CADT

KONRAD ADENAUER STIFTUNG

DIGITAL INSIGHTS

FUTURE OF EDUCATION

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Cambodia Academy of Digital Technology (CADT) is a national research and education institution for Digital Technology and Innovation. Its mission is to provide high-quality higher education and professional training in digital technology to students, professionals, and civil servants who want to excel in the digital economy and society. CADT is the first institution of its kind in Cambodia to focus on research and development in digital technologies that advances knowledge and creates value from digital adoption and transformation. CADT fosters a culture of innovation and entrepreneurship among digital talents and innovators to support academic and socio-economic development.

CADT was established in 2014 as the National Institute of Post, Telecom, and ICT (NIPTICT), a public institution under the Ministry of Post and Telecommunications. In 2021, it transformed into CADT with an expanded mission to support the country's digital transformation agenda and the development of digital economy and society.

Freedom, justice and solidarity are the basic principles underlying the work of the Konrad-Adenauer-Stiftung (KAS). The KAS is a political foundation, closely associated with the Christian Democratic Union of Germany (CDU). As co-founder of the CDU and the first Chancellor of the Federal Republic of Germany, Konrad Adenauer (1876-1967) united Christian-social, conservative and liberal traditions. His name is synonymous with the democratic reconstruction of Germany, the firm alignment of foreign policy with the trans-Atlantic community of values, the vision of a unified Europe and an orientation towards the social market economy. His intellectual heritage continues to serve both as our aim as well as our obligation today.

In our European and international cooperation efforts we work for people to be able to live self-determined lives in freedom and dignity. We make a contribution underpinned by values to helping Germany meet its growing responsibilities throughout the world.

KAS has been working in Cambodia since 1994, striving to support the Cambodian people in fostering dialogue, building networks and enhancing scientific projects. Thereby, the foundation works towards creating an environment conducive to economic and social development. All programs are conceived and implemented in close cooperation with the Cambodian partners on central and sub-national levels.

DIGITAL INSIGHTS

11/2023

FOREWORD

Dr. Sopheap SENG
President
Cambodia Academy of Digital Technology (CADT)

Jason CHUMTONG
Country Director
Konrad-Adenauer-Stiftung (KAS) Cambodia

Cambodia is in the midst of rapid development. With the ambitious aim of becoming an Upper-Middle-Income Country by 2030 and graduating from Least Developed Country (LDC) status even sooner, Cambodia faces numerous challenges. These goals are attainable only through innovation and diversification, especially considering that the primary economic drivers have been exports, construction, and tourism.

To boost the national competitiveness, Cambodia must prioritize digitalization. In an age where information flows quickly, digital technology integration is essential. A crucial resource is Cambodia's young population, who are increasingly interested in digital technologies. While the COVID-19 pandemic has been a setback, it has also served as a catalyst for digitalization. This year's "Digital Insights: The Future of Education" outlines this emerging landscape.

Learning is no longer limited to traditional classrooms, but the extent to which digital tools can enhance education in Cambodia remains underexplored. This edition, therefore, emphasizes the importance of digital tools and lifelong learning. Science, technology, engineering, and mathematics (STEM) skills are essential for Cambodia's future growth. Moreover, the publication addresses the integration of digital technologies into Cambodia's higher education system. It also touches on challenges that might limit digitalization, particularly in rural areas. Despite these obstacles, digital technologies can improve access to education, support reforms, and drive economic growth, helping Cambodia to transition from LDC status.

As a foreword to this year's Digital Insights, we aim for this publication to act as a catalyst for dialogue and change. It outlines the existing landscape and inspires innovative solutions. The responsibility to address these challenges and opportunities lies not just with a single entity but is a collective task for the government, academia, private sector, and civil society. Together, we can build a more digitally advanced and resilient Cambodia.

Dr. Sopheap SENG
President
Cambodia Academy of Digital Technology (CADT)

Dr. Sopheap SENG is the President of the Cambodia Academy of Digital Technology (CADT), a public research and education institution specialized in digital technology and innovation. Dr. Sopheap is also a lecturer in computer science, he teaches programming, database and data science.

At CADT he is currently directing the efforts to build a digital innovation center to contribute to the development of the digital startup ecosystem in Cambodia. CADT is pursuing deeper public- private cooperation and is trying to create supportive policies for technology entrepreneurship and innovation. CADT is a key player in digital skill development in Cambodia, nurturing digital talent and innovators and is playing an integral role as the country seeks to formulate ground rules for its budding startup and technology sector.

Jason CHUMTONG
Country Director
Konrad-Adenauer-Stiftung (KAS) Cambodia

Since June 2023, Mr. Jason Chumtong has been the Country Director of KAS Cambodia which is based in Phnom Penh. Previously, he worked as a Policy Advisor for Artificial Intelligence and also contributed to the supervision of the KAS Fellowship. Jason Chumtong's previous post for the Foundation was at the KAS office in Riga for the Regional Programme Nordic Countries. He completed his bachelor studies in politics and sociology at the Friedrich-Wilhelms-University in Bonn. After a stay abroad in a Buddhist monastery in Thailand, Jason Chumtong completed his Master of Science at the University of Edinburgh. His final thesis in the course "Science and Technology in Society" examined the use of artificial intelligence for autonomous driving.

EDITORIAL NOTES

Melanie GERSTER
Head of Program Department, KAS Cambodia

Pisal CHANTY
Director, Digital & Innovation Policy Research, CADT

Dear readers,

Education is one of the most important investments in our future that we can undertake. Lifelong learning, new technologies, Artificial Intelligence – these buzzwords are all around and affect the world of education just as much as the world of work and our everyday lives.

With the rapid advancement of digitalization in all areas, education can and should not fall behind when it comes to utilizing these tools for the advancement in classrooms, the workplace and all areas of life. On the contrary, for young people to be able to make use of all the possibilities that digitalization brings, they need to be exposed to them at an early stage. This does not only involve access to equipment and facilities which can be a challenge itself, but also refers to the understanding of how to use these tools responsibly, understanding their benefits, chances and limits.

This year's edition is a common project between Konrad-Adenauer-Stiftung (KAS) Cambodia and the Cambodia Academy of Digital Technology (CADT). In order to learn about the Future of Education, especially in the Cambodian context, CADT and KAS bring together researchers and practitioners from a wide range to share their expertise and their analysis when it comes to the adaption of learning within and beyond the traditional school context. How do teachers, universities and other institutions prepare the students and themselves for the changes that are already underway? How can we support learners along the way and what kind of knowledge needs to be taught when knowledge is available everywhere?

This edition of Digital Insights was compiled to analyze all these topics and shed light on the state of digitalization in the educational system in Cambodia and the region. We are looking at International and Regional Trends to see where this development came from, how the pandemic supported the speedy involvement of digital learning in certain areas and why the continuous investment in this sector is crucial. In the Future of Education and Lifelong Learning, we are further analyzing the importance of connecting digital learning in and beyond the K12 educational stage and dig deeper into what our teachers and trainers need in order to successfully transfer this knowledge to students and support their development even after they leave the formal education sector. One of the main topics of interest for this year's edition and the world of education will come as no surprise to anyone – the potential of Artificial Intelligence. How is AI used in Cambodia's schools and universities, how can it contribute to spark interest in STEM and what challenges can it pose to the realm of the dissemination of information? Our case studies are taking these questions one step further and show how digitalization is already included throughout Cambodia. Through practical examples and questionnaires, they share best practices and outline the potentials and challenges that the digitalization in education can pose.

We sincerely thank all of our authors and education enthusiasts who have contributed to this year's publication of Digital Insights. To all of our readers: We hope that you enjoy this volume of Digital Insights and we encourage you to embrace the sphere of education and lifelong learning in your own lives!

Let us shape the future of education together.

With best regards,

Melanie Gerster and Pisal Chanty

Melanie GERSTER
Head of Program Department
KAS Cambodia

Melanie Gerster is the Head of the Program Department at Konrad-Adenauer-Foundation Cambodia. Her research focus includes education policies, digitalization and global governance. She is qualified in governance and public policy with a keen interest in education policy programming, multilateral programmatic and administrative implementation along with policy research. Trained as a political scientist, her professional experience has included short-term associations with the United Nations, international conferences (G20, LAC, UNFCCC Conference of Parties, UN SDG Action Campaign Festival), national and local governments as well as the private sector. She holds a B.A. in Political Science and German Philology and an M.A. in Governance and Public Policy.

Pisal CHANTY
Director, Digital & Innovation
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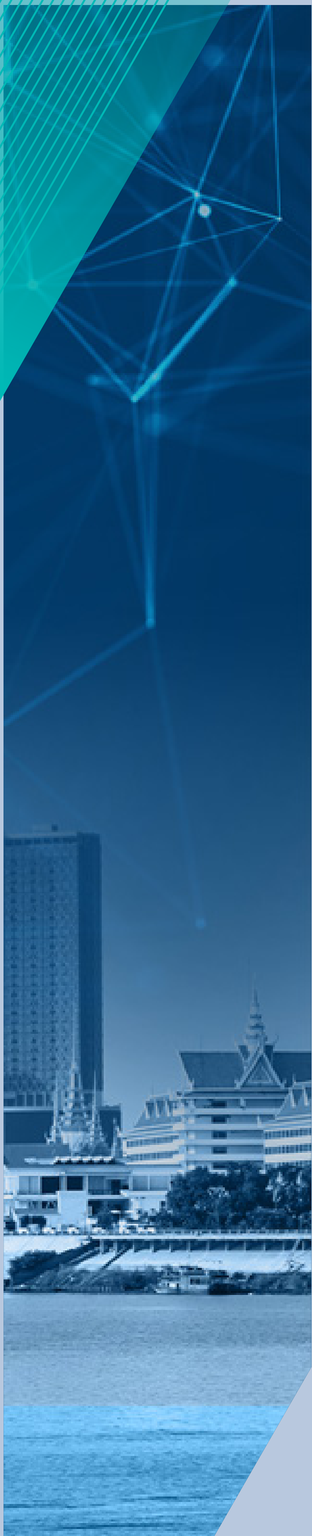
CADT

Mr. Chanty Pisal is the Director of Digital and Innovation Policy Research Center of the Cambodia Academy of Digital Technology (CADT). He is also the project coordinator of the Assessing Internet Development in Cambodia using UNESCO Internet Universality Indicators. Prior to this, he also served as Vice Director of the ASEAN ICT Center of the ASEAN Digital Sectoral Body (ADGMIN/ADGSOM) and worked for Ministry of Post and Telecommunications as international cooperation officers in charge of ASEAN, Mekong Cooperation, WTO and trade.

Pisal has played an active role in formulating and providing inputs to digital related policies in Cambodia as well as in ASEAN. He is also a member of the drafting team of the Digital Skill Development Roadmap in Cambodia, commissioned by the Ministry of Post and Telecommunications. Pisal holds master's in public policy specialized in Economic Policy and Policy Analysis from Australian National University, and master's in International Law from University of Paris 8. He conducts research and study on digital economy, digital and internet policy, cybersecurity, ASEAN Law and integration, and public finance.



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Education in the AI Era: The Future is Here!

Dr. Kieth Rethy CHHEM and Dr. Kathy HIBBERT

Introduction

The human fascination with Artificial Intelligence or Augmented Intelligence can be traced back through mythology and religion from 2000 years ago. Buddhism, for example, has long contended that there are sources of intelligence other than the human brain. The advances in technology have shattered previous beliefs about the relationship between humans and machines. We have moved beyond stand-alone technologies to a realization of the power of the convergence of the virtual and physical worlds – a new Artificial Intelligence (AI) metaverse. Within this new reality, we must grapple with the enormous questions about how working together in this new reality will create new capabilities for both machines and humans. In particular, we need to consider how education must lead our collective ability to navigate the profound technological disruption in ways that realize the promise of AI to enhance our human capabilities and unleash creativity.

