai & Ponciano (2016), where some online learning platforms act as a location where curricular resources are gathered to help teachers create meaningful learning communities where teachers, students and parents could all have access to them at their chosen place of study such as their homes outside of classrooms.

At the tertiary level, students with critical thinking skills who are more inclined towards innovation, have shown that higher order thinking was more prevalent in e-learning platforms. They mentioned that they were more confident to "trial and error" without the presence of a physical teacher. This aligns to a study which showed that as opposed to traditional classrooms, virtual classrooms can help students gain confidence and retain more knowledge (Heaton-Shrestha et al., 2009). Therefore, the usage of technology is useful for

higher education students for higher level learning as e-learning environments fosters innovation, independent learning and critical thinking amongst learners.

#### **4. *affected behavioral aspects***

Integrating technology with education has also influenced the behavioral outcomes of learners. It varies in its development depending on the usage of digital platforms and learners' age groups. In early childhood education, there were undoubtedly some challenges, these included not switching on the camera, not focusing on lessons and playing due to lack of motivation or having internet connection issues (Hayati, et al., (2022). These highlights the importance of parental guidance and involvement along with targeted strategies in supporting young learners' behavioral engagement in an online environment education.

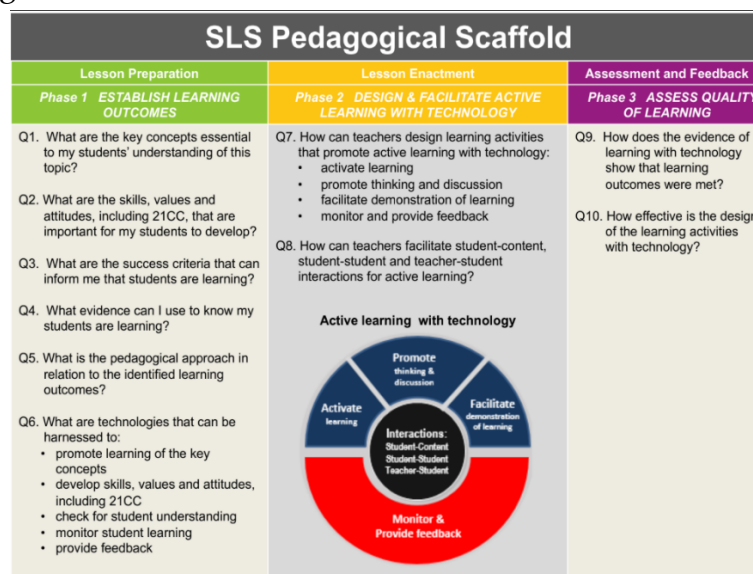
As for primary to pre-university students, classrooms have become more interactive and student-driven as they ask more questions and engage in discussions online. This is through usage of SLS and embedded tools such as mind maps, graphic organizers. There is a greater ownership of learning and teaching as technology has made education a much more responsive and dynamic one as it is no longer one way (Ministry of Education Educational Technology Division, 2017). The use of technology in education also has an impact on higher education. A study done in China on higher education students in traditional versus online learning showed mixed results between behavioral engagement of the students (Li et al., 2014). In this study, behavioral engagement refers to good conduct, being involved in tasks and participating in school activities. These can be observed through behaviors such as focusing, making queries and participation in class discussions. One result showed no significant difference in behavioral engagement and motivation levels whether the student is in a traditional classroom or an online classroom (Li et al., 2014). This shows that integrating technology with education can support the behavioral engagement of learners but it depends on the contextual factors of instructional design, digital infrastructure and learners' self-regulation.

