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The Cloud-Based Remote Learning via Digital Media Ecosystem to Enhance Learning Engagement among Undergraduate Students in Engineering Education

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Abstract

This research aimed to develop the Cloud-Based Remote Learning Digital Media Ecosystem (CbRL-DM Ecosystem) to enhance undergraduate engineering students' learning engagement. The study employed a mixed-methods research design, consisting of three phases: 1) A scoping review exploring the consistency between digital media exposure, technological infrastructure, and engagement strategies among Thai higher education students; 2) Development of the CbRL-DM Ecosystem; and 3) Assessment of learning outcomes among 45 first-year engineering students in Thailand. We assessed learning outcomes through pretest and posttest scores using paired t-tests for analysis. The findings revealed: 1) The scoping review identified digital media behaviors among Thai undergraduate students, including the use of Line, Facebook, Instagram, TikTok, and Google Workspace, which align with the technological infrastructure of Thai higher education institutions; 2) The CbRL-DM Ecosystem consists of three components: (1) Instructors, who manage the classroom by pre-designing lessons and communicating through remote learning while applying effective engagement strategies such as verbal and non-verbal communication technique (e.g., gestures, eye contact, tone), gamification technique, and collaboration technique; (2) Digital media, hosted on public cloud platforms (including LINE, Gmail, Google Classroom, Meet, Jamboard, Quizizz, Google Drive, and other tools like Google Add-ons); and (3) Students, who engage in self-regulated learning and learning by doing; 3) Undergraduate engineering students showed significantly higher levels of learning engagement and academic achievement after using the intervention, with statistical significance at the .05 level. Future research should integrate AI-powered tools such as ChatGPT, Gemini, and DeepSeek into the CbRL-DM Ecosystem to empower personalized learning experiences.

Keywords: cloud-based remote learning, digital media ecosystem, engineering education, gamification, learning engagement

1. Introduction

In today's rapidly evolving network society landscape (Sixto-García, J., Silva-Rodríguez, A., Rodríguez-Vázquez, A. I., & López-García, X., 2023), higher education institutions face unprecedented challenges in adapting their learning systems—such as digital contents, pedagogical methods, and technological tools—to ensure continuity in student learning (Napaporn, Maneewan, Thamwipat, & Nittayathammakul, 2023; Treve, 2021). Global crises, including the COVID-19 pandemic, rising levels of PM 2.5 pollution, and frequent natural disasters, have disrupted traditional classroom environments, highlighting the urgent need for more resilient and adaptive systems (Deaconu, Deaconu, Chitonu, & Taus, 2022; Huang et al., 2020; Muzaffar et al., 2021; Somabut et al., 2024). While these external factors push institutions toward remote learning solutions, disparities in technological infrastructure and instructional readiness often hinder the effectiveness of these systems, particularly in engaging students and supporting their diverse learning needs (Elumalai et al., 2021; Tang et al., 2021).

While these issues impact students across disciplines, the challenges are particularly pronounced in engineering education, where practical, hands-on learning experiences and collaborative problem-solving activities are critical for skill development (Brand, 2020; Van den Beemt et al., 2020). The transition to remote learning has made it difficult to replicate these experiences effectively, often leading to disengagement and reduced motivation among students (Bergdahl, N., 2022; Tulaskar, R., & Turunen, M., 2022). Furthermore, despite progress in adopting various technological approaches, engineering education in Thailand has yet to fully integrate digital media ecosystems as part of Technology Enhanced Learning (TEL) (Seetao & Surpare, 2020; Ansayam & Tan, 2021; Chumchuen & Akatimagool, 2022). Instructors frequently select digital tools based on personal preferences and familiarity, without fully considering the digital media exposure behavior of students or the technological infrastructure available in higher education institutions. This misalignment often leads to significant confusion among learners, reduced engagement, and suboptimal learning outcomes (Lazar, Panisoara, & Panisoara, 2020; Wekerle, Daumiller, & Kollar, 2022).

Effective communication is integral to fostering engagement in virtual classrooms. Horton (2011) categorized interpersonal communication into three key types: written word, spoken word, and body language. The written word involves conveying meaning or emotions through text, either synchronously or asynchronously, using tools like web pages, emails, and discussion boards. Spoken word refers to verbal communication that conveys meaning and emotions through tone and speech, delivered via mediums such as phone calls or voice conferencing. Body language emphasizes nonverbal cues, such as gestures and facial expressions, often conveyed through video conferencing. These three forms of communication are essential for maintaining engagement and facilitating effective interactions in virtual learning environments.

The adoption of appropriate tools within digital media ecosystems for cloud-based remote learning offers a promising solution to these challenges (Lousã & Lousã, 2023; Warschauer, 2011). These tools, powered by public cloud infrastructure and delivered through Software as a Service (SaaS) models, provide flexible learning environments accessible via web browsers without the need to download additional software (Kultawanich, Koraneekij, & Na-Songkhla, 2015; Maneewan, Nittayathammakul, & Lertyosbordin, 2017). They include features such as real-time collaboration, multimedia content delivery, and personalized feedback mechanisms, helping students maintain engagement (Huang et al., 2020). However, remote learning worldwide continues to face challenges in addressing the need for effective interaction and engagement. Verbal and nonverbal communication, such as tone, gestures, and visual cues, along with fostering two-way communication, are crucial for maintaining dynamic interactions, clarifying complex concepts, and supporting collaborative problem-solving in both traditional and virtual learning environments (Offir, Lev, Lev, Barth, & Shteinbok, 2004; Rosenberg & Sillince, 2000).

This study addresses these gaps by focusing on the development, validation, and evaluation of the cloud-based remote learning system within a digital media ecosystem. The specific objectives of this study are as follows: 1) To conduct a scoping review to explore the consistency between the digital media exposure behavior of Thai undergraduate students, the technological infrastructure in Thai higher education institutions, and the engagement strategies used to enhance effective remote learning; 2) To develop and validate the cloud-based remote learning via digital media ecosystem (CbRL-DM Ecosystem) to enhance learning engagement among undergraduate engineering students; and 3) To evaluate the effects of the developed CbRL-DM Ecosystem to enhance undergraduate engineering students' learning engagement and academic achievement.

2. Research Questions

1. What does the scoping review reveal about the alignment between the digital media exposure behavior of Thai undergraduate students, the technological infrastructure in Thai higher education institutions, and the engagement strategies for effective remote learning?

2. What are the key components of the CbRL-DM ecosystem that enhance learning engagement among undergraduate engineering students?

3. How does the developed CbRL-DM Ecosystem affect learning engagement and academic achievement among undergraduate engineering students?

3. Literature Review

3.1 Cloud-based Remote Learning

Remote learning is the provision of instruction, either synchronously or asynchronously, outside the traditional classroom. Synchronous learning connects students to real-time interactions, enabling immediate feedback from instructors (Alberto Muñoz-Najar et al., 2021). Asynchronous learning, on the other hand, allows students to engage at their own pace and schedule. Formats for remote learning range from paper-based materials to digital platforms, utilizing diverse channels such as mobile devices, television, radio, and online tools (Alberto Muñoz-Najar et al., 2021).

Cloud-based remote learning enhances these formats by leveraging cloud technologies to provide accessible, adaptable educational environments. These systems enable instructors and students to collaborate seamlessly across physical and virtual spaces, supporting both online and hybrid models (Czekierda et al., 2021; Huang et al., 2020). Tools like Google Classroom and Microsoft Teams facilitate both synchronous and asynchronous communication, addressing diverse learning needs (Christanto et al., 2023).