The pace and volume of both advances in AI, and writing and thinking about AI, makes it impossible to keep up with. On one hand we have techno-optimists or transhumanists, who believe that "if and when humans develop highly sophisticated, general purpose AIs, these AIs will be conscious".[1] Citing futurist and computer scientist Ray Kurzweil, she quotes: "Once we saturate the matter and energy in the universe with intelligence, it will 'wake up', be conscious, and sublimely intelligent. That's about as close to god as I can imagine."[2] On the other hand, we have biological naturalists who reject the possibility outright. Instead, they describe it in terms of conscious engineering, in which control is retained by the humans doing the design. However, there is a tentativeness to each position because we simply don't know how this is going to evolve. Despite that lack of understanding, it is still a worthwhile exercise to engage in thinking through how we got here, what possibilities are being imagined, how to navigate such disruptive times, and what all of this may mean for education in Cambodia.

Understanding the history behind AI

Technology in education has undergone significant advancements since the early investigations of the 1950s and 1960s. The term Artificial Intelligence was first coined in a proposal written by McCarthy et al in 1955. Over the years, researchers and innovators have made significant progress in leveraging artificial intelligence (AI) to enhance teaching and learning experiences. From early computer-based learning systems to the emergence of adaptive learning and virtual reality technologies, AI has demonstrated that it has the potential to revolutionize education in numerous ways.

One of the early developments in the field of AI in education was the advent of intelligent tutoring systems (ITS) in the 1970s and 1980s. These intelligent tutoring systems utilized AI techniques to provide personalized instruction to students. By adapting to individual learners' needs, ITS offered a more interactive and individualized learning experience than what was possible in traditional classroom settings. Moreover, ITS could also provide tailored feedback, track progress, and identify areas where students needed additional support. The introduction of Intelligent Tutoring Systems (ITS) revolutionized education by facilitating individualized learning experiences, allowing students to progress at their own speed and according to their preferred learning methods (see for example, Alkatlan et al. 2018).[3]

Another significant advancement in AI in education came with the rise of expert systems in the 1980s. Expert systems aimed to capture the knowledge and expertise of human specialists in specific domains. In education, expert systems were used to provide domain-specific guidance and support to both students and teachers. These systems could offer detailed explanations, answer questions, model and assist with problem-solving, effectively serving as virtual tutors or mentors. The access to a virtual tutor enabled students to gain knowledge and skills in a more timely and thorough way.

Cognitive modeling, which emerged at the intersection of cognitive science and AI, also contributed to the development of educational software. Researchers sought to understand and replicate human cognitive processes using AI techniques. By simulating human cognitive processes, AI-based educational tools could be tailored to align with how individuals learn and think. Cognitive modeling informed the design of instructional materials, allowing for more effective and engaging learning experiences.

AI in education has increasingly adopted data-driven approaches, leveraging big data and machine learning. This has given rise to prominent fields like educational data mining and learning analytics, which analyze large datasets to gain insights into student behavior, performance, and learning patterns. Leveraging data, educators could identify trends, personalize instruction, and make data-informed decisions to enhance student outcomes.

Adaptive learning systems have gained traction in recent years, harnessing AI algorithms to customize the learning journey for each student individually. These systems analyze data on student performance to dynamically adjust content and activities to suit each learner's strengths, weaknesses, and preferences. Adaptive learning promotes personalized and targeted instruction, enhancing students' engagement and outcomes. By tailoring the learning experience, adaptive learning systems can accommodate diverse learning styles and provide individualized support.

The emergence of virtual reality (VR) and augmented reality (AR) technologies has brought new possibilities to education. AI can enhance these technologies by providing intelligent interactions, personalized feedback, and adaptive content. VR and AR simulations offer immersive and experiential learning environments, enabling students to engage with subjects in a more hands-on and interactive manner. As an illustration, virtual operating rooms offer medical students the opportunity to simulate surgical procedures, while virtual tours enable history students to delve into ancient civilizations. AI-powered virtual assistants and chatbots can further enhance the learning experience by offering real-time support and guidance.

However, as AI becomes more prevalent in education, ethical considerations become crucial. Issues such as data privacy, algorithmic bias, and the impact of automation on teaching roles need to be carefully addressed. Promoting fairness and responsibility in the utilization of AI in education involves prioritizing equitable access to AI-driven educational tools and upholding transparency in algorithms. Educators and policymakers must prioritize the ethical implications of AI implementation to safeguard student rights and well-being.

AI also holds immense potential in supporting lifelong learning and upskilling efforts. Intelligent tutoring systems, personalized learning platforms, and AI-powered assessment tools can aid individuals in acquiring new knowledge and skills throughout their lives. By providing tailored recommendations and adaptive content, AI can facilitate continuous professional development and career advancement in an ever-evolving job market. This helps individuals stay competitive and adapt to the changing demands of the workforce.

Looking ahead, the future of AI and education is promising. Advancements in natural language processing, computer vision, and robotics can further enhance the learning experience. AI-powered chatbots and virtual assistants can offer real-time support to learners, answering their questions and providing guidance. The concept of an AI metaverse, where virtual and physical worlds converge, opens up new possibilities for collaborative and immersive learning environments. Students can explore complex concepts and scenarios in a more engaging and interactive manner, fostering creativity, critical thinking, and problem-solving skills.

AI has the potential to revolutionize education by personalizing instruction, providing intelligent support, and creating immersive learning experiences. From early computer-based learning systems to the current advancements in adaptive learning, virtual reality, and augmented reality, AI continues to shape the future of education. Addressing ethical considerations and promoting equitable access to AI-powered educational tools is of utmost importance. By implementing AI responsibly, we can empower learners, facilitate lifelong learning, and open up new possibilities in the field of education.

Understanding what may be possible

The advances are exciting, and daunting. Adrienne Mayer argues that "we are approaching what some call the new dawn of Robo-Humanity … As humans are enhanced by technology and become more like machines, robots are becoming infused with something like humanity".[4] Schneider speculates that "Homo Sapiens may not be the most intelligent species for that much longer" as she considers Earth's "evolution of mind in a cosmic context".[5]

The building blocks of what is possible are becoming increasingly clear: Rapid and free access; shifting identities; multisensory, immersive experiences; and decentralized structures (see for example, Dwivedi et al, 2022).[6] The capacity for personalized instruction and adaptive assessment (including improved and immediate feedback) holds enormous potential for meeting the unique and complex cognitive needs of learners. However, the emergent and accelerated capabilities of both machine and humans will have an impact on the socio-emotional needs of learners, of existing infrastructures, policies and current educational architecture (see for example, Anderson et al., 2018).[7]

What might this look like over the coming years? Lim et al. (2023)[8] define generative AI as *"a technology that i) leverages deep learning models to (ii) generate human-like content (e.g., images, words) in response to (iii) complex and varied prompts (e.g., languages, instructions, questions).* [9] Despite the transformative potential, they express concern with the ability of educators and education systems to transition in a timely and cohesive way. They present their concerns through a discussion of paradoxes: 1) Generative AI is a 'friend' yet a 'foe'; 2) Generative AI is 'capable' yet 'dependent'; 3) Generative AI is 'accessible' yet 'restrictive'; and 4) Generative AI gets even more 'popular' when 'banned'.[10] This set of paradoxes does not bode well for promoting seamless transitions of AI into educational policy, resourcing or application in classrooms. Calls for culture change in education are moot if educators, systems and policies are not systematically supported to not only weather but embrace such massive disruption to past ways of thinking, teaching, assessing, and credentialing learners.

Matthew Montabello[11] considers how AI is likely to influence the future of e-Learning. Rather than engaging in the debate of whether AI is likely to replace educators, Montabello focuses on advancements that can support the development of an "ambient intelligent learning environment"[12] independent of a particular hardware device, and including the often-discussed trends in gamification, biometrics and pedagogical personalization, and augmented reality possibilities. The semantic web can only be as good as the data that it has to draw upon. While the race to develop new and innovative technologies continues, it may be as important to ensure that these intelligent systems are able to access the ways in which data must be contextualized, nuanced, localized, or dependent upon multiple factors that more closely resemble the variability of learners, learning environments, histories, knowledges, abilities and so on. Or as Selwyn (2019)[13] articulated, "technologically smart' but 'socially stupid' systems" in which "there are not enough data points in the world to adequately capture the complexities and nuances of who a student is, or how a school functions".[14]

Speculation about what may be possible ranges from unlimited improvements in all facets of our lives to frightening predictions about the end of humanity as we know it.[15] *Enchanted Determinism* is a term that describes the "*belief that AI systems are both magical and superhuman- beyond what we can understand or regulate, yet deterministic enough to be relied upon to make predictions about life-changing decisions*".[16] The implicit bias, racism, and inaccurate information that we 'input' into the language models AI relies on, must be explicitly addressed or we will simply replicate existing inequity. Achieving such goals requires grappling with deeply philosophical discussions about values (whose?), ends, means, and how we will manage AI in this unregulated global experiment as we live it.

What is needed to navigate the new reality?

Susan Schneider[17] coined the term "mind design' to describe that AI has "opened up a vast design space … much faster than biological evolution … [where] we humans, not God, are the designers".[18] She finds this both exciting and frightening, given the fact that our social development as a species seems to lag behind our technological advances. At the same time, research characterizes the advancement of AI as the "Fourth Industrial Revolution" where decision-making shifts from humans to machines.[19]

The massive changes will require an examination of the roles of reckoning (calculative prediction and formulaic decision-making) and judgement (deliberative thought grounded in ethical commitment, unbiased and contextually situated). The need for a critical and ethical focus on human experience within transparent systems will be paramount. A healthy skepticism will require improved analytic and authentication technologies as we shift toward a more collaborative, communal approach to knowledge building, curation and stewardship. An approach that draws on the North American Indigenous concept of 'Hozho' and the Buddhist philosophy of life centre harmony, balance, interrelatedness and connectedness to ensure *humanity* remains at the centre of all we do in these turbulent times may prove fruitful.

Educators, researchers and scientists have long been interested in the impact of science and technology on society, and curious about the impact society has on science and technology. Science Technology and Society, or STS as it has come to be known, is an interdisciplinary field that combines multiple disciplines and approaches relevant to the issues being studied. With respect to AI, it seems that STS combined with philosophy, history, sociology, economics and ethics will be a pragmatic starting point. Philosophical questions surrounding ethics have been especially present given the ethical concerns posed by AI (privacy, security and equity) along with the ethical principles (fairness, respect).

Can machines be taught values, morals and ethical reasoning? There are implications for the way we have historically conceptualized agency, autonomy, and intelligence as we have always presumed them to be uniquely human capacities. Balancing our expectations and fears (over-estimation of AI ability vs underestimation of AI risks – see for example Graham Scott's (2022) *The Doctor and the Algorithm*[20] – calls on us to engage in deep philosophical questions for these times – bridging the wisdom and thinking from ancient cultures into our current context. For example, both Aristotle and Confucius grappled with how to develop both human excellence and well-being or happiness (see for example, Aristotle's Nicomachean Ethics[21], and Confusius' Analects[22]).