#### **5. *The role of context and moderation***

Contextual factors of conditions and elements that influence a situation such as infrastructural readiness, cultural expectations and stakeholder engagement, significantly shaped the effectiveness of technology. In Singapore's education system, there is a great emphasis on the leverage of technology. For example, the creation of SLS which is Singapore's Ministry of Education's core platform where teaching and learning can happen online for primary school to pre-university students (*MTS Blended Learning - Useful ICT Tools for T&L*, 2021; Overview of Student Learning Space, n.d.). Bacher-Hicks et al. (2021) defined an online

platform as a portal that allows for online learning through the uploaded educational resources and real-time instruction. These include Google Classroom, Seesaw and ClassDojo which can host digital resources (e.g., e-books, videos), and allows teachers to create and share custom lesson plans. SLS also falls under this definition and is specially designed by educators in MOE. According to Overview of Student Learning Space (n.d.), SLS has truly transformed the landscape of education as Singaporean students effectively leverage this technology. The platform keeps evolving from shared feedback by educators and students alike leading to new tools to better support teaching and learning. The flexibility of the system helped integrate many outside resources for educators to easily tap on within the platform. For example, more than 250 external sites and tools are already linked to it and this includes the mentioned Google suite applications.

According to an interviewed MOE teacher, teachers also frequently share their lessons on SLS where educators from different schools have access to use directly or modify to meet their own student's needs. Technology has changed the way educators think and behave. So much so that MOE came up with the SLS pedagogical scaffold which Singapore teachers use to ensure we use the platform as a tool to design active learning experiences with technology so students can have a technology- enriched learning experience. According to the Ministry of Education Educational Technology Division (2017), the 3 design phases being 1) establishing learning outcomes, 2) design and facilitating active learning with technology and 3) assess quality of learning are used to help guide educators in designing digital lessons.

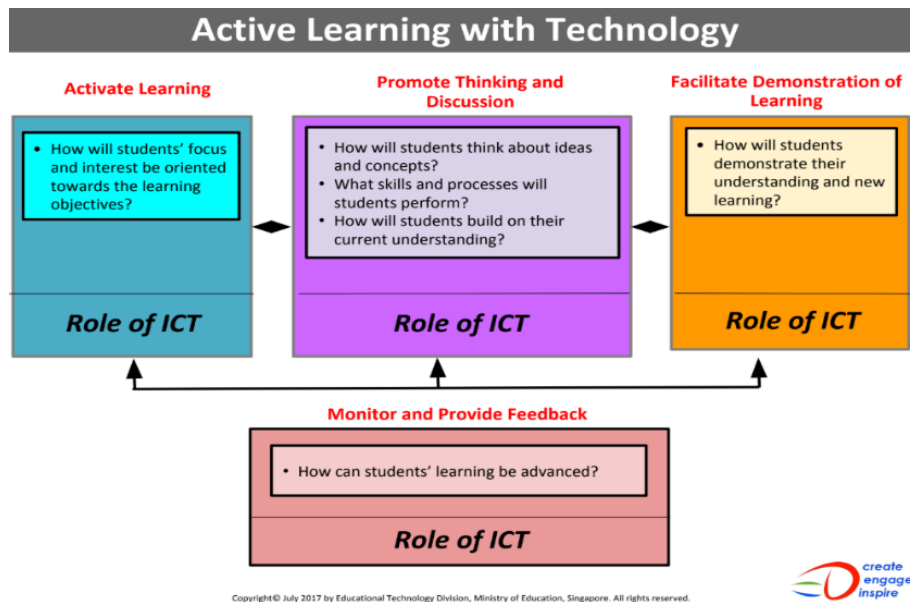


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Source: Ministry of Education Educational Technology Division, 2017

**Figure 1.** SLS Pedagogical Scaffold

Figure 1 presents the SLS Pedagogical Scaffold, a three-phased framework to integrate technology into teaching pedagogy. It shows how teachers can plan lessons by firstly, providing a clear learning outcomes, secondly, designing and facilitating active learning with technology and lastly, assessing the quality of learning to ensure that the intended learning outcomes are achieved.



Source: Ministry of Education Educational Technology Division, 2017

**Figure 2.** Active learning with Technology

Figure 2 outlines the process of active learning with technology, highlighting how the role of ICT supports each stage. It shows that technology can help with captivating active learning by capturing students' attention and connecting them with the objectives, promote thinking and discussion by enabling exchange of ideas and deeper understanding, facilitate demonstration of learning through digital creation and performance tasks, and monitor and provide feedback by tracking progress and giving timely responses to improve learning outcomes.