Modes of communication in remote learning play a pivotal role in engagement and accessibility. Synchronous communication allows real-time interaction, fostering immediate feedback and active engagement. Examples include virtual classrooms and instant messaging through tools like Zoom, Microsoft Teams, and Google Meet. This mode is ideal for discussions and collaborative tasks but requires stable internet and synchronized schedules (Christanto et al., 2023). Asynchronous communication, in contrast, provides flexibility by enabling learners to engage at their own pace through discussion boards, email, and pre-recorded videos. Tools like Google Classroom, Moodle, and Open Edx empower learners to access materials anytime, supporting self-directed learning. While this mode promotes accessibility, it may lack the immediacy of real-time interaction (Iskakova, 2024).

At the core of these capabilities are public cloud and Software as a Service (SaaS) solutions. Public cloud services, such as Google Cloud and AWS, offer scalable and cost-effective infrastructure, while SaaS platforms, like Google Workspace for Education, provide ready-to-use tools that simplify collaboration and resource management. These technologies ensure affordability, data security, and seamless integration for institutions of all sizes (Xuan & Rana, 2024). Thus, the effectiveness of cloud-based remote learning depends significantly on the roles of instructors and learners. Instructors act as facilitators and designers of the learning experience, leveraging tools like Google Classroom and Zoom to provide structured guidance, feedback, and resources while fostering collaborative and engaging activities. They must also adapt their teaching strategies to accommodate diverse learner needs across synchronous and asynchronous modes. Meanwhile, learners play an active role in managing their time and utilizing cloud-based tools for self-directed learning, collaboration, and resource exploration. By engaging proactively in both real-time and flexible learning opportunities, students enhance their autonomy, digital literacy, and collaborative skills, which are essential for success in modern educational contexts.

3.2 Digital Media Ecosystem

The digital media ecosystem refers to a communication system where humans act as both media users and content creators within a cloud-powered network (Sixto-García, Silva-Rodríguez, Rodríguez-Vázquez, & López-García, 2023; Zuckerman, 2023). This ecosystem fosters bidirectional interactions between individuals, digital content, communication channels, and systemic structures, forming a multidimensional framework for modern communication and engagement. Operating across various domains—business, entertainment, healthcare, and education—it serves as a cornerstone for how people interact, share, and consume information in the digital age (Raji et al., 2024; Zuckerman, 2023).

In the education sector, the digital media ecosystem has transformed teaching and learning into highly interactive and participatory processes. This ecosystem aligns with Schramm's Model, emphasizing feedback loops and dynamic role alternation, unlike traditional linear communication models that fix roles like "Sender" and "Receiver". For instance, students take on the role of Senders when asking questions or sharing ideas, while instructors act as Receivers by providing feedback. Conversely, during lectures or instructional delivery, instructors become senders, and students engage as receivers through listening or interaction. These fluid interactions not only promote mutual understanding but also encourage active participation, making learning more collaborative and engaging (Lin, X., & Lin, C., 2020). At the heart of the digital media ecosystem lies the integration of cloud-powered learning tools (Napaporn, Maneewan, Thamwipat, & Nittayathammakul, 2023; Tomczyk, Limone, & Guarini, 2024; Wan, Wang, Wang, & Bai, 2024), which can be categorized into six core functions essential for education:

1. Social communication tools: Platforms such as LINE, Facebook, Line, Telegram, and Discord facilitate interpersonal and group communication, helping learners and educators build relationships and collaborate effectively.
2. Browsing and seeking tools: Applications like Google Chrome, Firefox, Microsoft Edge, and Safari enable access to a wide range of digital resources, supporting research and information retrieval.
3. Interactive collaboration tools: Platforms such as Google Meet, Jamboard, and Zoom provide real-time communication and teamwork opportunities, enabling immersive virtual interactions in classrooms and projects.
4. Multimedia creation tools: Tools such as Canva and Padlet allow users to design and present engaging visual and interactive content, fostering creativity and enhancing communication.
5. Productivity and File-sharing tools: Solutions like Gmail, Google Drive, and Google Add-ons support resource management, collaborative editing, and workflow automation, improving both individual and group productivity.
6. Assessment and evaluation tools: Tools such as Kahoot!, Quizizz and Google Forms offer personalized feedback,

gamified assessments, and data-driven insights, supporting both formative and summative evaluations.

These tools seamlessly integrate with learning management systems (e.g., Google Classroom, Moodle), enabling instructors and students to engage deeply with content and each other. The integration of these platforms fosters accessibility, interactivity, and collaboration, transforming traditional classrooms into dynamic and participatory educational spaces.

3.3 Digital Media Exposure Behavior

Digital media exposure behavior refers to the selective process by which individuals choose, process, interpret, and retain information from digital platforms. Klapper (1960) introduced a four-stage framework—Selective Exposure, Selective Attention, Selective Perception and Interpretation, and Selective Retention—to explain how people filter and internalize information based on their interests, attitudes, and prior experiences.

1. Selective Exposure: Individuals deliberately choose communication channels and content that align with their preferences and needs. For example, users may engage with Facebook or YouTube to access content that satisfies their motivations (Klapper, 1960). Katz et al. (1973) expand on this by linking selective exposure to Uses and Gratifications Theory, which highlights how individuals actively seek media to fulfill cognitive, emotional, or social needs.
2. Selective Attention: People focus on messages that resonate with their beliefs while ignoring contradictory information. This behavior reinforces existing attitudes and fosters cognitive consistency (Klapper, 1960). Festinger's (1957) Cognitive Dissonance Theory complements this view by suggesting that individuals avoid dissonant information to maintain psychological comfort, a phenomenon particularly evident in social media environments where users curate their feeds to align with their perspectives.
3. Selective Perception and Interpretation: Personal experiences and biases shape the processing and interpretation of media messages. For instance, individuals with opposing ideological views can interpret the same piece of content differently. Berlo's (1960) SMCR Model supports this by emphasizing how personal factors, such as the receiver's background and attitudes, influence message interpretation.
4. Selective Retention: People remember information that aligns with their beliefs while discarding conflicting details. This selective memory reinforces existing attitudes and shapes long-term perceptions (Klapper, 1960). Digital platforms, according to Neuman et al. (2014), amplify selective retention through algorithmic reinforcement, ensuring that users encounter content that aligns with previously consumed information.

3.4 Technological Infrastructure

Technological infrastructure is the foundation of cloud-based remote learning, consisting of five key components: peopleware, hardware, networks, software, and data. Peopleware includes educators, students, administrators, and IT teams, each playing a critical role. Educators utilize tools like Google Workspace and Microsoft 365 to deliver lessons and provide feedback, while students actively engage in self-directed learning and collaboration. Hardware encompasses personal devices such as laptops and smartphones, institutional equipment like servers and networking hardware, and peripherals like webcams and interactive whiteboards that facilitate communication and collaboration. Networks, supported by high-speed internet and robust LAN/WAN systems, ensure seamless access to platforms like Google Classroom and Microsoft Teams for synchronous and asynchronous learning. Software integrates tools for course management, virtual meetings, and real-time collaboration, with platforms like institution-specific systems adding scalability and customization. Lastly, data drives personalized learning through analytics, supports secure storage on platforms like Google Cloud, and ensures compliance with regulations such as PDPA to protect privacy and foster trust while enhancing learning outcomes (Alberto Muñoz-Najar et al., 2021; Harini et al., 2024; Napaporn et al., 2023; Tinmaz, 2009; Tomczyk et al., 2024; Wan et al., 2024).

3.5 Engagement Strategies in Remote Learning

Engagement strategies in remote learning are essential for overcoming the challenges of physical and emotional distance in virtual environments. By adopting methods that enhance communication, interaction, and participation, educators can create dynamic learning experiences that foster connection and active engagement. Five key strategies—written word, spoken word, body language, gamification, and collaboration—form the foundation for effective remote learning.