In some contexts, the application of AI is going to require placing trust in its ability. As Winter and Carusi note, "if you are going to trust the machine, then that trust has got to be built on something".[23] They consider that trust is generally built upon "common ethical frameworks … to improve morally good outcomes".[24] However, they question the assumption that "pre-identified evaluation criteria" is possible in a design that relies on such criteria for validation – which is central to building the desired trustworthiness. The insights produced through their work argues that building trust occurs in processes that are "inextricably socio-technical" where criteria are not pre-defined, but "emerge during the process"[25]. They conclude that trust and validation are closely connected, and continually built and rebuilt through multiple processes in which humans are iteratively querying, interpreting, testing and refining the technology. They argue that it is not a singular pronouncement, but a collective, interdisciplinary process, wherein the human (in this case the clinician) functions as a sort of "mediator of trust"[26] in the process. Likewise, Makarius et al., (2020)[27] who take an "organizational socialization approach" to understand how to navigate AI in our future, also conclude that a combination of "cognitive, relational and structural"[28] considerations will be critical to integration, adoption and application.

These developments will have a transformative role on students, teachers and curriculum. While we can only speculate for now what the extent of that impact will be, it is clear that it will be disruptive whether positively or negatively.

Selwyn does not argue that we reject AI's place in education, but rather, he wants to think about it in terms of achieving what he calls "more just education outcomes"[29] that include more than the voices of privileged and vested interest groups.

What does this mean for education in Cambodia?

The implementation of AI in Cambodia has the potential to significantly impact the education system in several ways. AI can be utilized to improve the quality and accessibility of education in Cambodia. Intelligent tutoring systems and personalized learning platforms powered by AI can provide tailored educational content and adaptive learning experiences to students. This can help address individual learning needs and enhance the overall quality of education. In the era of big data, AI can enable data analytics and predictive modeling to support decision-making processes in education. By analyzing large volumes of educational data, including student performance, attendance, and engagement, AI algorithms can provide insights to educators and policymakers. This can assist in identifying areas of improvement, optimizing curriculum design, and developing targeted interventions for students. The COVID-19 pandemic has accelerated the adoption of remote and online learning. AI can play a role in enhancing virtual learning experiences by offering intelligent content recommendations, automated assessments, and virtual tutoring support. It can also facilitate remote collaboration and communication among students and teachers. As AI becomes more prevalent across industries, there will be a growing demand for individuals skilled in AI-related technologies. To prepare students for the future workforce, the education system in Cambodia may need to incorporate AI education and training programs. This includes teaching AI concepts, programming skills, and ethical considerations related to AI technology. AI technology has thus provided revolutionary ways to transform our current education system and patterns of teaching and learning. Yet, AI raises important ethical considerations, such as privacy, bias, and transparency. The education system can play a role in educating students about these ethical implications of AI technology. By integrating ethics and digital literacy into the curriculum, students can develop a critical understanding of AI and its impact on society. Beyond its use to enhance students teaching and learning, AI can support teachers by automating administrative tasks, providing real-time feedback on student progress, and offering personalized teaching recommendations. By relieving teachers from routine tasks, AI can enable educators to focus more on individual student support, mentoring, and facilitating collaborative learning experiences. Finally, in order to fully leverage AI in education, there will be a need for robust technical infrastructure, including reliable internet connectivity, access to devices, and data storage capabilities. Investment in the necessary technological infrastructure will be crucial to ensure equitable access to AI-enabled education across different regions of Cambodia.

Overall, the implications of AI in the education system of Cambodia include improved quality and accessibility of education, data-driven decision making, virtual learning opportunities, skill development, ethical education, teacher support, and the need for adequate technical infrastructure. It is important for policymakers, educators, and stakeholders to address these implications and ensure that AI is harnessed effectively to benefit students and the education system as a whole.

Summary

The integration of AI technology in education should be guided by a human-centered approach and ethical principles rooted in Buddhist values such as wisdom, non-harm, and interconnectedness, along with similar values from the Indigenous concept of Hozho. Wisdom calls for thoughtful implementation of AI to meet students' needs, while non-harm emphasizes using AI responsibly and protecting privacy. Interconnectedness promotes collaboration and a harmonious balance between AI and human educators. By prioritizing students' well-being and growth, AI can empower learners and enhance education, ensuring a positive impact on humanity.

1 Susan Schneider, "Artificial You: AI and the Future of Your Mind", Princeton University Press (Oktober 2019): 23.

2 Ibid., 33.

3 Ali Alkhatlan and Jugal Kalita, "Intelligent Tutoring Systems: A Comprehensive Historical Survey with Recent Developments," arXiv, (December 2018): https://doi.org/10.48550/arxiv.1812.09628.

4 Adrienne Mayor, "Gods and Robots: Myths, Machines and Ancient Dreams of Technology" Princeton University Press (2018): 218, https://doi.org/10.2307/j.ctvc779xn.

5 Susan Schneider, "Artificial You: AI and the Future of Your Mind", 97.

6 Yogesh K. Dwivedi, Laurie Hughes, Abdullah M. Baabdullah, Samuel Ribeiro-Navarrete, et al., "Metaverse Beyond the Hype: Multidisciplinary Perspectives on Emerging Challenges, Opportunities, and Agenda for Research, Practice and Policy," International Journal of Information Management 66 (October 2022): https://doi.org/10.1016/j.ijinfomgt.2022.102542.

7 Janna Anderson, Lee Rainie and Alex Luchsinger, "Artificial Intelligence and the Future of Humans", Pew Research Center: Pew Research Center (December 2018): https://www.pewresearch.org/internet/2018/12/10/artificial-intelligence-and-the-future-of-humans/.

8 Weng Marc Lim, Asanka Gunasekara, Jessica Leigh Pallant, Jason Ian Pallant and Ekaterina Pechenkina, "Generative AI and the Future of Education: Ragnarök or Reformation? A Paradoxical Perspective from Management Educators", The International Journal of Management Education 21, no. 2 (July 2023): 1-13.

9 Ibid., 2.

10 Ibid., 8.

11 Matthew Montabello, "AI Injected e-Learning: The Future of Online Education" (New York: Springer International Publishing, 2018).

12 Ibid, 70.

13 Neil Selwyn, "Invited Dialogue: What's the Problem with Learning Analytics?", Journal of Learning Analytics 6, no. 3 (December 2019): 11-19, https://doi.org/10.18608/jla.2019.63.3.

14 Ibid., 12.

15 Kevin Roose, "A.I. Poses 'Risk of Extinction", New York Times, May 30, 2023, https://www.nytimes.com/2023/05/30/technology/ai-threat-warning.html.

16 Alexander Campolo and Kate Crawford, "Enchanted Determinism: Power Without Responsibility in Artificial Intelligence", Engaging Science, Technology and Society 6, (2020): 1, https://doi.org/10.17351/ests2020.277.

17 Susan Schneider, Artificial You: AI and the Future of Your Mind (Princeton: Princeton University Press, 2019).

18 Ibid., 1.

19 E. E. Makarius, Debmalya Mukherjee, Joseph D. Fox and Alexa K. Fox "Rising With the Machines: A Sociotechnical Framework for Bringing Artificial Intelligence Into the Organization", Journal of Business Research 120 (March 2020): 262-273.

20 Graham Scott, "The Doctor and the Algorithm: Promise, Peril and the Future of Health AI" (London: Oxford University Press, 2022).

21 Aristotle "Nicomachean Ethics", translated by Terence Irwin (New York: Oxford University Press, 1999), https://eclass.uoa.gr/modules/document/file.php/PHS433/Nicomachean%20Ethics.pdf.

22 Arthur Waley, "The Analects of Confucius" (Ware: Hertfordshire, Wordsworth, 1996).

23 Peter Winter and Annamaria Carusi, "'If You're Going to Trust the Machine, Then That Trust Has Got to Be Based on Something': Validation and the Co-Constitution of Trust in Developing Artificial Intelligence (AI) for the Early Diagnosis of Pulmonary Hypertension (PH)", Science & Technology Studies 35, no. 4 (March 2022): 58.

24 Ibid., 59.

25 Ibid., 63.

26 Ibid., 70.

27 E. E. Makarius, Debmalya Mukherjee, Joseph D. Fox, and Alexa K. Fox, "Rising with the machines: A sociotechnical framework for bringing artificial intelligence into the organization", 262-273.

28 Ibid., 262.

29 Ibid., 629.

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Digital Advanced Training – Trends, Opportunities and Limits

Dr. Denis SUARSANA

1. Introduction

Digitization is disrupting the world of work. Some jobs might be replaced by technology in the future while new ones will be created. And certainly, most remaining jobs will be substantially altered by digital changes. Lifelong Learning is increasingly becoming a must if workers want to secure their long-term employability. Keeping up with rapid technological change means that the significance of advanced training[1] is growing for businesses and their employees alike.

At the same time, digital technologies create new opportunities for advanced training. In the past decade, a wide range of digital learning tools and platforms have been developed – from openly accessible video tutorials covering everything from developing programming skills to repairing your broken dishwasher to highly individualized collaborative assistance systems that help guide workers through complex tasks on the factory floor.

The COVID-19 pandemic has sped up the digitization process of advanced training. While workers were confined to their homes and getting accustomed to remote work, they increasingly picked up digital learning methods. Furthermore, many workers used their additional spare time to learn new skills online. For many, especially young and digitally savvy professionals, learning on their electronic devices has become increasingly natural. Hence, today´s digital learning is an integral part of advanced training programs in many companies.

However, digital learning has its limits and may even have negative consequences. It could e.g. further deepen the divide between young workers and their more senior but less digitally literate peers who are traditionally less inclined to take part in advanced trainings. Further, it may discriminate against blue collar workers as digital learning methods are often less effective regarding more manual tasks that need a certain degree of physical presence and training.

This paper gives an introductory overview over the many different types of digital learning tools and describes how these tools have been integrated into the field of advanced training, especially during the pandemic. Further, taking into consideration the different tools, the paper discusses the potential opportunities as well as the limits and possible negative consequences of the increasing digitization of advanced training.