| Roles of Teacher, Student and Technology in Active Learning                                                                                                                                                |                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ACTIVE LEARNING                                                                                                                                                                                            | Role of Student                                                                                                                                                                                          | Role of Teacher                                                                                                                                                                                                                                                                          | Role of Technology                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|                                                                                                                                                                                                            | Interactions between teacher, student & content                                                                                                                                                          |                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Activate Learning</b><br>How will students' focus and interest be oriented towards the learning objectives?                                                                                             | <ul style="list-style-type: none"> <li>Set own or group learning goals</li> <li>Connect prior knowledge to the task</li> </ul>                                                                           | <ul style="list-style-type: none"> <li>Clarify learning objective and success criteria</li> <li>Design trigger activity to elicit students' prior knowledge</li> </ul>                                                                                                                   | <ol style="list-style-type: none"> <li><b>Multimodal representation of a concept</b> e.g. multimedia resources, websites, podcasts, webcasts, animations, videos</li> <li><b>Facilitate planning, participation and development of ideas</b> e.g. wikis, email, online calendar</li> <li><b>Task environments that represent and simulate real-world problems, situations and contexts</b> e.g. microworlds and simulations, virtual/augmented reality, role-play simulations, serious games and immersive environment, manipulatives to facilitate problem-solving</li> <li><b>Analysis and synthesis</b> e.g. graphic organisers, mindmap, spreadsheets, computational tools or software</li> <li><b>Iterative discussions</b> e.g. web conferences, live or asynchronous online chat or forum</li> <li><b>Collection of data</b> e.g. data-logging devices, online survey</li> <li><b>Access to information for research</b> e.g. online libraries, databases, search engines</li> <li><b>Access to learning partners or experts</b> e.g. email, web conferencing, social media tools, online learning network, webinars, online courses, MOOCs</li> <li><b>Creation of digital products</b> e.g. video editing, infographics, slideshows, animations, website, blog, e-books</li> <li><b>Tracking and assessing</b> e.g. clickers to gather responses to questions, online quizzes, classroom management system</li> <li><b>Communicate feedback</b> e.g. email, web conferencing, social media tools, annotation tools</li> </ol> |
| <b>Promote Thinking and Discussion</b><br>How will students think about ideas and concepts?<br>What skills and processes will students perform?<br>How will students build on their current understanding? | <ul style="list-style-type: none"> <li>Engage in thinking through discussion, negotiation and meaning making</li> <li>Use peers' and teacher's ideas and concepts to refine own understanding</li> </ul> | <ul style="list-style-type: none"> <li>Design tasks to connect, challenge, deepen or extend students' thinking</li> <li>Provide thinking routines or scaffolds</li> <li>Get students to share their ideas and concepts</li> <li>Teacher articulates his/her ideas and concept</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Facilitate Demonstration of Learning</b><br>How will students demonstrate their understanding and new learning?                                                                                         | <ul style="list-style-type: none"> <li>Articulate understanding of concepts</li> <li>Demonstration of skills</li> <li>Apply learning by creating a digital product</li> </ul>                            | <ul style="list-style-type: none"> <li>Design performance tasks for students to apply their learning in various ways</li> </ul>                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Monitor and Provide Feedback</b><br>How can students' learning be advanced?                                                                                                                             | <ul style="list-style-type: none"> <li>Provide feedback to peers</li> <li>Use feedback from peers and teacher to refine own understanding</li> <li>Reflect on goals and learning process</li> </ul>      | <ul style="list-style-type: none"> <li>Check for understanding using students' works</li> <li>Give timely and targeted feedback</li> <li>Provide opportunities for feedback from peers or experts</li> <li>Ensure learning objectives and success criteria are met</li> </ul>            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

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Source: Ministry of Education Educational Technology Division, 2017

**Figure 3.** Roles of Teacher, Student and Technology

Figure 3 illustrates the roles of teachers, students, and technology in fostering active learning. It shows how active learning is set in motion, thinking and discussion are being encouraged, and understanding is applied, tracked and improved. Teachers are to design and facilitate learning experiences by providing scaffolds and giving targeted feedback. Whereas students set goals, connect prior knowledge, engage in discussions, apply concepts and reflect on their progress. Whilst technology supports the process by offering resources, interactive environments, collaboration tools, data collection and feedback mechanisms—enabling rich, multimodal and student-centered learning experiences.