1. Written word plays a fundamental role in remote learning by providing clarity and structure. Platforms like Google Classroom and Microsoft Teams allow educators to share announcements, assignments, and resources in written form, ensuring that students have access to well-organized content. Asynchronous tools such as discussion boards and chat features enable learners to express their thoughts, engage in reflective dialogue, and revisit information at their own pace. Clear, concise, and accessible written communication is crucial for

maintaining engagement and supporting diverse learning needs (Alberto Muñoz-Najar et al., 2021; Horton, 2011; Offir, Lev, Lev, Barth, & Shteinbok, 2004).

2. Spoken word enhances remote learning by enabling real-time interaction and fostering a sense of connection between instructors and students. Tools like Zoom, Google Meet, and Microsoft Teams allow educators to deliver live lectures, host discussions, and provide immediate feedback. The effectiveness of spoken communication lies in its tone and pacing. A warm and engaging tone captures attention and conveys enthusiasm, while a steady, deliberate pace ensures clarity and comprehension. These elements work together to create a meaningful and interactive learning experience, allowing students to remain attentive and motivated (Alberto Muñoz-Najar et al., 2021; Horton, 2011; Offir, Lev, Lev, Barth, & Shteinbok, 2004).
3. Body language remains an integral part of communication, even in virtual environments. Through video conferencing, instructors can use gestures, facial expressions, and posture to emphasize key points, convey enthusiasm, and foster engagement. For example, maintaining eye contact through the camera and using open hand gestures can help build trust and connection. Similarly, observing students' non-verbal cues, such as nodding or smiles, provides instructors with valuable feedback on their understanding and participation. Effective use of body language bridges the gap between instructors and students, making remote interactions more personal and engaging (Alberto Muñoz-Najar et al., 2021; Horton, 2011; Offir, Lev, Lev, Barth, & Shteinbok, 2004).
4. Gamification transforms the learning process by incorporating game-like elements to increase motivation and participation. Tools like Kahoot!, Quizizz, and ClassDojo allow educators to design interactive quizzes, challenges, and reward systems that make learning enjoyable and immersive. Leaderboards, badges, and points encourage students to actively engage with the material and foster a sense of achievement. By adding an element of fun, gamification not only enhances learning engagement but also improves knowledge retention and makes remote learning more dynamic. (Božić, Hoić-Božić, Dlab, Stančin, & Jagušt, 2024; Cigdem, Harun, et al., 2024)
5. Collaboration fosters a sense of community and teamwork in remote learning environments. Group projects, brainstorming sessions, and peer-to-peer activities conducted through tools like Google Drive, Jamboard, and Microsoft OneDrive encourage students to work together, share ideas, and solve problems collaboratively. Features such as breakout rooms in platforms like Zoom and Microsoft Teams support small-group discussions, enabling deeper engagement and interaction. Collaborative activities not only enhance interpersonal skills but also promote critical thinking and problem-solving, creating a richer and more meaningful learning experience (Alberto Muñoz-Najar et al., 2021; Itani, Palmer, & El-Sabbagh, 2024).

4. Methodology

This study employed a mixed-methods research approach using an exploratory sequential design (Creswell & Plano Clark, 2018). This design integrated qualitative and quantitative methods to explore the consistency between digital media exposure, technological infrastructure, and engagement strategies among Thai higher education students through a documentary research approach. The scoping review served as the foundation for synthesizing insights from existing literature, followed by the development of cloud-based remote learning procedures tailored to enhance learning engagement and academic achievement among engineering students. After development, these procedures were implemented and tested to evaluate their effectiveness in real-world educational contexts. We chose the exploratory sequential design to address complex issues within digital media ecosystems and remote learning strategies in higher education. We divided the research process into three phases to ensure a systematic and comprehensive analysis.

4.1 The First Phase

In the first phase of this research, we collected and analyzed quantitative data through a scoping review to explore the interconnections between digital media exposure behavior, technological infrastructure, and engagement strategies within the context of higher education students in Thailand. This approach was particularly relevant as the COVID-19 pandemic, which began in 2020, significantly accelerated the adoption of remote learning practices. Recognizing this transformation, the scoping review focused on identifying the devices and tools accessed by Thai students, the technological infrastructure employed by higher education institutions, and the strategies implemented to enhance learning engagement in remote education environments.

The review followed the PRISMA-ScR framework (Tricco et al., 2018), which was applied to guide the systematic process of conducting the scoping review. The research instruments used in this phase included (1) the data extraction form to collect relevant details from selected studies, (2) the coding framework for categorizing and organizing data related to the three core areas of focus, and (3) the synthesis matrix for summarizing and comparing findings.

The review began with the formulation of key review questions aimed at addressing three specific areas: (1) What devices and tools are accessed by higher education students in Thailand in relation to digital media exposure behavior?, (2) What types of technological infrastructure are utilized by Thai higher education institutions for educational management?, and (3) What engagement strategies are implemented to sustain student participation in remote education?

A systematic search of electronic databases was conducted, including Scopus, ERIC, ThaiJo, and the database of the Office of the Education Council, Ministry of Education, Thailand. We combined Boolean operators with targeted keywords like "digital media exposure", "technological infrastructure", "engagement", "remote learning", and "digital learning resources" to enhance precision. We limited the search scope to peer-reviewed articles published from 2020 onward to incorporate the latest advancements in remote learning practices after the COVID-19 pandemic. After retrieving relevant studies, a rigorous selection process was undertaken based on predefined inclusion and exclusion criteria. The inclusion criteria required that studies focus on higher education students in Thailand, address at least one of the three core areas, and be published in either English or Thai. Articles that did not meet these criteria, such as those not set in the context of higher education institutions, were excluded.

Once the selection process was complete, the data were extracted and analyzed using thematic analysis. The analysis revealed key insights, which were categorized into three themes. The findings from this scoping review provided a foundation for the subsequent development of cloud-based remote learning procedures.

4.2 The Second Phase

In the second phase of this research, we collected and analyzed quantitative data to develop and validate the cloud-based remote learning procedures via a digital media ecosystem. This phase aimed to ensure that the procedures effectively supported learning engagement among undergraduate engineering students. Building on insights from Phase 1, the focus was on refining the procedures and verifying their content validity through expert evaluation.

The research instruments used in this phase included: (1) the diagram and details of the cloud-based remote learning procedures (draft version), (2) the Content Validity Index (CVI) form based on a four-point Likert scale, and (3) the diagram and details of the cloud-based remote learning procedures (revised version). These tools provided a structured framework for both the development and validation processes.

This phase was conducted in three key steps: 1) the draft version of the cloud-based remote learning procedures was developed, informed by the findings from Phase 1, 2) procedures were evaluated for content validity by a panel of five experts, each holding a doctoral qualification and possessing at least three years of relevant experience in education technology, digital media, or engineering education, and 3) the Content Validity Index (CVI) was calculated to ensure that the procedures met the acceptable standard (S-CVI/Ave $\geq$ 0.90). Feedback from the experts was incorporated to revise and finalize the procedures for implementation in the next phase.

4.3 The Third Phase

In the third phase of this research, we collected and analyzed quantitative data to evaluate the effects of the developed cloud-based remote learning procedures on learning engagement and academic achievement among undergraduate engineering students. This phase aimed to assess the practical outcomes of the intervention and determine its effectiveness in enhancing both learning engagement and academic achievement in a real-world educational setting.

The study employed a quasi-experimental design with a one-group pretest-posttest approach, involving 45 first-year engineering students enrolled in the Engineering Economics course at King Mongkut's University of Technology North Bangkok during the first semester of the 2024 academic year. Participants were selected through purposive sampling. The sample size met the minimum requirement of 27 participants, as determined by G*Power calculations for a paired-samples t-test, which specified a medium effect size (0.5), an alpha level of 0.05, and a power of 0.8. With a total of 45 participants, the study achieved an actual power well above the required threshold, ensuring sufficient statistical power to detect meaningful effects of the intervention.