2. COVID and digital learning – boosting an emerging trend

The emergence of the COVID-19 pandemic in early 2020 had a choking effect on many aspects of public, social and economic life all around the world. Education was one of the most affected sectors as schools and other institutions had to suspend their onsite operations. Advanced training was also strongly affected. This was basically due to two underlying reasons. Firstly, the social restrictions implemented during the pandemic made most training activities impossible. Secondly, the severe impact of the pandemic on the economy cut deeply into businesses' finances. Consequently, businesses were less inclined to pay for their employees' upskilling although many idle workers were having the needed extra time for advanced training.[2 3]

But while advanced training activities were massively reduced in general, the pandemic meant a boost for the uptake of digital advanced training methods. Before the pandemic, advanced training was predominantly taking place as in-person events like seminars or workshops in classrooms or on-the-job-trainings on the shop floor. During the COVID-19 pandemic digital training methods not only were dominating (unsurprisingly as in-person training was basically impossible), but became increasingly popular among employers and workers.[4] According to a survey in Germany, for instance, 44% of all companies in the country expanded the use of digital learning methods during the pandemic, while 35% of all companies even stated that they picked up digital advanced training for the first time.[5]

Although digital advanced training has experienced a strong boost during the pandemic, it had been on the rise before. Another German study shows that between 2016 and 2019 (i.e. before the pandemic) businesses already had significantly increased their use of digital training methods.[6] As a McKinsey report shows, even before COVID appeared, digital education startups were disrupting the market for training and venture capital funding in the U.S. for so/called EdTech (education technology) companies already skyrocketed.[7] Such businesses could then capitalize on the uptake of digital learning during the pandemic as education and training companies which had already invested in digital infrastructure and learning programs before COVID were much more flexible to quickly adapt to the growing demand.[8]

But the trend towards more digital training is not just driven by companies alone. Students and workers themselves demand more possibilities to learn and study digitally. Today, digital devices are ubiquitous. According to the International Telecommunication Union (ITU), 4.8 billion individuals own a mobile phone worldwide while almost 5.3 billion people have access to the internet.[9] The mobile revolution has already upended many parts of people's personal and professional life including communication, finance, retail or even dating. How people learn has also changed dramatically. Another German study already showed in 2017 that for around half of the population informal digital learning had become an integral part of their daily lives. 80% of those that already learned digitally did so online and at home. It is important to notice that learning mainly took place informally, meaning that people were learning self-directed and situational-based on the concrete needs in their daily life situations. Hence, short and solution-focused learning formats were the preferred choice. The most popular entry points for digital learning were not websites of established education companies or institutions, but simply the likes of Google and YouTube.[10]

Due to the pandemic, this openness to digital learning has increasingly spilled over from everyday life to the professional level. Years of experience of private usage of the internet and mobile phones have created basic digital literacy among the broader workforce and lowered the mental and cultural hurdle regarding digital training formats. This trend has been further amplified by the sudden and extensive shift into the virtual world during COVID. Today, digital technology and especially mobile devices are increasingly becoming an integral part of the educational world. And this is not only changing the technological side of learning (i.e. using mobile devices and the internet), but also the very nature of advanced learning and training. Just like informal digital learning in everyday life, as mentioned above, advanced training becomes more flexible, self-directed and situational. Upskilling becomes front and center of advanced training. Instead of degree-based, comprehensive training programs, workers use digital training formats to learn specific skills – skill acquisition comes before degree acquisition. Hence, learning is not finished after successfully getting a degree. Instead, learning becomes continuous and situational with workers acquiring skills they might need to address a certain challenge at work or in order to develop their individual skill set for a promotion and/or to enhance their employability.[11]

Although the end of the pandemic has triggered a substantial return to in-person advanced training, the share of digital training formats is still significantly higher than before COVID hit. Further, the post-pandemic advanced training world is witnessing more and more hybrid learning formats that combine both in-person and digital training methods.[12] The potential of digital advanced training remains high and demand for digital learning formats will certainly increase further in the future. One frequently cited estimate puts the overall value of the global online education market at USD 350 billion in the year 2025.[13] In fact, digital advanced training may become a crucial solution for the mounting challenges that technological change poses to companies and workers alike.

According to the World Economic Forum's (WEF) most recent Future of Job Survey, employers anticipate that in 2027, 42% of all business tasks will be automated, up from 34% today. They estimate that 44% of workers' skills will be disrupted in the next five years. 59.7% of all surveyed companies identify the skills gap as the main barrier to the successful transformation of their business. And 81.2% of all employers state that investing in learning and training is their number one workforce strategy for the future.[14] The developments underlying these numbers will have massive consequences on labor markets and workers. The very nature of professional careers will change profoundly. Getting a degree will probably remain the best starting point into one's professional life. But as professions will evolve more rapidly due to technological change the value of such degrees will diminish more quickly, too. Workers might have to get used to changing jobs more frequently and being assigned to new or changing tasks within their existing jobs more regularly. This increasingly changing world of work will require workers to update their skill set continuously in order to secure their own employability. Instead of updating their initial degree once or twice during their career they will have to adopt life-long skill acquisition. And this will also include experienced workers who are already on advanced echelons of the career ladder.[15] Hence, advanced training will increasingly have to become flexible, situational and skills focused. Life-long learning and continuous upskilling may become an integral part of the new normal of advanced training – and so probably will digital learning.

3 The different types of digital learning tools in advanced training

Digital learning formats can range from narrowly focused online videos (e.g. teaching people how to prepare the perfect basil pesto) to full blown education programs that let students obtain an entire degree online. Further, digital learning tools can be blended into in-person training

formats (blended or hybrid learning). Thus, the digital learning ecosystem is very diverse, and many different formats cater to many different needs and demands. The following paragraphs present an overview of the most important digital learning formats used in advanced training distinguishing between platforms (i.e. Learning Management Systems and mobile learning), programs (i.e. MOOCs, Microdegrees, Trainings, Games and Apps) and tools (i.e. Videos, Podcasts, Webinars, Quizzes and Simulations including Augmented and Virtual Reality).

3.1 Digital learning platforms

Although digital learning could simply consist of watching an instructive video on YouTube, following some interesting and educative channel on Twitter or Tik Tok (Social Media based learning) or browsing the internet, in the field of advanced training learning tools are most often incorporated into specialized learning platforms. Probably the most common and most popular kind of digital learning

platforms are so-called ***Learning Management Systems (LMS)***. LMS help training providers and users to administer digital learning. LMS may just host different digital learning tools (e.g. videos and knowledge quizzes), entire courses (e.g. business strategy or python programming) or even full blown degree programs (comparable to an online university). On LMS, users can individually manage their personal learning paths on just one platform. So called ***Learning Experience Platforms (LXP)*** are more interactive and focused on user experience. LXP may learn from the interaction with users about their learning speed and habits, their skill set, or could even recommend specific learning formats and content adapted to the individual learner's upskilling needs or career path.[16] LMS and LXP can be run by traditional educational institutions like schools or universities (frequently using Moodle), by private digital training providers (e.g. LinkedIn Learning, Udacity, Coursera, Udemy, etc.), or they can be set up internally by companies to train their own workforce (due to high cost and complexity this is an option only for bigger companies with the necessary funds as well as a sufficient number of workers to use the platform). Although some LMS and LXP offer entire degree programs, most learners choose courses that are much more narrowly focused in order to plug gaps of very specific skills, especially technical ones such as programming, web design or cyber security.[17]

As mentioned above, mobile devices – especially smartphones – have become ubiquitous and ***mobile learning*** is increasingly popular. Using one's smartphone as the preferred learning platform offers a high level of flexibility for learners. Learning on-demand and on-the-go becomes ever easier. Instead of playing online games or 'doom scrolling' on social media, commuters could use their phones to learn and study while taking the train or bus to work. For this, learning formats need to be short, focused and entertaining (i.e. Micro Learning). Mobile learning may incorporate videos, quizzes and games. It is often stated that due to the short formats, mobile learning is limited mainly to less complex content.[18] But if the different short formats (sometimes called Learning Nuggets) are integrated as building blocks, well designed learning apps can help learners to acquire complex skills like new languages, financial investment or even programming. Digital training providers are increasingly adapting the courses on their LMS to mobile learning, transforming these complex learning platforms into easy-to-use mobile learning apps. With this, mobile learning is lowering the threshold for all groups of workers to participate in advanced training.[19]

3.2 Digital learning programs

Digital Learning Programs can take a variety of forms. The most traditional formats are so-called ***Massive Open Online Courses (MOOCS)***. MOOCS were primarily set up by universities to make some of their courses accessible to a broader audience online. Typically, MOOCS consist of pre-recorded videos (lectures) combined with further readings and quizzes. At the end of the course learners may pass a final exam and obtain a certificate. Some MOOCS allow learners to interact via chatrooms or even provide online tutors. While MOOCS were open and free of charge, private learning providers have developed a business model around the idea of such online courses. Often such companies (many of them tech-related learning platforms from the US) offer courses that are not provided by more traditional training providers (your local chamber of commerce will rarely offer a comprehensive course on programming autonomous driving software). Such courses often teach highly complex issues, may take months to complete and can cost hundreds of dollars in fees. Upon successfully completing learners are granted so-called ***micro degrees***.

Programs like Webinars or simple digital trainings are mostly less complex and much shorter than MOOCS and micro degree programs. ***Webinars*** are basically substitutes for traditional in-person workshops or trainings but provide the advantage of not being limited to a certain number of participants. However, contrary to most digital learning formats, Webinars are live formats which means that they don't offer the flexibility of on-demand.

Digital trainings are shorter courses that may be used to make your workforce familiar with certain topics. Trainings may consist of different tools like videos, quizzes or texts. Typically, trainings are not individually adjustable nor interactive. They may be used to present new company guidelines to the workforce or teach basic knowledge on data security or workplace safety.[20]

3.3 Digital learning tools

Videos, podcasts, quizzes or online games can be typical digital learning tools. All of these tools may be used as stand-alone learning formats (e.g., short tutorial videos on YouTube), but in the field of digital advanced training they are typically integrated into more comprehensive learning programs. Each learning tool caters to a specific training or learning goal. ***Videos*** are used to explain a well-defined content and are typically not longer than 15 minutes in order to keep the learner engaged. ***Podcasts*** are often longer than videos and can be used to discuss more complex issues like market development or a new company strategy. ***Quizzes and online games*** are typically tools to practice and repeat freshly learned content and skills. Some more complex digital learning tools are ***simulations*** and ***augmented and virtual reality*** applications. Augmented reality can be integrated into highly individualized and interactive assistance systems and is typically used to provide learners with real time data in a real-life environment, e.g., during training an engineer on how to maintain a complex machine. Simulations – both screen-based or in virtual reality – are used especially if training in a real-life environment is either too dangerous or too complex or costly. Prominent examples are flight simulators or trainings in dangerous environments like contaminated areas. [21]

4. The benefits and limits of digital advanced training

Digital advanced training has experienced a boom in recent years not just because it provided a handy substitute for in-person trainings during the pandemic, but because digital learning offers a number of advantages over traditional in-person formats. The biggest advantage certainly is the local and temporal flexibility of digital training formats. Digital learning allows users to study on-demand (i.e. whenever and wherever they need or want to learn). Therefore, learning can easily be integrated into workers' daily routines – both in the office or on the shop floor as well as in their daily life. By this, digital learning formats mitigate the lack of time as the most often cited barrier to advanced training. Another important benefit of digital advanced training is the lower costs in comparison to traditional in-person trainings. This helps to reduce the barrier for companies – especially smaller ones – to invest in the skill development of their workforce. Further, it also lowers the barrier for workers to develop their own skill set in order to boost their individual careers. Finally, digital training formats can facilitate highly individualized and bespoke learning, thus addressing specific skill development needs of individual workers and companies.[22]

The advantages of digital training are not only confined to the level of individual workers and companies, but also extend to society as a whole. Digital learning formats significantly broaden the accessibility to training as it reduces the financial, technological and geographic threshold to participation. Especially in the developing world, the dissemination of mobile devices has provided millions of people in rural areas with access to information beyond their narrow local environment. Mobile learning could allow them to access advanced training that had not been available "in remote areas before. Thus, digital training methods have the potential to severely mitigate the rural knowledge and skill gap – in both developing and developed countries.[23]

However, despite all of these advantages and virtues, digital learning also has its limits and potential downsides. First of all, digital learning requires certain preconditions from learners. In order to be able to use digital training formats one has to have at least a basic amount of digital literacy i.e., the knowledge of how to use digital devices and internet-based applications. In addition, in contrast to traditional in-person trainings, digital learning provides much less "handholding"[24] as learners are expected to manage their learning experience individually. Hence, such digital formats require a high level of self-discipline and self-learning skills. And finally, many digital trainings covering highly sophisticated digital skills like Artificial Intelligence or other complex software development are provided especially by learning platforms from the United States of America, thus requiring advanced English language skills.[25] This requirement for specific (and in some cases relatively advanced) skills as a pre-condition for digital learning means that the growing popularity of digital advanced training could further deepen the skill and training divide among different groups of the workforce. As digital learning formats are more often used by younger and higher skilled workers, it comes as no surprise that such formats are less frequently taken up in companies with a relatively higher share of less qualified (i.e., elementary or early secondary education, no final degree from the institutions) and/or older workers.[26]

Another limitation to the potential of digital learning formats is its inadequacy to useful training regarding a number of tasks, circumstances and industries. Digital learning of course will not be able to substitute personal encounter and exchange. Therefore, any training that requires a significant amount of collaboration or creative cooperation cannot be transferred into the digital sphere entirely (although hybrid formats might be possible and suitable). Further, digital formats are an insufficient substitute for physical experience and tasks or skills that require physical training. Digital training is therefore much more frequently used for teaching academic or theoretical content and in knowledge and service-dominated sectors. It is much less common in health service, crafts industries or on the shop and factory floor.[27] Thus, digital training and learning (just like mobile working) could increasingly become the prerogative of white-collar workers driving a wedge between different groups of workers in a company.