From Figures 1, 2 and 3 above, we see how technology impacts the way teaching and learning happen cognitively and behaviorally. Looking at the role of teachers, they are no longer simply vehicles to deliver information but now have to perform the roles of designers, facilitators and co-learners. There is a need for them to deliberately utilize technology tools to design a learning experience, to monitor the progress of students working collaboratively and to use the digital trail created by students' comments, edits and annotations to assess their level of understanding. There is a higher cognitive demand for teachers as instead of a

pen and paper traditional form of teaching, they need to design their lessons digitally. That said, the digital affordances are helpful as teachers can decide which form of media they wish to use – be it videos or websites. The digital platform allows teachers to link problems to real-world situations through the use of virtual or augmented reality and simulations. This is exceptionally helpful for students as it is highly immersive and engaging. Moreover, there are opportunities for them to collaborate in a safe experiential learning environment (Concepción, 2024).

According to Mirau (2017), the usage of online platforms can create learning opportunities without the restrictions of location and with less time. This includes real-time video conferencing tools such as Zoom and Google Meet. This is similar to Graham et al. (2019)s' stance where they shared that teachers can create online learning communities and use it to facilitate meaningful interactions online (Graham et al., 2019). Affordance such as flexible, asynchronous engagement could also be provided through the use of technology.

However, students' ability to benefit from technology is restrained by age, digital literacy, and cultural context. In developing countries like Indonesia, parental involvement can help students focus better and also learn better (Hayati et al., 2022). They also adopted blended learning to aid students who face difficulties in online learning. Hybrid learning is used for selected students who would gain from both face-to-face and online learning (Hayati, et al., 2022). As stated by Graham et al., (2019), hybrid learning helps assist different learning needs as there is a flexibility in the pedagogical approach.

## **B. Discussion**

### **1. *Integration of theoretical framework***

Theoretical framework is a field study of disciplines that needs incorporation in educational pedagogies as it impacts the cognitive and behavioral outcomes in every aspect of where change occurs, like learning through the means of online digital platforms, such as the constructivist learning theory, Community of Inquiry (CoI) model and engagement theory. The viewpoint of these variations shows how technological advancement of digital platforms affects students' critical thinking, problem solving skills, participation, motivation and engagement.

The findings above can be interpreted through these five key theoretical frameworks: constructivist learning theory, the Community of Inquiry (CoI) model, blended learning theory, motivation and engagement theory, and crisis-responsive education.

a. Constructivist learning theory

According to Hein, G. E. (1991), learners learn through active knowledge construction where participation in discussions, problem-solving and applying knowledge would help in achieving academic progress and success rather than passively listening and taking notes without any knowledge retention. This also involves relating new information to prior knowledge, reflecting on experiences, and constructing meaning through interaction with others. Hence, requiring real-world contextual and knowledge retention concepts of teaching should be integrated into designing the digital learning tools. Thereby explaining why digital tools like Google suite, VoiceThread, Mindomo foster co-construction and reflective thinking (Hein, 1991).

b. Community of Inquiry (CoI) model

The Community of Inquiry (CoI) model encompasses three correlating presences; a. teaching presence where pre-planning preparation of course design along with facilitation would develop analytical thinking, b. social presence in which group bonding and open discussion would enhance participation and amplify engagement, and c. cognitive presence where the sequence of exploration in an inquiry cycle—involving phases like formulating questions, gathering data, analyzing information, and drawing conclusions—would nurture critical thinking, problem-solving, reflective thinking and active recall (Garrison & Arbaugh, 2007; Understanding and Nurturing Critical Thinking Professional Learning & Support Series, n.d.). All three presences are fundamental elements in education through all modalities. Hence, these presences made available in platforms such as SLS and Zoom scaffolds promotes engagement, problem-solving, and critical thinking (Garrison & Arbaugh, 2007).

c. Blended learning design/theory

According to Graham and Halverson (2022), scaffold learning and versatility in blended or hybrid learning where it integrates two modalities together would enhance further cognitive analytical thinking and encourage behavioral engagement.

d. Engagement and motivation theory

Synchronous interaction produces higher engagement, if navigated properly by using CoI method and rigorous evaluation of conceptual design methods, would reinforce cognitive performance and behavioral diligence (Martin et al. 2021; Akpen et al., 2024).

e. Educational response to crisis

The sudden disorder of COVID-19 brought an impact to the accessibility of knowledge, albeit its flexibility in attaining education, lies in injustices where connectivity and supportive environments are not obtainable worldwide. Even

for those who had the accessibility to adapt to changes of digital technologies, it brought upon cognitive and behavioral impact on learners due to the lack of knowledge in adopting the pedagogy (Reuge et al., 2021; UNICEF, 2021).