The research instruments utilized in this phase comprised: (1) the developed learning engagement questionnaire consisting of 15 items measured on a 5-point Likert scale and (2) the developed academic achievement test comprising 40 multiple-choice questions. Both instruments, developed by the researchers, achieved an IOC value of $\geq$ 0.8, ensuring validity and alignment with the study objectives.

The intervention, developed using the ADDIE model based on findings from Phase 2, was implemented with the participants over an 8-week period. The content of the intervention was drawn from the Engineering Economics course, which includes topics such as the time value of money, interest rates, economic decision-making, and cost analysis. Statistical analyses were conducted to evaluate the outcomes, including the calculation of means (M) and standard deviations (SD) for pretest and posttest scores. Paired t-tests were used to measure the effects of the intervention on both learning engagement and academic achievement.

5. Results and Discussion

5.1 Alignment of Digital Media Exposure Behavior, Technological Infrastructure, and Engagement Strategies among Higher Education Students in Thailand

The findings from this research highlight the interconnectedness between digital media exposure behavior, technological infrastructure, and engagement strategies among Thai higher education students, as illustrated in Table 1.

The alignment of these factors forms a cloud-based remote learning ecosystem that effectively supports higher education in Thailand. Students predominantly rely on mobile devices, laptops, and tablets, along with platforms like LINE and Google Workspace for Education, to facilitate communication, collaboration, and resource sharing. Social media platforms, such as Facebook, Instagram, and TikTok, enhance engagement and informal interaction but are generally used as supplementary tools rather than primary resources for remote learning.

Thai higher education institutions should prioritize adopting Google Workspace for Education, as Gmail is widely used among students, ensuring compatibility and ease of access. Tools such as Google Classroom provide greater flexibility and scalability compared to platforms like Moodle and EdX, which often require more technical expertise for implementation. Supporting tools like Google Chrome, Google Meet, and Google Drive further enhance communication and collaboration. Conversely, while Microsoft 365 tools, including Word, Excel, PowerPoint, and OneDrive, offer robust functionality, newer generations of students may be less familiar with them, making them less intuitive compared to the more widely adopted Google tools.

Engagement strategies bridge the gap between remote learning technology and educational outcomes. Instructors play a pivotal role by employing verbal and non-verbal techniques during video conferencing, integrating gamification elements like points and leaderboards, and facilitating collaborative activities such as group assignments. This alignment between digital media usage, infrastructure, and teaching practices creates an interconnected and adaptable ecosystem tailored to the evolving needs of Thai higher education students.

The research findings align with Wannapiroon et al. (2021), who emphasized that modern learning platforms must be accessible, easy to use, and capable of delivering diverse and personalized content. Google Workspace for Education exemplifies these qualities by combining flexibility with a range of tools that meet the needs of both students and educators. Similarly, Nilsook et al. (2021) highlighted the importance of learning platforms that seamlessly integrate across devices and promote interaction. This study corroborates these insights by demonstrating how tools like Google Meet and LINE effectively support communication and collaboration, particularly in remote learning contexts. Moreover, the incorporation of gamification and collaborative strategies, such as group assignments, reflects Nilsook et al.'s assertion that interactive learning elements significantly enhance learning engagement.

The findings also align with the guidelines from the Office of the Education Council, Ministry of Education, Thailand (2020), which stress the integration of digital tools like LINE, Facebook, and YouTube to support effective learning in higher education. These tools resonate with the learning preferences of Thai undergraduate students, who primarily use mobile phones and laptops for academic purposes. The Council's recommendation to adopt hybrid learning environments that combine physical and digital resources further complements this study's emphasis on accessibility and interactivity.

The research also supports Thamwipat et al. (2024), who demonstrated the potential of user-centric platforms like TikTok in promoting learning engagement and satisfaction. While TikTok's use has primarily been informal, its ability to foster motivation and interaction suggests opportunities for its structured application in remote learning environments. Future studies could explore strategies for incorporating TikTok into formal educational frameworks to enhance engagement and learning outcomes further.

Finally, the findings align with Sangboonraung et al. (2024), who examined digital technologies in instructional management during the New Normal and Next Normal phases in Thailand. Both studies highlight the critical role of tools like LINE, Google Classroom, and Quizizz in supporting communication, assignment management, and engagement strategies. This research builds on these findings by emphasizing the additional value of gamification, collaborative learning, and interactive assessments in fostering learning engagement. These strategies are particularly relevant for adapting Thai higher education to the evolving demands of the Next Normal, ensuring instructional practices remain dynamic and effective in a digital-first learning environment.

Table 1. Overview of the Alignment of Digital Media Exposure Behavior, Technological Infrastructure, and Engagement Strategies among Higher Education Students in Thailand

Themes	Sub-Themes	Key Insights	References
Digital Media Exposure Behavior	Device Usage	Mobile devices, laptops, and tablets are the most commonly used tools for learning. Most users favor Gmail accounts, followed by Microsoft accounts (e.g., Outlook, Hotmail). Their ease of use and compatibility with modern learning resources make them essential for communication, assignments, and accessing virtual tools.	Nilsook et al. (2021), Office of the Education Council (2020), Wannapiroon et al. (2021)
	Platforms and Tools	Students frequently integrate platforms such as LINE, Facebook, Instagram, and Google Workspace for Education into their academic and social activities. These platforms effectively support communication, collaboration, and resource sharing in both formal and informal learning contexts. TikTok, as explored by Thamwipat et al. (2024), has been applied in Thai higher education to enhance learning engagement.	Nilsook et al. (2021), Office of the Education Council (2020), Thamwipat et al. (2024)
Technological Infrastructure	Google Workspace for Education	Google Workspace tools streamline education by supporting key activities. Google Chrome provides access to tools, Google Calendar manages schedules, and Google Classroom handles assignments and resources. Google Drive ensures secure storage, while Google Docs, Sheets, and Slides enable collaborative content creation. Google Meet facilitates virtual communication.	Nilsook et al. (2021), Sangboonraung et al. (2024), Wannapiroon et al. (2021)
	Microsoft 365 for Education	Microsoft 365 are essential for professional learning, with Word, Excel, and PowerPoint for content creation, Teams for collaboration, and OneDrive for cloud storage and sharing.	Nilsook et al. (2021), Sangboonraung et al. (2024)
	Institution-Specific Systems	Many universities use custom-built systems, such as Moodle-based platforms, to address specific needs, while global platforms like EdX support interactive online learning and course delivery.	Nilsook et al. (2021), Sangboonraung et al. (2024)
Engagement Strategies	Verbal and Non-verbal Techniques	Engagement during video conferencing is enhanced through verbal strategies (e.g., clear explanations, enthusiastic delivery) and non-verbal techniques (e.g., gestures, tone, eye contact) used by teachers to maintain students' attention and foster interaction. These strategies help create an engaging and supportive virtual classroom environment, encouraging students to actively participate and comprehend the material being discussed.	Grothaus, C. M. (2023), Sangboonraung et al. (2024)
	Gamification and Collaboration	Gamification implemented by instructors enhances engagement by incorporating interactive and educational elements (e.g., points, leaderboards, rewards), while teacher-designed collaborative strategies, such as assigning group projects, foster peer-to-peer learning and meaningful interaction.	Nilsook et al. (2021), Wannapiroon et al. (2021)

5.2 The developed CbRL-DM Ecosystem

The CbRL-DM Ecosystem was developed to enhance cloud-based remote learning through the integration of three essential elements: instructors, digital media, and students. These components work collaboratively to create a dynamic and engaging learning environment that supports both synchronous and asynchronous learning processes. Figure *1* illustrates the structure of the CbRL-DM Ecosystem, showing how these three components interact within the ecosystem to enhance learning engagement. The ecosystem consists of three key components, as follows:

1. Component 1: Instructors drive the CbRL-DM Ecosystem through four key steps, supported by specific digital tools:
    1. Manage Virtual Classroom
       Instructors design and organize virtual classes using Google Classroom to distribute materials, manage assignments, and share announcements, ensuring a well-structured learning environment. Additionally, LINE and Gmail are used to provide updates, reminders, and guidance outside of class sessions.