5. Conclusion

The pandemic has significantly boosted digital advanced training. The use of digital learning methods as substitutes for in-person trainings has popularized digital training by showing its many benefits and advantages to companies and workers that had not been accustomed to such formats before. However, digital learning also has the potential to further deepen the skill and knowledge divide among the workforce. In order to avoid this, employers as well as governments (by implementing the right labor market policies) have to make sure that all groups of workers – especially lower skilled and/or older ones – acquire the necessary basic digital and learning skills in order to be able to participate in digital advanced training. Only then, companies and workers may use the full potential of digital advanced training.

1 *This paper uses a broad definition of advanced training as does for instance the UNESCO Institute of Statistics (https://uis.unesco.org/en/glossary-term/vocational-education) - not only including the traditional forms of vocational education and training (VET) (e.g. apprenticeships, formal occupational trainings), but also taking into account other (and often less formal) forms of education in the context of professional skills' development (e.g. academic courses, training on the shop floor/learning on the job, private learning).*

2 *Gerhard Bosch, "Weiterbildung in der Corona-Krise", WSI Mitteilungen, 74. JG, (6/2021), 481.*

3 *In fact, before the pandemic the available time of workers was the most cited limiting factor regarding participation in advanced training, see: Susanne Seyda, "Digitale Lernmedien beflügeln die betriebliche Weiterbildung: Ergebnisse der zehnten IW-Weiterbildungserhebung", IW-Trends, 48. Jg., Nr. 1 (2021), 79.*

4 *Jonathan Kohl and Elisabeth Denzl "Corona-Pandemie und die Folgen für die Weiterbildung", in Sarah Widany, Elisabeth Reichert, Johannes Christ and Nicolas Echarti (Eds.): Trends der Weiterbildung, DIE-Trendanalyse 2021, 2nd Edition, (2022), 255.*

5 *Bosch, "Weiterbildung in der Corona-Krise", 481.*

6 *Seyda, "Digitale Lernmedien beflügeln die betriebliche*

Weiterbildung: Ergebnisse der zehnten IW-Weiterbildungserhebung", 82.

7 Nadine Diaz-Infante, Michael Lazar, Samvitha Ram and Austin Ray, "Demand for online education is growing. Are providers ready?", accessed July 6, 2023, https://www.mckinsey.com/industries/education/our-insights/demand-for-online-education-is-growing-are-providers-ready.

8 Kohl, Jonathan/Elisabeth Denzel, "Corona-Pandemie und die Folgen für die Weiterbildung", 253.

9 "Individuals using the Internet", ITU, accessed July 6, 2023, https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx.

10 Ulrike Schmid, Lutz Goertz and Julia Behrens, "Monitor Digitale Bildung – Die Weiterbildung im digitalen Zeitalter", Bertelsmann Stiftung (2017), 6.

11 Larry Dignan, "Online Learning gets its moment due to COVID-19 pandemic: Here's how education will change", ZDNET, accessed July 6,2023, https://www.zdnet.com/article/online-learning-gets-its-moment-due-to-covid-19-pandemic-heres-how-education-will-change/.

12 Stefan Koschek, Johannes Christ, Hana Ohly and Andreas Martin "Digitale Weiterbildung in Zeiten der Coronapandemie, Ergebnisse der wbmonitor-Umfrage 2021", Bundesinstitut für Berufsbildung, (2022), 19 f.

13 Laura Wood, "Online Education Market Study 2019 World Market Projected to Reach $350 Billion by 2025, Dominated by the United States and China", accessed July 6, 2023, https://www.globenewswire.com/news-release/2019/12/17/1961785/0/en/Online-Education-Market-Study-2019-World-Market-Projected-to-Reach-350-Billion-by-2025-Dominated-by-the-United-States-and-China.html.

14 The WEF's Future of Job Survey covers 803 companies employing more than 11.3 million workers across 27 industry clusters and in 45 economies from all world regions; for the results see: World Economic Forum (2023): "Future of Jobs Report 2023", Insight Report May 2023, https://www.weforum.org/publications/the-future-of-jobs-report-2023/in-full/4-skills-outlook/

https://www3.weforum.org/docs/WEF_Future_of_Jobs_2023.pdf

15 "Bildung neu denken, Bildung neu machen – Was sich in der digitalen Transformation ändern muss," BDAdigitalrat, accessed July 6, 2023, https://www.futurework.online/files/futurework/bda-digitalrat/downloads/BDA_Digitalrat_Thesenpapier_Bildung_web.pdf.

16 Bundesvereinigung der Deutschen Arbeitgeberverbände (BDA) "Neue digitale Weiterbildungstools in der betrieblichen Praxis – Trends, Chancen, Hürden", 2021, July 6, 2023, https://www.futurework.online/files/futurework/bda-digitalrat/downloads/Digitale-Bildungs-Tools_Web.pdf.

17 World Economic Forum "Future of Jobs Report 2023", 44.

18 See for example: Bundesvereinigung der Deutschen Arbeitgeberverbände (BDA) „Neue digitale Weiterbildungstools in der betrieblichen Praxis – Trends, Chancen, Hürden", 8.

19 Claudia Munoz-Reyes, "Can mobile learning bridge the rural knowledge gap?", World Economic Forum (WEF), 2015, https://www.weforum.org/agenda/2015/05/can-mobile-learning-bridge-the-rural-knowledge-gap/.

20 Bundesvereinigung der Deutschen Arbeitgeberverbände (BDA), "Neue digitale Weiterbildungstools in der betrieblichen Praxis – Trends, Chancen, Hürden", 7.

21 For a more detailed overview of digital learning tools see: Bundesvereinigung der Deutschen Arbeitgeberverbände (BDA), https://arbeitgeber.de/en/.

22 Seyda, "Digitale Lernmedien beflügeln die betriebliche Weiterbildung: Ergebnisse der zehnten IW-Weiterbildungserhebung", 89 f.

23 Munoz-Reyes, "Can mobile learning bridge the rural knowledge gap?."

24 Larry Dignan, "Online Learning gets its moment due to COVID-19 pandemic: Here's how education will change", ZD NET, last modified March 22, 2020, https://www.zdnet.com/article/online-learning-gets-its-moment-due-to-covid-19-pandemic-heres-how-education-will-change/.

25 Bundesvereinigung der Deutschen Arbeitgeberverbände (BDA)", Neue digitale Weiterbildungstools in der betrieblichen Praxis – Trends, Chancen, Hürden", 17.

26 Simon Janssen and Ute Leber, Weiterbildung in der Corona-Krise: E-Learning ist eine Chance für Unternehmen, IAB-Forum, accessed July 6, 2023, https://www.iab-forum.de/weiterbildung-in-der-corona-krise-e-learning-ist-eine-chance-fuer-unternehmen.

27 Stefan Koschek, Johannes Christ, Hana Ohly and Andreas Martin, "Digitale Weiterbildung in Zeiten der Coronapandemie, Ergebnisse der wbmonitor-Umfrage 2021", 20 ff.

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Research & Development: There is No Way Out

Riccardo CORRADO, Prohim TAM and Audrey LIWAN

Cambodia experienced an exceptional growth pre-pandemic with its economy having recorded a growth of more than 7% per annum in average, in the period between 2010 and 2019, representing one of the fastest growing economies in the world.[1] Yet, this growth, for the first time since 1994, experienced a slowdown due to the challenges related to COVID-19. The pandemic affected mainly three sectors, namely tourism, manufacturing exports, and construction, which by themselves contributed to more than 70% of the country's growth in 2019.[2] To limit the impact of the pandemic, the Cambodian authorities promptly acted introducing emergency measures to contain the outbreak while providing fiscal assistance to affected households, workers, and enterprises.[3] In roughly two years, the country was able to move ahead with a general re-opening, due to an impressive vaccination campaign accompanied by pragmatic economic policies which have represented pivotal elements to support the Cambodian recovery.[4] Yet, to make sure that the country can continue on the right growing path, three main challenges should be clearly addressed, as pointed out by Freedman and Menon from the Yusof Ishak Institute (ISEAS): Improving health surveillance and healthcare capacity, rebalancing the financial sector, and sustaining future growth.[5]

And it is about the last criticality where education plays a fundamental role, together with another essential element: research and development (R&D). There are several studies that pointed out the importance of R&D for countries' sustainable development, mostly to avoid stagnation in their growth, due to their inability to energise and then sustain a dynamic growth at the middle-income stage of their development.[6] For the case of Cambodia, due to its remarkable economic growth, the Kingdom reached the goal of becoming a lower-middle-income country in 2015, with a pathway set by the Royal Government of Cambodia (RGC) to become an upper-middle-income country by 2030, and a high-income country by 2050.[7] [8] The education system and the R&D ecosystem in Cambodia need to be equipped and ready to prepare the youth to answer to the needs from the job market, aiming to sustain the economic growth envisioned by the RGC. To achieve this, it is important to begin from understanding the current scenario we are in, for then explaining the reason underpinning the statement: “R&D, there is no way out”.

The current scenario

It is well recognized that science, technology, engineering, and mathematics (STEM) skills represent the key to support the growth of Cambodia, in an era where digitalization and technological advancement are necessities for the overall development of a society. [9] This has been already recognized by the Cambodian Ministry of Education, Youth and Sport (MoEYS) who has in fact acknowledged the importance of it for the country and worked toward fostering it. As noted by Kao et al.,[10] “strengthening the quality of education, science and technology education is one of the four strategic rectangles of Rectangular Strategy Phase IV and at the heart of Cambodia’s ambition to achieve higher-middle-income status by 2030 and high-income status by 2050”. The RGC has initiated several projects and initiatives in this regard, with several official documents, policies and frameworks to prepare the Kingdom for this journey.[11] [12]

At this stage, the Cambodian education engine is still struggling to prepare enough equipped professionals to sustain the growth that the Kingdom is experiencing and envisioning. As noticed by Ung et al.[13] and reported in the Cambodia Industrial Development Policy 2015-2025, the industry sector in the Kingdom still experiences low technological adoption and application, struggling to find talent and skilled labour.