This emphasizes the importance of incorporating frameworks and taking into consideration how different modalities require different approaches of design tools to overcome the cognitive and behavioral impact of education.

**Table 2.** Summary of Framework

| Theory/Model                        | Key Ideas                                                            | Cognitive Impact                        | Behavioral Impact                         |
|-------------------------------------|----------------------------------------------------------------------|-----------------------------------------|-------------------------------------------|
| <b>Constructivist Learning</b>      | Learning through active participation and real-world tasks           | Better understanding, critical thinking | Active learning, collaboration            |
| <b>Community of Inquiry (CoI)</b>   | Learning through teaching, social, and cognitive presence            | Reflective thinking, problem-solving    | Engagement, group interaction             |
| <b>Blended Learning</b>             | Mix of online and in-person learning; flexible and scaffolded        | Analytical thinking, adaptability       | Self-regulation, consistent participation |
| <b>Engagement &amp; Motivation</b>  | Synchronous learning + good course design = high engagement          | Focus, better performance               | Motivation, diligence                     |
| <b>Crisis Response in Education</b> | COVID-19 disrupted access; highlighted global inequality in learning | Mixed outcomes, cognitive stress        | Uneven participation, resilience in some  |

Source: Results of the research study

#### 1. The relationship between technology and higher-order thinking skills

The research studies above show that well-designed educational technologies influence the development of higher-order thinking skills (HOTS). Combining collaborative and multimedia platforms with active learning strategies could enrich and strengthen the capability of reflecting, problem-solving, and justifying. For instance, in Singapore, the SLS platform integrates the use of technology with HOTS through pedagogical scaffolds focusing on the learning outcomes, active engagement and quality assessment (Ministry of Education Educational Technology Division, 2017).

#### 2. Challenges in measuring the impact of technology on behavior

In the discussion of integrating technology in educational pedagogy, the behavioral aspect of assessment in its outcomes has remained inconsistent despite its positive indicators. Its definition of engagement, motivation, and participation varies across the studies making it difficult to establish a universal benchmark. The limit of these studies which are short-term observations without

an in-depth, drawn-out understanding of observing the outcomes makes it tough to predict a lasting behavioral impact and change (Li et al., 2014; Hayati et al., 2022)

### 3. Technology as a facilitator verses a distractor

In the studies above, integrating technology in education has been observed to be supporting the development of the cognitive aspect but it could also disrupt ones' attention and provide an act of distraction. The younger learners face difficulties in maintaining focus and self-regulation in learning through an online environment (Hayati et al., 2022). This enhances the need for digital literacy education and appropriate scaffolding in mitigating the risks of excessive screen use and decreased attention span.

### 4. Pedagogical Implications

The reviewed literature highlights the need to adapt with technological advances along with developing a context-sensitive design of learning environments to cater the needs in integrating digital platforms with the education modalities.

In response to the evolving aspect of education, according to MOE (2023), Singapore's MOE is steering into the future with its "Transforming Education through Technology" Master Plan 2030. It builds on earlier ICT initiatives and responds to the realities of learning post-COVID, with a sharper focus on digital tools as everyday enablers of teaching and learning. MOE wants Singaporean students to be empowered by technology to be future-ready learners in this 21<sup>st</sup> century. This is achieved through utilizing a plethora of technology tools which allows seamless collaboration which in turn helps co-construction and sharing of knowledge. They must also be digitally literate in terms of being able to filter the immense information that technology provides through cyber wellness strategies to remain safe and discerning in the digital world (MOE, 2023).