2. Communicate via Remote Learning
   Effective communication is facilitated through Google Meet for live sessions, where instructors use both verbal and non-verbal strategies (e.g., tone, gestures, and eye contact) to foster interaction and ensure clarity.
3. Build Student Engagement
   Gamified activities are implemented using tools like Quizizz for live quizzes with points and leaderboards to motivate participation and sustain engagement. Collaborative tools such as Jamboard enhance interactive brainstorming activities during lessons.
4. Track Learning Progress
   Instructors assess student performance using Google Forms for quizzes and surveys, while Google Classroom is used for collecting assignments. Google Drive enables storage and tracking of submissions, with instructors providing constructive feedback to guide learning progress.

2. Component 2: Digital media, hosted on a Software as a Service (SaaS) model within public cloud infrastructure, serves as the backbone of the CbRL-DM Ecosystem, supporting both synchronous and asynchronous learning. Through an integrated suite of tools, digital media facilitates communication, course management, collaboration, and gamified learning, creating a dynamic and engaging environment for instructors and students. The tools, categorized by functionality, include:
   1. LINE and Gmail
      These communication tools are essential for providing announcements, updates, and reminders, ensuring that students and instructors remain well-informed and connected throughout the learning process.
   2. Google Classroom
      As the primary platform for course management, Google Classroom enables instructors to distribute assignments, share learning materials, and manage communication with students effectively, serving as the central hub for classroom organization.
   3. Google Meet
      Designed for real-time interaction, Google Meet facilitates live virtual sessions, enabling instructors and students to communicate and collaborate synchronously, fostering an interactive learning environment.
   4. Jamboard
      This tool enhances collaborative brainstorming and supports case-based learning activities. It provides a digital canvas for students and instructors to visualize ideas, solve problems, and work together creatively.
   5. Quizizz
      Encouraging gamified learning, Quizizz offers live quizzes, points, and leaderboards to sustain student motivation and engagement. Its interactive design helps reinforce knowledge in a fun and competitive way.
   6. Google Drive and Productivity Tools
      Google Drive serves as the central storage and collaboration platform within the CbRL-DM Ecosystem, seamlessly integrating with productivity tools to enhance learning and teamwork. Google Docs supports real-time document creation and editing for individual and group assignments, while Google Sheets facilitates data organization, numerical analysis, and spreadsheet management. Google Slides enables the creation of interactive presentations for collaborative projects, and Google Forms provides tools for surveys, quizzes, and feedback collection to evaluate learning outcomes. Additionally, Google Add-ons extend functionality by integrating third-party applications, offering advanced capabilities such as project management, data analysis, and creative design.
3. Component 3: Students play an active role as participants in the CbRL-DM Ecosystem and follow four key steps, supported by specific tools to enhance their learning experience:
   1. Participate in the Class
      Students attend live classes via Google Meet, and stay updated through notifications via LINE and Gmail. These tools support self-regulated learning by helping students manage their time, track assignments, and stay connected with both instructors and peers.

2. Engage Actively in Remote Learning

   Students participate in case-based learning using Jamboard for brainstorming and collaborative problem-solving, as shown in Figure 2. They actively engage with course materials and assignments on Google Classroom, allowing them to manage their learning process and set personal learning goals.

3. Assess Comprehension and Knowledge

   Students assess their comprehension through gamified quizzes on Quizizz and complete formative assessments via quizzes. These tools provide instant feedback, allowing students to evaluate their understanding, identify areas for improvement, and track their progress, as shown in Figure 3.

4. Perform Learning Tasks
   Students apply their knowledge through practical assignments and group projects, using Google Docs, Sheets, and Slides for real-time collaboration. All submissions are stored securely on Google Drive, ensuring easy access, version control, and seamless teamwork.

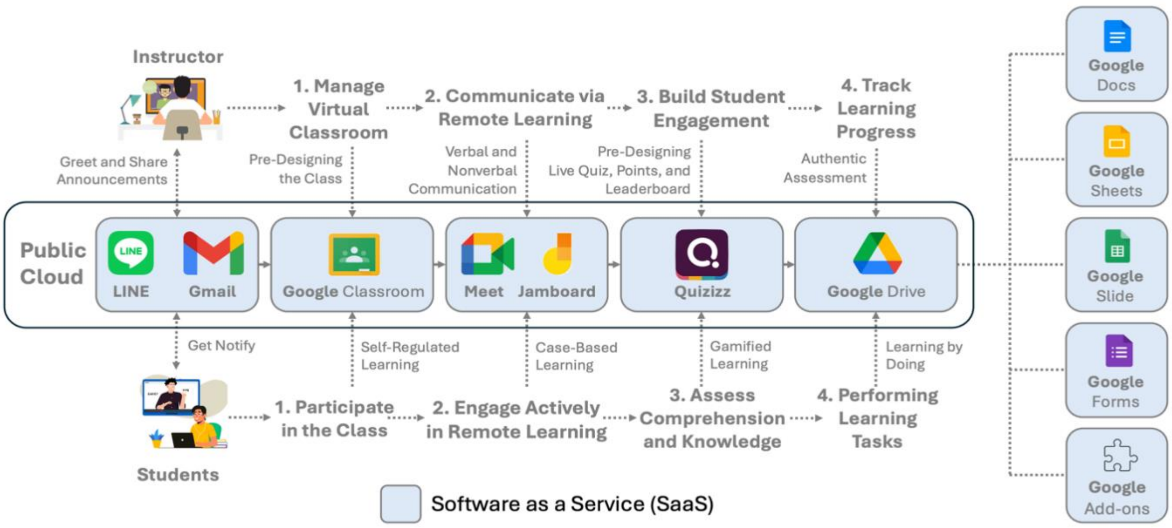

Figure 1. The Cloud-Based Remote Learning via Digital Media Ecosystem (CbRL-DM Ecosystem) to Enhance Learning Engagement among Undergraduate Students in Engineering Education

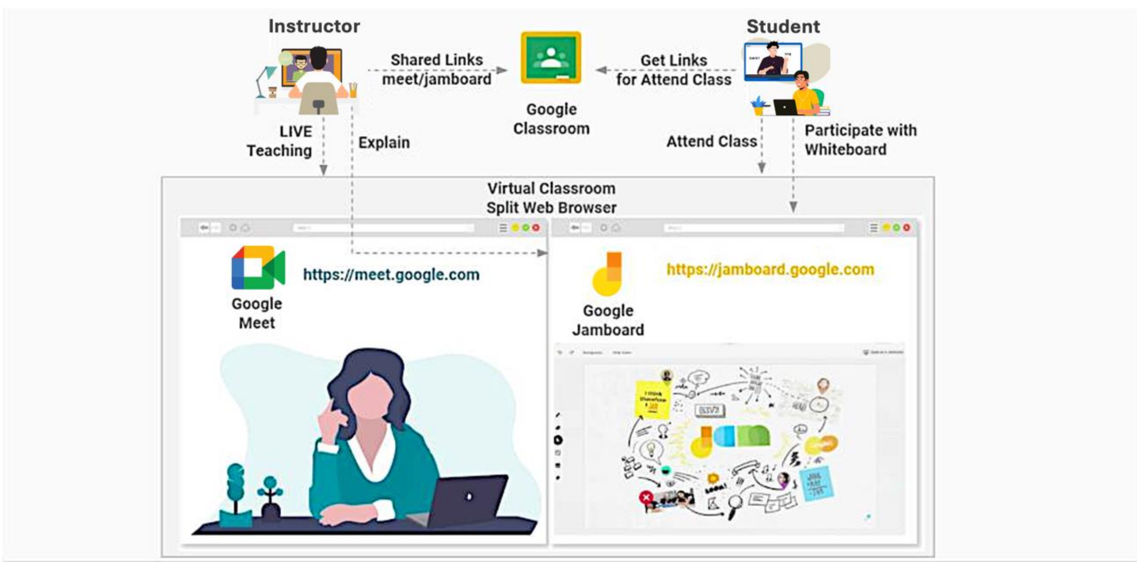

Figure 2. An Example of The Integration of Google Meet and Jamboard in the CbRL-DM Ecosystem