“The skills mismatch and skills gap issues in Cambodia are not new”.[14] Skills mismatch is used here as an overall term, encompassing various forms of skills that are not adapted to the needs of the market or the area which they are needed in.[15] To address this from the educational perspective, the Ministry of Education, Youth and Sport (MoEYS) incorporated for the first time a tracking system in 2010, intended as a practice of shifting students to programs and educational institutions through a selection based on ability, interest and/or achievements.[16] Specifically, at grade 11, students have been requested to choose between a science track or social science track, which overlap on some aspects, and differentiate on others. Specifically, in both tracks students are expected to study topics such as Khmer literature, a foreign language between English or French, physical education, and mathematics. But where students in the science track focus on other subjects such as earth and environment, physics, chemistry and biology, the students who chose the social science track study subjects related to history, geography, morality and civics, and economy.[17]

Additionally, Ung et al. noted a decline in students selecting the science track in Cambodia, with over 80% shifting from scientific high school tracks to non-STEM university majors, in contrast to only 10% of social science track students transitioning to STEM majors.[18] This trend to shift from science track in high school to a non-STEM major in university is even more pronounced when talking about female students, with 94% of those in a scientific track shifting to a non-STEM major for their undergraduate studies.[17] The major reasons influencing the decision to opt out from a career in STEM have been found to be the family pressure and low performance (D grade) in STEM topics in high school[19], with females usually deciding to switch to other study fields, and specifically preferring business, management, accounting or finance.[20] These findings were also supported by Chea and Chea who highlighted that parents, especially mothers, "play a crucial role socially and financially in influencing individuals' technology readiness".[21] Technological readiness refers to the ability of an individual or society to use technology effectively, which includes the skills, knowledge, attitudes, and resources needed to interact with different technologies. While technological readiness is a broad concept that applies to all fields, it is particularly important in STEM fields. In addition to this, Corrado et al.[22] also pointed out that the offering of majors at universities is heavily skewed toward undergrad programs in non-STEM fields. This possibly affects the ability of Cambodia to prepare enough skilled professionals to sustain the digital transition of the country, and the plans outlined in the Cambodia Digital Economy and Society Policy Framework 2021-2035.[23] [24]

To ensure that Cambodian high school students can reach an informed decision on their undergraduate studies, the MoEYS developed an university guidebook, illustrating skills provided by universities, and making sure it is distributed annually to high schools.[25] Yet, many students still do not really engage with this information, heavily relying on their trust, intuition and emotion, or following their parents´ advice.[26] In this regard, Peou remarked how also due to the strong family orientation in Cambodian social life, "deciding what to study at university involves not only individual interests and knowledge, but also those of the parents and older relatives".[27] The decision process on which major to pursue at university becomes a negotiation process, "involving both the individual and the family, the outcome of which could go either in favour of or against the will of the students".[28] The result is that due to the overall inability of young people and their families to make rational decisions on which field of study to pursue, or simply due to the lack of information supporting their decision-making, the undermining issue of lacking skilled labour in the required fields to support the economic growth is increasing.[29]

It is in this ecosystem that the country is experiencing a shortage in STEM-skilled labour. The digital transition is causing this shortage. Companies need these skilled workers to adapt to the changing technological landscape. STEM-trained individuals have the skills necessary to handle complex technology, data analysis, innovation, and data-driven decision-making, all of which are essential for digital transformation. Without a sufficient pool of STEM talents/students, companies will find it difficult to stay competitive and harness the benefits of the digital age.
In this regard, a study performed across public and private companies highlighted how Cambodian companies realise the importance of the digital transition, with a specific focus on leveraging data for their decision making, yet, they also realise that they are not yet ready for it.[30] In this ecosystem, young Cambodians often enter the job market with limited educational levels and unprepared, with more than 40% of young workers lacking sufficient education to perform the task required by their job position.[31]

The efforts

The remarkable economic growth experienced by the Kingdom in the past decades has been characterised by a dependency on foreign direct investment (FDI)-led growth from the labour-intensive industry.[32] Cambodia introduced the Industrial Development Policy (2015-2025) in 2015 to shift the economic structure from a low-skilled labour one to one backed up by a skilled and knowledge-based workforce. The policy focuses on transforming and modernizing the industrial sector, increasing the export of non-extile goods, and better regulating small and medium enterprises.[33]To achieve this, the RGC embraced four strategies: (1) attracting more foreign investments and private domestic ones focusing on large industry and enhancing technology transfer; (2) developing and modernising small and medium enterprises; (3) foster the country competitiveness with a revitalised regulatory framework, and (4) boost the "development of human resource, technical training, improvement of industrial relations, development of support infrastructure such as transportation/logistics and information and -information communication system (ICT), supply of electricity and clean water, and public, social and financial services".[34] As a result of the Industrial Development Policy (2015-2025), many strategic documents have been adopted, including "Industrial Development Policy (IDP) 2015-2025, Science, Technology, Engineering & Mathematics (STEM) Education Policy 2016, Small and Medium Enterprises (SMEs) development policy 2017-2021, Technical and Vocational Education and Training (TVET) Policy 2017-2025, Modernized TVET Strategic Action Plan 2019-2023, Education Strategic Plan 2019-2023, Cambodian Higher Education Roadmap 2030 and Beyond, STI Policy 2020-2030, and Cambodia Digital Economy and Society Policy Framework 2021-2035".[35]

Besides these strategic documents, the RGC designed various interventions to promote Science Technology and Innovation (STI), mainly "associated with mentorship, technical assistance, training program, SMEs financing and digital transformation and promotional activities related to STI".[36] For instance, as an implementation unit of the Entrepreneurship Development Fund (EDF), Khmer Enterprise (KE) was created to "mobilize, invest, and manage resources, from all legitimate sources, to support the development of a vibrant entrepreneurial ecosystem and to provide financial and non-financial supports to related entrepreneurial ecosystem builders".[37] In 2019, the SME Bank was created to promote and facilitate SMEs access to finance, and in 2020, Techo Startup Centre (TSC) was transformed into a public administrative institution, with the goal to "nurture startups to grow into successful businesses by enhancing talents, entrepreneurship, and innovation capacities through the well supported programs".[38]

Also, the Ministry of Post and Telecommunications (MPTC) supports the digitalization in the country, not only through the improvement of the current telecommunications infrastructure, but also enhancing public awareness, and education in relation to Information Technology (IT). In 2013, the National

Authority for Information and Communication Technology Development (NiDA) was integrated in the MPTC, and the national information infrastructure network is used by ministries and institutions to this day.[39] In 2014, the Communication Technology Master Plan of Cambodia 2020 was adopted with the aim of "promoting the development of communication technology and information, and strengthening the development of human capital, internet connectivity, digital security, and public services through electronic systems".[40] Furthermore, in 2015, the Law on Telecommunications was promulgated, and in 2016 the Development Policy for Telecommunications, Information and Communication Technology 2020 was introduced, setting out "measures and goals to strengthen the basis of the development of the telecommunications, information and communication technology sectors, digital security, to promote industrial development, and the use of information and communication technology".[41] In addition, the Kingdom adopted the E-Commerce Law in late 2019, which "determines the authenticity, accuracy, security, and reliability of electronic forms and communications, and the Consumer Protection Law to promote fair competition".[42] The MPTC has also been working on the law on cyber security, on personal data protection, along with the National Policy for the development of the digital sector, and the national policy on the prioritisation of cloud-based solutions, called Cloud First Policy. On the other side, the Ministry of Interior has been working on a cybercrime law aiming to make Cambodia a resilient ecosystem against cyberthreats.

But also, along with policies, laws and master plans, campaigns have been initiated and carried out. Specifically, MPTC has initiated and conducted public awareness programs such as the Kit Kou Kon ("Caring for Children") in collaboration with other institutions, to foster awareness on how to protect children while being online. Also, through MPTC's regulatory arm, the Telecommunication Regulator of Cambodia (TRC), MPTC has initiated an investigation campaign, specifically for targeting and closing malicious websites and URLs considered dangerous for internet users.[43] In June 2023, the MPTC launched a program called Digital Talents, with the goal to empower students from a younger age by introducing them to diverse digital skills, challenging their knowledge, and showcasing their creativity and problem-solving abilities. This is just one of the numerous projects supported financially by the Capacity Building and Research and Development (CBRD) fund, introduced in 2017 by the MPTC with the goal to boost the tech startup ecosystem in Cambodia, and mainly financed by the

telecom operators in the Kingdom. The CBRD fund has been pivotal in supporting financially digital-related projects in the country, enhancing the digital Cambodian ecosystem in the past years.

Finally, to support ICT education and training, the MPTC rebranded and expanded its education arm, previously known as National Institute of Posts, Telecommunications, Information, and Communication Technology (NIPTICT), into the current Cambodia Academy of Digital Technology (CADT),[44] and developing three subordinate institutes, namely the Institute of Digital Technology, the Institute of Digital Governance, and the Institute of Digital Research and Innovation, highlighting once more the importance of fostering a culture of Research and Development (R&D) for the country.

Research and Development: The key

Following the structural change approach, "economic development is seen as a process where production is shifted increasingly towards activities with greater technological spillovers, increasing returns and higher demand elasticities, in other words, towards higher productivity activities".[45] It is in this ecosystem that the middle-income trap emerges, and it can be intended as a situation "where a middle-income country can no longer compete internationally in standardised, labour-intensive commodities because wages are relatively too high, but it can also not compete in higher value-added activities on a broad enough scale because productivity is relatively too low".[46] To escape the middle-income trap, an effective TVET infrastructure[47], coupled with R&D to boost innovation[48], is necessary.

Specifically, about R&D, the Organisation for Economic Co-operation and Development (OECD) shows researchers have generally found a positive and statistically significant impact of R&D on productivity and economic growth.[49] Yet, it was also highlighted how "markets fail to generate sufficiently large incentives for firms to undertake R&D and that firms consequently underinvest in R&D from the social perspective".[50] In the paper of Soete et al., [51] the authors investigated the relations between total factor productivity (TFP) and public and private R&D, together with gross domestic product (GDP) for a pool of 17 OECD countries for the period 1975–2014, using a vector-error-correction model. The result showed a general positive effect of R&D on productivity, with some cases of negative effects, mainly driven by two factors: a "fishing out" effect, and a "creative destruction" one.[52] The first effect refers to the concept that easier ideas are the ones easier to develop, while the more complicated ones remain undiscovered, thus requiring more R&D efforts. The second effect, creative destructions, refers to the concept that new ideas make older ones obsolete, de facto negatively impacting those who have invested resources on the now-obsolete ideas.[53] Additionally, there is another aspect related to who arrives first at the production of an outcome. In fact, those who are capable of arriving first in the development of a product or service, will usually get the majority of the rewards, while the other competitors may lose part of the investments spent on the R&D. Yet, in general the overall findings from the Soete et al.[54]

work showed that “a permanent shock to public R&D suggest that this will increase the growth rate of TFP (and GDP)”, with a “relatively strong effect on productivity of the complementarity between public and private domestic R&D investments: i.e., when the public R&D shock leads to extra private R&D, the effect on productivity is stronger”.