Students must also be grounded in values as they innovate using digital tools to find solutions to real-world problems. Teachers are to be more collaborative, proficient and confident with use of technology in education in order to design better learning experiences for the students. Together, schools will be flexible, multi-functional learning spaces as physical classrooms and digital platforms work hand-hand (MOE, 2023).

Classrooms must be equipped to adapt to the teaching and learning needs with use of new technology. At the same time, the online learning spaces help support learning anywhere and anytime the student wishes to engage on the digital content. Thus, we are no longer bound to the limits of a physical classroom but are now able to connect in-school learning with after-school hours and the

real outside world. Eventually, leading to strengthening of connections across schools, institutions, and private partners (MOE, 2023).

The strategic outline of the Master Plan 2030 suggests that Singapore aims to leverage technology to impact education as more positive effects will be seen cognitively and behaviorally on educators and students (MOE, 2023). On the other hand, hybrid models of educational pedagogies combine the strengths of both traditional and online methods of teaching, increasing its benefits across different educational levels ensuring flexibility whilst retaining its structure.

From the above, it can be concluded that the usage of technology in education has a positive impact on behavioral and cognitive outcomes. This applies through the range of education levels from kindergarten to elementary to secondary to pre-tertiary and even tertiary levels. In spite of challenges such as access to digital tools or motivation, it is crucial to bear in mind that technology in education helps students to collaborate easily, be independent and foster higher-order thinking skills such as being critical. Thus, it is important that schools partner up with the community and government to invest in technology in education. Of course, the educators have to also play their part to develop themselves professionally and learn how to design their lessons using technology effectively. Ultimately, the goal should be to encourage and aim for a hybrid learning model where we make use of the best aspects of both traditional and online learning so that we can have a robust education for our children.

## **2. *Critical synthesis and research gaps***

The limitations of most studies in the given context relied on qualitative data or short-term observation that lacked the depth of longitudinal or mixed-methods research. The lack of these approaches can lead to limitations in generalization that may not apply to a wider population and a lack of in-depth understanding of the complexities of the research topic. These reviewed studies are also significantly focused on the research of developed countries such as Singapore, China and the USA. The limitations of data from underrepresented or low-resources contexts may affect the bias of the study as they may face a different challenge in the implementation of technology in education (Hayati et al., 2022).

Despite referencing several frameworks such as the MOE pedagogical scaffolds, many studies lack in incorporating the cognitive and behavioral learning theories into their pedagogies that are designed to cater with the integration of digital platforms. Furthermore, there is insufficient research on examining the impact of prolonged use of technology in learning strategies and character development in students.

Future research should explore an in-depth analysis of the of the integration of technology with specific pedagogical theories that includes metacognition, motivation and behavior change models. Aside from that, make the research a diverse cultural and socio-economic context to ensure a broader applicability of assessment. This includes incorporating longitudinal, mixed-method studies to avoid bias and limitations in measuring long-term cognitive and behavioral outcomes. Other than that, to investigate further the role of community and parental support in enhancing the digital learning effectiveness.

## **Conclusion**

Technology-based learning has a significant potential to improve both cognitive and behavioral outcomes across different levels of education. The findings indicate that the use of digital tools, interactive multimedia, and online learning platforms can support learners' cognitive development by promoting active participation, collaboration, problem-solving, higher-order thinking, and metacognitive skills. At the behavioral level, technology-based learning can enhance learners' motivation, engagement, participation, autonomy, and self-regulation, although its effectiveness varies according to learners' age, learning context, teacher competence, and digital infrastructure. The integration of constructivist learning principles and the Community of Inquiry framework further strengthens the effectiveness of technology-based learning by providing meaningful, interactive, and reflective learning experiences. However, technological integration does not automatically guarantee positive learning outcomes, as differences in access, digital literacy, instructional design, and contextual support may influence its effectiveness. Therefore, successful technology-based learning requires well-designed digital pedagogy, continuous teacher professional development, adequate technological infrastructure, and collaboration among schools, families, and educational stakeholders. Overall, technology-based learning should be positioned not merely as a technological innovation but as a pedagogical approach that strategically integrates digital technology to develop learners' cognitive abilities and positive behavioral engagement in contemporary education.

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