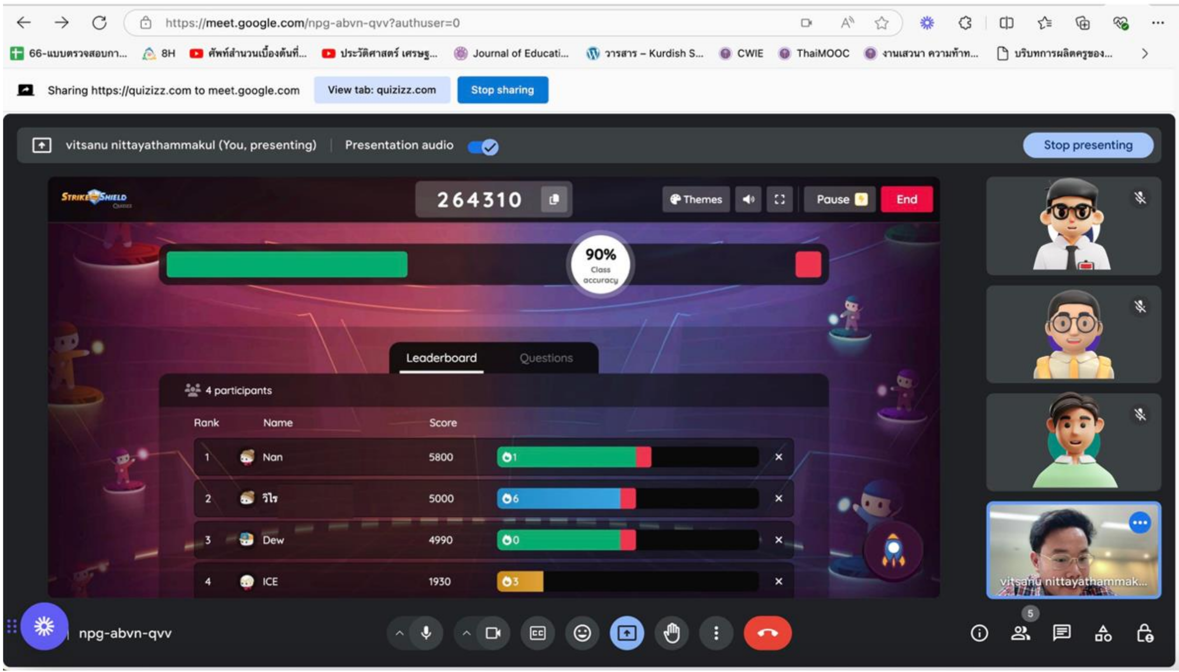

Figure 3. An Example of The Integration of Google Meet and Quizizz on Web Browser in the CbRL-DM Ecosystem

5.3 Effects on Learning Engagement and Academic Achievement

Participants' learning engagement and academic achievement were measured before and after using the CbRL-DM Ecosystem through a pre-test and post-test design. As presented in Table 2, there was a statistically significant improvement in both engagement and achievement scores following the intervention.

The mean score for learning engagement increased from 52.62 ± 4.16 before the intervention to 65.38 ± 6.08 after the intervention. Similarly, the mean score for academic achievement improved from 25.56 ± 3.07 to 35.22 ± 3.25. Paired t-tests indicated significant differences between the pre-test and post-test scores:

- Learning Engagement: $t(44) = 11.23$, $p < .001$
- Academic Achievement: $t(44) = 13.99$, $p < .001$

These findings suggest that the implementation of The Cloud-Based Remote Learning via Digital Media Ecosystem significantly enhanced both participants' learning engagement and achievement ($p < .05$).

Table 2. Pre-test and Post-test Results for Learning Engagement and Academic Achievement (N = 45)

Measure	Pre-test (M ± SD)	Post-test (M ± SD)	t	p
Learning Engagement	52.62 ± 4.16	65.38 ± 6.08	11.23	.001*
Academic Achievement	25.56 ± 3.07	35.22 ± 3.25	13.99	.001*

Note. p* < .05 indicates statistical significance.

The findings from this study align closely with the reviewed literature on cloud-based remote learning and the digital media ecosystem, demonstrating how technological advancements and structured engagement tools enhance educational outcomes. The significant improvement in both learning engagement and academic achievement after implementing the CbRL-DM Ecosystem reflects the potential of cloud technologies to create accessible, adaptable, and interactive learning environments. This is exemplified in the integration of tools like LINE, Gmail, and Google Classroom for managing virtual classrooms and pre-designing lessons, which enable instructors to effectively organize and deliver content. Platforms such as Google Meet and Jamboard further empower instructors to utilize verbal and non-verbal communication, facilitating clear explanations, immediate feedback, and dynamic teaching approaches that engage students (Czekierda et al., 2021; Christanto et al., 2023).

Additionally, the system's ability to enhance learning engagement and academic achievement is supported by interactive and gamified tools like Quizizz, which assess comprehension through live quizzes, leaderboards, and points. This aligns with Schramm's Model of communication, as instructors play a central role in designing and delivering engaging content while shifting roles dynamically to provide feedback and guidance. Moreover, the use of Google Drive and associated tools like Docs, Sheets, and Slides enables instructors to track student progress and support collaborative, learning-by-doing activities. These tools ensure structured assessments and resource management, fostering critical thinking, creativity, and self-regulated learning among students (Napaporn et al., 2023; Tomczyk et al., 2024). These findings confirm the importance of instructor-led strategies combined with technological infrastructure in creating dynamic, inclusive, and impactful learning experiences.

6. Conclusion

This study proposed the Cloud-Based Remote Learning Digital Media Ecosystem (CbRL-DM Ecosystem) to improve both learning engagement and academic achievement among undergraduate engineering students. The ecosystem incorporates three key components: 1) instructors, 2) digital media hosted on public cloud platforms, and 3) students. Instructors play a central role in managing virtual classrooms, fostering engagement through gamification and collaboration, and tracking progress using tools such as LINE, Gmail, Google Classroom, Meet, Jamboard, Quizizz, Google Drive, and other tools like Google Add-ons.

Digital media tools, supported by Software as a Service (SaaS), empower instructors to facilitate communication, collaboration, and assessment, leading to measurable improvements in learning engagement and academic achievement. The findings revealed statistically significant improvements in both learning engagement and academic achievement at the 0.05 significance level, supporting the ecosystem's effectiveness. By aligning technological tools with well-structured pedagogical strategies, the CbRL-DM Ecosystem fosters an inclusive and interactive learning environment tailored to the unique needs of Thai higher education. We anticipate that the CbRL-DM Ecosystem will serve as a reference for designing and implementing cloud-based remote learning interventions, not only in engineering education but also in other fields.

Although the study yielded promising results, it is important to acknowledge its limitations, including the lack of a randomized controlled trial (RCT) design, which could provide more rigorous evidence of the causal effects of the CbRL-DM Ecosystem on learning engagement and academic achievement. Additionally, the relatively small sample size of 45 students from a single institution may limit the generalizability of the findings.