Accounting for the importance of R&D, it can be said that STI infrastructure are the basic component to support and foster an ecosystem of STI, and “Infrastructure is the form of a wide variety of infra-technologies, and associated standards” essential to conduct R&D.[55] In Cambodia, prior to the establishment of Ministry of Industry, Science, Technology & Innovation (MISTI), the National Science and Technology Council (NSTC) was created in 2014, with its secretariat under the management of the Ministry of Planning (MoP). The NSTC has focussed on enabling “national research and development in an efficient and effective way focusing on the adaptation of acquired technologies to the local context and enhancing capacity to absorb foreign technologies”.[56] Additionally, the Cambodian ICT Masterplan for 2014-2020 was introduced in 2014, with the vision to lead toward an ‘ICTopia Cambodia’, building the Kingdom as “an intelligent and comfortable nation with intelligent people, intelligent society and intelligent government by ICT”.[57] In the document, it is clearly outlined how “the vision for the Cambodian ICT R&D sector is to boost national competitiveness through ICT R&D” with the goal to “enhance ICT technological capacity through R&D and to help reinforce national competitiveness” while contributing to “the development of the ICT industry and economic growth based on national competitiveness strengthened through ICT R&D”.[58]

Yet, even if efforts have been spent, the overall R&D in Cambodia remains very low. Universities are falling short in investing and pursuing research. Peou[59] highlighted how “with profit-seeking private ‘universities’ mushrooming since 1997” the majority of HEIs are “basically teaching-based institutions, making profits or sustaining themselves through the generation of tuition fees, and the structure of training provided is rather uniform with most providing four-year undergraduate degrees with the exception of medical and engineering programmes and a few private colleges”.[60] Additionally, the linkage between private sector and HEIs is weak, with a clear disconnection between what HEIs offers, and what private sector needs, something not present only in Cambodia.[61] Furthermore, in the Kingdom, besides the action plans and policies, a major boost toward enhancing digital readiness was placed with the creation of Techo Digital Talent Scholarships, to support students in pursuing their studies in digital-related majors, in leading public or private universities such as Royal University of Phnom Penh, CADT, or the American University of Phnom Penh. Additionally, initiative from private universities in attracting more students, mostly female, to IT-related majors, have been initiated, to enhance the generation of a tech-savvy pool of professionals capable to support the vision of the RGC and thus provide talent to the private and public sector. Yet, at this stage, the threat of having many universities struggling to survive and battling for having enough qualified instructors remains at the horizon.

Finally, it is important to notice that the need to give more traction to the R&D ecosystem in the Kingdom has been outlined by MISTI in the form of a National Research Agenda. Specifically, to comply with the decision of the RGC and “fulfil the assigned tasks successfully, MISTI has developed National Research Agenda 2025 (NRA) which serves as the national strategic document that guides the efforts of line ministries and other key stakeholders toward creating a research ecosystem suitable for the ambitions of Cambodia's Vision 2030 and 2050”.[62] In this document, MISTI identified 8 research missions, indicating what should be the main focus of research activities in the country: local food, reliable energy supply, quality education, electronic and mechanical spare parts, cloud-based services, electricity and potable water, carbon neutrality, and digitally enhanced health.[63] MISTI also highlighted specific challenges currently present in the Cambodian ecosystem: “underinvestment in R&D; limited alignment between research activities and national challenges, private sector activities and policymaking needs; limited research capacity in the public and private sectors; a weak research infrastructure; and limited academia-industry linkages”. At the same time MISTI proposed 4 main complementary pathways to address the aforementioned challenges: (1) “investing in research to support the eight research missions”, (2) “strengthening the role and capacities of public research institutions”, (3) “supporting research careers”, and (4) “incentivising research activities and collaboration”.[64]

Conclusions

In conclusion, attracting students to the right majors is something that must be done, but hopefully, not at the detriment of quality. More attention must be placed on R&D, as also clearly outlined by MISTI, together with a closer relationship between universities and private sectors, possibly increasing the national budget for it, and creating mechanisms to reward companies investing in this field. Furthermore, the process of accreditation of institutions initiated by the Accreditation Committee of Cambodia (ACC) should continue and become even more rigorous, aligning accreditation with degree validity, together with an increased transparency and visibility of mechanisms, and accredited institutions. This would also facilitate exchange programs with foreign institutions, avoiding pesky situations of countries unsure on recognizing degrees from some Cambodian universities, due to unclear accreditation process or at least transparency on it. Furthermore, knowledge transfer and program for enhancing people connectivity between Cambodia and ASEAN, and also with other partners could be the right move to boost R&D in the country.[65] Focus and involvement in R&D, aligned with the transformative competencies of creating value, reconciling tensions and dilemmas, and taking responsibility, defined by the OECD[66], represent what Cambodia, and also other countries, need in order to sustain their economic growth: young citizens ready to be innovative, responsible, and aware, while being creators, and not only users.

1 David Freedman and Jayant Menon, 2022, "Cambodia's Post-Pandemic Recovery and Future Growth: Key Challenges", 6.
2 World Bank Group, 2020, "Cambodia Economic Update Cambodia in the Time of COVID-19 - Special Focus Teacher Accountability and Student Learning Outcomes", 3.
3 Ibid.
4 Freedman and Menon, "Cambodia's Post-Pandemic Recovery and Future Growth: Key Challenges.", 2.
5 Ibid., 3
6 Raveen Ekanayake, "Growth Slowdowns and Stagnation in the Middle".
7 Vireak Thou, "2030 Innovation Roadmap to Make Headway on Key Economic Visions", Phnom Penh Post accessed October 25, 2023, Khmer Times. https://www.phnompenhpost.com/business/2030-innovation-roadmap-make-headway-key-economic-visions
8 World Bank Group, accessed October 25, 2023 "Cambodia Overview."
9 Riccardo Corrado and Patchanee Tungjan, 2022, "STE(A)M Education for South East Asia".
10 Kao, Chea, and Song, "Upper Secondary School Tracking and Major Choices in Higher Education: To Switch or Not to Switch."
11 MISTI, "Cambodia's Science, Technology & Innovation Roadmap 2030".
12 RGC, "Rectangular Strategy Phase IV".
13 Ung Uy Lim, Ryuto Minami and Phal Chea, "How Strong Is the Link between High School Streaming and University Major Choices?", 1.
14 Sophea Chuon, "Skills Gap and Mismatch in Cambodia: Causes and Implications for Economic Development", 6-7.
15 International Labour Organization (n.d.): ILO Skills challenge innovation call . Finding solutions to skills mismatch; https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/documents/genericdocument/wcms_735524.pdf (21 October 2023).
16 Ung Uy Lim, Ryuto Minami and Phal Chea, "How Strong Is the Link between High School Streaming and University Major Choices?", 1
17 Ibid.,2
18 Ibid., 3
19 Ung, Minami and Chea. "How Strong Is the Link between High School Streaming and University Major Choices?" ,5
20 Sovansophal Kao, Phal Chea, and Sopheak Song, "Upper Secondary School Tracking and Major Choices in Higher Education: To Switch or Not to Switch.", 19.
21 Phal Chea and Vatana Chea, "Family Background as the Determinant of University Student's Technological Readiness."
22 Riccardo Corrado, Sowinta Kay, and Patchanee Tungjan, "Digital Transformation: Exploring the Tertiary-Education Offering in Cambodia".
23 Riccardo Corrado, Rady Mok, and Sokoudom Ung, 2021"AVI PERSPECTIVE ISSUE: 2021: Cambodia Digital Economy and Society Policy Framework 2021 - 2023".
24 Royal Government of Cambodia, May 2021, "Cambodia Digital Economy and Society Policy Framework 2021 – 2035".
25 Sophea Chuon, Februrary 2023 "Skills Gap and Mismatch in Cambodia: Causes and Implications for Economic Development".
26 Chivoin Peou, 2015, "On Cambodian higher education and skills mismatch: young people choosing university majors in a context of risk and uncertainty".
27 Ibid.
28 Ibid.
29 Ibid.
30 Riccardo Corrado, Sereyvuth Khat, and Enrico Corrado, 2021, "Business Values and Digitalization in Cambodia 4.0".
31 Tapas Dash, Bunthorn Yem and Sita An, "COVID–19, Digital Transformation, and Skills Gap among the Cambodian Young Labor Force".
32 MISTI, "Cambodia Science, Technology & Innovation", 2021.
33 Royal Government of Cambodia, "Cambodia Industrial Development Policy 2015 – 2025."
34 Ibid.
35 MISTI, "Cambodia Science, Technology & Innovation", 2021.
36 Ibid.
37 Ibid.
38 Sopheara Ek and Paul Vandenberg, 2022 "Cambodia's Ecosystem for Technology Startups."
39 Royal Government of Cambodia, "Cambodia Industrial Development Policy 2015 – 2025."
40 Ibid.
41 Ibid.
42 Ibid.
43 Riccardo Corrado, Sokthearin Than and Vatanak In, "Cambodia's Digital Transformation: Not Only an Urban Matter", 5.
44 CADT, "NIPTICT Officially Rebranded to CADT", accessed October 25, 2023, https://www.cadt.edu.kh/news/announcement-niptict-national-institute-rebranded-to-cambodia-academy-of-digital-technology-cadt/#:~:text=NIPTICT%20National%20Institute%20Offici-ally%20Rebranded%20to%20Cambodia%20Academy,to%20the%20Cambodia%20Academy%20of%20Digital%20Technology%20%28CADT%29.
45 Eva Paus, 2017, "Escaping the Middle-Incme Trap: Innovate or Perish".
46 Ibid.
47 Richard Doner and Ben Ross Schneider, 2019, "Technical Education in the Middle Income Trap", 3.
48 Eva Paus, 2017, "Escaping the Middle-Incme Trap: Innovate or Perish".
49 OECD, 2015, "The Impact of R&D Investment on Economic Performance: A Review of the Econometric Evidence", 4.
50 Ibid..
51 Luc Soete, Bart Verspagen, and Thomas H. W. Ziesemer, 2022, "Economic Impact of Public R&D: An International Perspective", 11.
52 Ibid.
53 Ibid.
54 Ibid.
55 MISTI, "Cambodia Science, Technology & Innovation", 2021.
56 Ibid.
57 KOICA, "Cambodian ICT Masterplan 2020."
58 KOICA.
59 Peou, "On Cambodian Higher Education and Skills Mismatch."
60 Ibid.
61 Tantanee et al., "Policies to Promote Research and Innovation in Developing Countries' Universities."
62 MISTI, "National Research Agenda", 2023
63 Ibid.
64 Ibid.
65 Riccardo Corrado, "Space Economy."
66 OECD, "The Future of Education and Skills".

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FUTURE OF EDUCATION AND LIFELONG LEARNING

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Digital Skill Competencies Framework – A Common Language in the Future of Digital Skill Development in Cambodia

Samboeun HEAN, Pisal CHANTY, Panharith IN and Kunly SARAY

1. Introduction

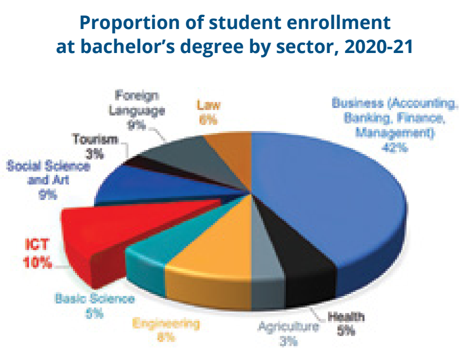
The need for digital transformation for emerging economies are substantial, promising unprecedented paces in socio-economic development and regional and global integration. It is of significant concern that the digital sector's rate of growth is surpassing that of the traditional economy on a global scale. Consequently, nations that fail to engage in digitalization efforts may find themselves at a growing disadvantage.[1] In this context, Cambodia has prioritized its country strategy toward the development of digital economy and society, as articulated in Pentagonal Strategy Phase 1. This article examines Cambodia's digital skill development landscape against the backdrop of such transformational imperatives. It uncovers the systemic challenges that obstruct progress from supply-side perspective, alongside opportunities afforded by demographic trends and its ecosystem. The development of a co-created digital skill competencies framework emerges as a critical catalyst in this context, serving as a conduit for standardizing and elevating digital proficiencies to meet the demand of the digital labor market. The paper engages with regional and global benchmarks to develop lessons applicable to Cambodia's situation. Arguing for the significance of common competencies framework, the analysis underscores its role as a cornerstone in the nation's broader digital transformation agenda, positing that such a framework is not just beneficial but indispensable for Cambodia to harness the full potential of its digital transformation.