Future research should focus on conducting longitudinal studies to assess the ecosystem's long-term impacts. Expanding the sample to include diverse institutions and disciplines would enhance the generalizability of the findings. Incorporating qualitative methods, such as interviews or focus groups, would provide deeper insights into user experiences, complementing quantitative findings. Moreover, comparative studies within ASEAN countries could offer valuable insights into how the CbRL-DM Ecosystem performs in diverse educational and cultural contexts within the region. Given ASEAN's shared focus on digital transformation in education, such research could examine factors such as technological infrastructure, digital literacy, and pedagogical adaptation, further validating the ecosystem's applicability beyond Thailand.

Finally, further exploration of advanced tools, such as personalized learning platforms integrated with generative AI models like ChatGPT, Gemini, and DeepSeek, alongside AI-driven analytics, could enhance the adaptability and efficacy of the learning ecosystem. Future research should investigate these areas to ensure continuous innovation and sustainable improvements in AI-assisted educational environments.

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Authors contributions

Pranee Sroyprapai was responsible for conceptualization, investigation, software development, formal analysis, and writing the original draft. Dr. Alisa Songsriwittaya supervised the study and contributed to methodology design and validation. Dr. Nutthapat Kaewrattanapat assisted with validation and visualization, while Dr. Vitsanu Nittayathammakul contributed to resource acquisition and writing—review and editing. All authors read and approved the final manuscript.

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Competing interests

Not applicable.

Informed consent

Obtained.

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The Publication Ethics Committee of the Redfame Publishing.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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References

Alberto, Muñoz-Najar, Alison, G., Amer, H., Cristobal, C., Joao Pedro, A., & Maryam, A. (2021). *Remote learning during COVID-19: Lessons from today, principles for tomorrow.* World Bank Publications. https://doi.org/10.1596/36665

Analysis of Google Workspace. In *Proceedings of the ACM on Web Conference 2024* (pp. 1892-1901).

Ansayam, M. P. G., & Tan, D. A. (2021). Investigating the utilization of digital instructional materials and digital tools for online learning in teacher education courses. *International Journal of Scientific & Technology Research*, *10*(9), 125-137.

Bergdahl, N. (2022). Engagement and disengagement in online learning. *Computers & Education*, *188*, 104561. https://doi.org/10.1016/j.compedu.2022.104561

Berlo, D. K. (1960). *The process of communication: An introduction to theory and practice*. Holt, Rinehart, and Winston.

Božić, A. V., Hoić-Božić, N., Dlab, M. H., Stančin, K., & Jagušt, T. (2024, September). Analysis of the Gamification Aspects of Digital Educational Tools Using Gamification Classification. In *2024 International Conference on Software, Telecommunications and Computer Networks (SoftCOM)* (pp. 1-6). IEEE. https://doi.org/10.23919/SoftCOM62040.2024.10721650

Brand, B. R. (2020). Integrating science and engineering practices: outcomes from a collaborative professional development. *International Journal of STEM Education*, *7*, 1-13. https://doi.org/10.1186/s40594-020-00210-x

Christanto, H., et al. (2023). Usability analysis of human computer interaction in google classroom and microsoft teams. *Journal of Theoretical and Applied Information Technology*, *101*(16), 6425-6425.

Chumchuen, N., & Akatimagool, S. (2022, September). Remote Virtual Laboratory Innovation on MIAP Engineering Teaching Model for Electrical Measurement Course. In *International Conference on Interactive Collaborative Learning* (pp. 423-431). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-031-26876-2_40

Cigdem, H., Ozturk, M., Karabacak, Y., Atik, N., Gürkan, S., & Aldemir, M. H. (2024). Unlocking student engagement and achievement: The impact of leaderboard gamification in online formative assessment for engineering education. *Education and Information Technologies*, 1-26. https://doi.org/10.1007/s10639-024-12845-2

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). SAGE Publications.

Czekierda, Łukasz, et al. (2021). Leveraging cloud environment flexibility to smoothen the transition to remote teaching during COVID-19 pandemic–a case study. *Bulletin of the Polish Academy of Sciences Technical Sciences*, e137934-e137934. https://doi.org/10.24425/bpasts.2021.137934

Deaconu, O., Deaconu, A. M., Chitonu, G. C., & Taus, D. (2022). The Online Teaching System as a Sustainable Way of

Learning. *Sustainability*, *14*(18), 11556. https://doi.org/10.3390/su141811556

Elumalai, Kesavan Vadakalur, et al. (2021). Factors affecting the quality of e-learning during the COVID-19 pandemic from the perspective of higher education students. *COVID-19 and Education: Learning and Teaching in a Pandemic-Constrained Environment*, *189*(3), 169. https://doi.org/10.28945/4628

Festinger, L. (1957). *A theory of cognitive dissonance*. Stanford University Press. https://doi.org/10.1515/9781503620766

Grothaus, C. M. (2023). Engagement in Online Learning among Thai and German Students: The Role of Classmates, Instructors, and Technology across Country Contexts. *Online Learning*, *27*(3), 188-208. https://doi.org/10.24059/olj.v27i3.3413

Harini, H., Ripki, A. J. H., & Putri, A. (2024). Digital Transformation: The Utilization of Information and Communication Technology to Enhance Educational Management Efficiency in the Modern Era. *Jurnal Minfo Polgan*, *13*(2), 1668-1674. https://doi.org/10.33395/jmp.v13i2.14195

Horton, W. (2011). *E-learning by design*. John Wiley & Sons. https://doi.org/10.1002/9781118256039

Huang, R., et al. (2020). Guidance on Providing Open and Distance Learning for Students withDisabilities during School Closures: Enhancing Inclusive Learning under COVID-19. Smart Learning Institute of Beijing Normal University (SLIBNU).

Iskakova, M. (2024). Prospects for Using E-Learning Tools to Implement the Concept of "Lifelong Learning". *E-Learning Innovations Journal*, *2*(2), 80-101. https://doi.org/10.57125/ELIJ.2024.09.25.05

Itani, M., Palmer, K., & El-Sabbagh, R. (2024). Transforming Education through Digital Technology: Shifting the Role of Innovation and Critical Thinking to Students. In *Transformative Leadership and Sustainable Innovation in Education: Interdisciplinary Perspectives* (pp. 191-198). Emerald Publishing Limited. https://doi.org/10.1108/978-1-83753-536-120241012

Katz, E., Blumler, J. G., & Gurevitch, M. (1973). Uses and gratifications research. *Public Opinion Quarterly, 37*(4), 509–523. https://doi.org/10.1086/268109

Klapper, J. T. (1960). *The effects of mass communication*. Free Press. https://doi.org/10.1037/006189

Kultawanich, K., Koraneekij, P., & Na-Songkhla, J. (2015). A proposed model of connectivism learning using cloud-based virtual classroom to enhance information literacy and information literacy self-efficacy for undergraduate students. *Procedia-Social and behavioral sciences*, *191*, 87-92. https://doi.org/10.1016/j.sbspro.2015.04.394

Lazar, I. M., Panisoara, G., & Panisoara, I. O. (2020). Digital technology adoption scale in the blended learning context in higher education: Development, validation and testing of a specific tool. *PloS one*, *15*(7), e0235957. https://doi.org/10.1371/journal.pone.0235957

Lin, X., & Lin, C. (2020, March). Communication theories applied in mentimeter to improve educational communication and teaching effectiveness. In *4th International Conference on Culture, Education and Economic Development of Modern Society (ICCESE 2020)* (pp. 870-875). Atlantis Press. https://doi.org/10.2991/assehr.k.200316.191

Lousã, E. P., & Lousã, M. D. (2023). Effect of technological and digital learning resources on students' soft skills within remote learning: The mediating role of perceived efficacy. *International Journal of Training and Development*, *27*(1), 1-17. https://doi.org/10.1111/ijtd.12280

Maneewan, S., Nittayathammakul, V., & Lertyosbordin, C. (2017, March). A development of knowledge management process on cloud computing to support creative problem solving skill on studio photography for undergraduate students. In *2017 6th International Conference on Industrial Technology and Management (ICITM)* (pp. 27-31). IEEE. https://doi.org/10.1109/ICITM.2017.7917890

Muzaffar, A. W., Tahir, M., Anwar, M. W., Chaudry, Q., Mir, S. R., & Rasheed, Y. (2021). A systematic review of online exams solutions in e-learning: Techniques, tools, and global adoption. *IEEE Access*, *9*, 32689-32712. https://doi.org/10.1109/ACCESS.2021.3060192

Napaporn, S., Maneewan, S., Thamwipat, K., & Nittayathammakul, V. (2023). The cloud-powered hybrid learning process to enhance digital natives' analytical reading skills. *International Journal of Advanced Computer Science and Applications*, *14*(1). https://doi.org/10.14569/IJACSA.2023.0140168

Nilsook, P., Wannapiroon, P., Nittayathammakul, V., & Anupan, A. (2021). Problems and needs of using modern learning resources in the digital age for learners in the working age. *Journal of Learning Innovation and Technology, 1*(1), 64–71.

Office of the Education Council. (2020). *Guidelines for developing learning resources in the digital age suitable for* *school-age learners.* Office of Education Standards and Learning Development.

Offir, B., Lev, Y., Lev, Y., Barth, I., & Shteinbok, A. (2004). An integrated analysis of verbal and nonverbal interaction in conventional and distance learning environments. *Journal of Educational Computing Research*, *31*(2), 101-118. https://doi.org/10.2190/TM7U-QRF1-0EG7-P9P7

Raji, M. A., Olodo, H. B., Oke, T. T., Addy, W. A., Ofodile, O. C., & Oyewole, A. T. (2024). Business strategies in virtual reality: a review of market opportunities and consumer experience. *International Journal of Management & Entrepreneurship Research*, *6*(3), 722-736. https://doi.org/10.51594/ijmer.v6i3.883

Rosenberg, D., & Sillince, J. A. (2000). Verbal and nonverbal communication in computer mediated settings. *International Journal of Artificial Intelligence in Education*, *11*, 299-319.

Russell Neuman, W., Guggenheim, L., Mo Jang, S. A., & Bae, S. Y. (2014). The dynamics of public attention: Agenda-setting theory meets big data. *Journal of communication*, *64*(2), 193-214. https://doi.org/10.1111/jcom.12088

Sangboonraung, W., Daungtod, S., Nilsook, P., Jitsupa, J., Skunhom, V., & Techachokwiwat, N. (2024). Empowering Pre-Service Teachers for the Digital Transformation of Education from New Normal to Next Normal. *Journal of Education and Learning*, *13*(4), 211-230. https://doi.org/10.5539/jel.v13n4p211

Seetao, C., & Surpare, K. (2020, November). Integrating MIAP Learning Activities Management and Cooperative Learning using Internet of Things Learning Package. In *2020 5th International STEM Education Conference (iSTEM-Ed)* (pp. 34-37). IEEE. https://doi.org/10.1109/iSTEM-Ed50324.2020.9332795

Sivakumar, A., & Singaravelu, G. Cloud Computing in Education. In *Transformative Digital Technology for Disruptive Teaching and Learning* (pp. 208-220). Auerbach Publications. https://doi.org/10.1201/9781032675176-18

Sixto-García, J., Silva-Rodríguez, A., Rodríguez-Vázquez, A. I., & López-García, X. (2023). Redefining journalism narratives, distribution strategies, and user involvement based on innovation in digital native media. *Journalism*, *24*(6), 1322-1341. https://doi.org/10.1177/14648849211062766

Somabut, A., Soodphakdee, D., Tuamsuk, K., & Kwangmuang, P. (2024). Navigating to the next normal: ICT readiness and online learning in higher education during and after COVID-19-a case study of Thailand. *Education and Information Technologies*, 1-27. https://doi.org/10.1007/s10639-024-13276-9

Tang, Y. M., Chau, K. Y., Kwok, A. P. K., Zhu, T., & Ma, X. (2021). Comparative analysis of Student's live online learning readiness during the coronavirus (COVID-19) pandemic in the higher education sector. *Computers & education*, *168*, 104211. https://doi.org/10.1016/j.compedu.2021.104211

Thamwipat, K., Princhankol, P., Maneewan, S., Pintong, M., & Eaksombun, T. (2024). Development and Assessment of Review Clips by Disabled Students for a Teenage Soul Healing Program on the TikTok Platform. *Studies in Media and Communication*, *12*(3), 168-176. https://doi.org/10.11114/smc.v12i3.6896

Tinmaz, H. (2009). Instructional Technology Plans for Higher Education Institutions. In *Handbook of Research on Technology Project Management, Planning, and Operations* (pp. 419-438). IGI Global. https://doi.org/10.4018/978-1-60566-400-2.ch027

Tomczyk, Ł., Limone, P., & Guarini, P. (2024). Evaluation of modern educational software and basic digital competences among teachers in Italy. *Innovations in Education and Teaching International*, *61*(2), 355-369. https://doi.org/10.1080/14703297.2023.2173632

Treve, M. (2021). What COVID-19 has introduced into education: Challenges facing higher education institutions (HEIs). *Higher Education Pedagogies*, *6*(1), 212-227. https://doi.org/10.1080/23752696.2021.1951616

Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., … & Straus, S. E. (2018). PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. Annals of Internal Medicine, 169(7), 467-473. https://doi.org/10.7326/M18-0850

Tulaskar, R., & Turunen, M. (2022). What students want? Experiences, challenges, and engagement during Emergency Remote Learning amidst COVID-19 crisis. *Education and information technologies*, *27*(1), 551-587. https://doi.org/10.1007/s10639-021-10747-1

Van den Beemt, A., MacLeod, M., Van der Veen, J., Van de Ven, A., van Baalen, S., Klaassen, R., & Boon, M. (2020). Interdisciplinary engineering education: A review of vision, teaching, and support. *Journal of engineering education*, *109*(3), 508-555. https://doi.org/10.1002/jee.20347

Wan, L., Wang, K., Wang, H., & Bai, G. (2024, May). Is It Safe to Share Your Files? An Empirical Security. https://doi.org/10.1145/3589334.3645697

Wannapiroon, P., Nilsook, P., Kaewrattanapat, N., Wannapiroon, N., & Supa, W. (2021). The Virtual Learning Resource Center for the Digital Manpower. *International Education Studies*, *14*(9), 28-43. https://doi.org/10.5539/ies.v14n9p28

Warschauer, M. (2011). *Learning in the Cloud*. Teachers College Press.

Wekerle, C., Daumiller, M., & Kollar, I. (2022). Using digital technology to promote higher education learning: The importance of different learning activities and their relations to learning outcomes. *Journal of Research on Technology in Education*, *54*(1), 1-17. https://doi.org/10.1080/15391523.2020.1799455

Xuan, C. Z., & Rana, M. E. (2024, January). Revolutionizing Higher Education: A Critical Analysis of Cloud Computing's Impact, Suitability, and Challenges. In *2024 ASU International Conference in Emerging Technologies for Sustainability and Intelligent Systems (ICETSIS)* (pp. 733-738). IEEE. https://doi.org/10.1109/ICETSIS61505.2024.10459441

Zuckerman, E. (2023). Why study media ecosystems?. In *Understanding Movement Parties Through their Communication* (pp. 169-187). Routledge. https://doi.org/10.4324/9781003369363-10