2. Current landscape of digital skill development in Cambodia

In this section, the article examines the current status of digital skill development in Cambodia by first focusing on digital skill education as the supply-side of digital talent development, including data on student enrollment and graduates, education and training providers, and programs offering. Then the skill assessment based on findings of the scientific study conducted by the Cambodia Academy of Digital Technology (CADT) and Cambodia Development Research Institute (CDRI) in 2021, *the Demand for and Supply of Digital Skills in Cambodia*, are presented to form arguments for the government intervention.

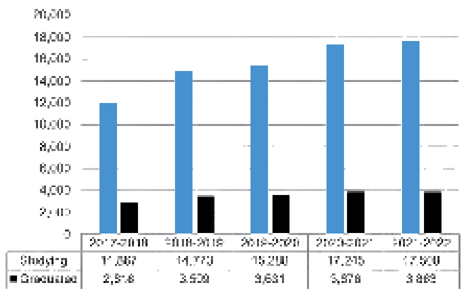
First, an examination of Cambodian student enrollment and graduation rates shows that in the 2021-2022 academic year, there was an noticeable interest in digital fields, with ICT programs attracting roughly 10% of all undergraduates, though business related programs were more dominant, at 42% of the total enrollment (see Figure 1).[2] This trend points to a greater preference among Cambodian students toward business related majors over ICT disciplines, suggesting where current educational focuses and potential digital skill gaps lie. Moreover, over the span from 2019 to 2022, Cambodia has annually produced an average of approximately 3,800 ICT graduates.[3] Despite the natural growth of the students' interest in ICT or digital related field, it remains inadequate to cater to the growing demands of the job market (see Figure 2). The current graduate output slightly grows in comparison to the surging requirements of a rapidly evolving digital landscape.

Figure 1: **Proportion of student enrollment at bachelor's degree by sector, 2020-21**[4]



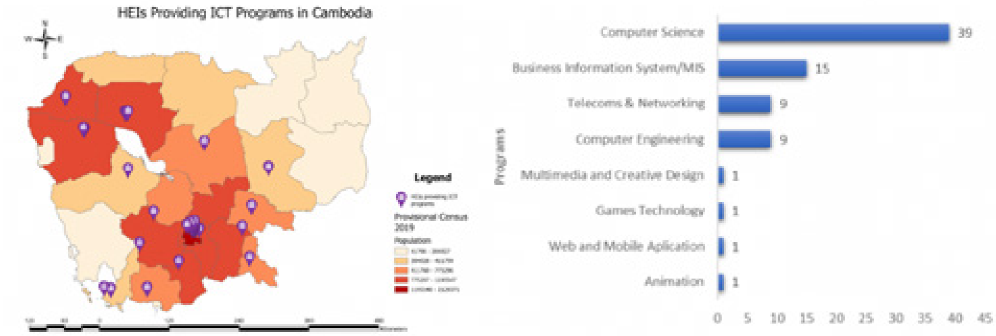
Source: MoEYS 2022, Education Congress

Figure 2: **Number of students studying and graduated in digital related field, 2017-22** [5]



Looking into the digital skill training providers and programs, Cambodia hosts 53 higher education institutes (HEIs) providing ICT programs, with a significant concentration of 39 institutions in the capital, Phnom Penh.[6] However, a prominent redundancy prevails among these institutions – they predominantly offer bachelor's degrees in computer science. As shown in Figure 3, computer science programs are offered by 39 different HEIs, following by Business Information System, Telecommunications and Networking, and Computer Engineering. This redundancy in program offerings raises concerns regarding the diversity and adequacy of curricula in addressing the specific and dynamic skill demands of the country's digital economy. The predominance of generalist computer science programs emphasises the need for diversification and specialization in digital skill education and training offerings.

Figure 3: Mapping of HEIs providing ICT program in Cambodia and program offerings[7]



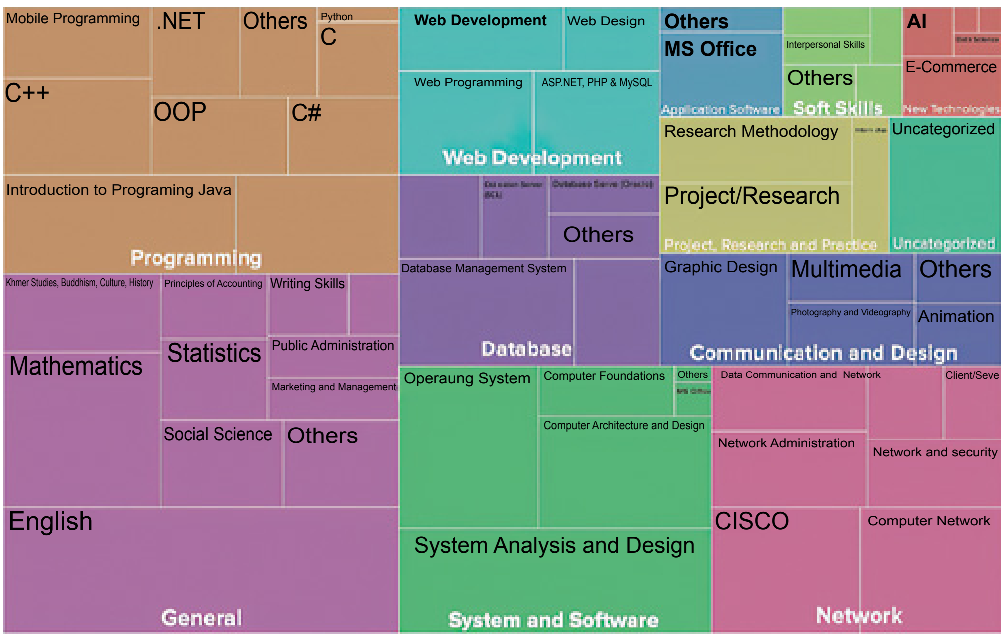
According to a firm survey that targeted 202 firms (135 ICT firms and 67 non-ICT firms) and the key informant interview of 18 selected HEIs of *the Demand for and Supply of Digital Skills in Cambodia*, there are digital skill gaps of the ICT graduates, lacks of digital talents in the labor market, and a rising future demand of digital talent in Cambodia. First, the study finds that top skill gaps identified by both ICT and non-ICT firms in Cambodia are in the areas of basic digital skills, soft skills, and language (commonly refer to English) proficiency.[8]

Figure 4: Digital skill gaps based on firm survey[9]

Digital Skills	ICT Sector		Non-ICT Sector	
	ICT employees	Non-ICT employees	ICT employees	Non-ICT employees
Professional Skills				
Developing and re-purposing content	27	13	0	1
Adopting appropriate good practice regarding copyright and licensing	12	7	0	1
Applications/programming skills	24	15	1	3
Evaluating and using physical versus cloud-based ICD infrastructures	11	9	0	2
Solving information, software and technical (hardware) problems	14	13	0	2
Creativity and innovation using technology	21	8	2	2
Reviewing and evaluating ICT developments	9	7	0	2
Protecting sensitive information	14	7	0	2
Cybersecurity-Securing IT infrastructures	8	8	0	2
Policies and practies for securing extended information infrastructures	9	7	0	2

Moreover, Figure 4 presents the top 5 advanced digital skill gaps reported by the surveyed firms include developing content, programming, creativity and innovation, solving information, software and technical problems, and protecting sensitive information.[10] This is well reflected in curriculum analysis based on subjects taught at HEIs in Cambodia. Roughly 25% of the foundational year curriculum is allocated to core subjects such as English, mathematics, and statistics, adhering to the guidelines set by the Accreditation Committee of Cambodia (ACC).[11] [12] Programming-related subjects made up 17% of the overall curriculum, with systems and software at 14%, and networking at 12%.[13] It's important to highlight that while the HEIs interviewed have implemented a credit system, the options for students to select electives based on their interests were non-existent or extremely limited. Interviews with key informants revealed that the majority of the HEIs surveyed provide all students, not just those in ICT, with an introductory computer course in the first year, focusing primarily on Microsoft Office, as well as internet and email usage. Most of the leading professions in the future are related to new technologies. However, subjects related to emerging technologies such as cloud computing, data science, machine learning, AI, and fintech, which are highly demanded by the market and the future of work, are only accountable for a small fraction of subjects offered by HEIs (see Figure 5).[14]

Figure 5: ICT related circular of HEIs [15]



Another major finding of the assessment shows that limited digital skills among employees and lack of digital talent remain challenges for both ICT and non-ICT firms. [16] More importantly, it is projected by the owners of the survey'\s firms that there will be an increasing need of digital talent between 2021and 2022 at 41% for ICT firms and 20% for non-ICT firms, making an average future demand of 30%. [17] Based on these findings, it is argued that despite the on-going effort of the Royal Government of Cambodia and relevant stakeholder in digital talent development, Cambodia's digital skill landscape is yet to fulfill the growing demand of the industry as well as the development priorities of the country. It is mainly due to the discrepancy of university enrollment in digital technology majors, high prevalence of redundancy of digital related programs offered by HEIs, and high skill gaps and shortages as there is no common understanding of the demand and supply of specific skill in the digital talents. These imply the need of co-created tools or instruments to bridge the gaps between the demand and supply side of digital talent. It emphasizes the need for a holistic approach to address the multifaceted skill requirements of the digital economy.

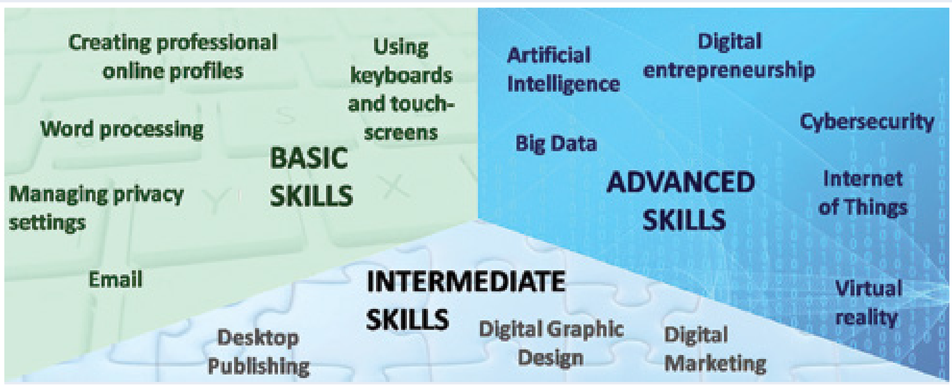
3. Why Digital Skill Competencies Framework?

The article argues for the need of a comprehensive digital reference framework to narrow the gaps among the demand and supply side of the digital skill development in Cambodia. Digital Skill Competencies frameworks are increasingly developed by countries across the globe.[18] A flexible and comprehensive digital skill competencies framework provides a systematic approach to categorizing and structuring the complexity and range of digital skillsets.[19] Digital Competence Framework for Citizens (DigComp) of the European Commission, Digital Literacy Global Framework (DLGF) developed by UNESCO, Digital Skills to Tangible Outcomes (DiSTO) developed by London School of Economics, and New Essential Digital Skills Framework of UK are common example of the competencies framework.

The framework is not only to define a "common understanding through agreed definitions and set vocabulary" [20] but also serves as a foundation for the formulation of inclusive, equitable and sustainable policy interventions. Moreover, the framework is also used for education and training purposes including curriculum design and reforms, certification, and also the skill assessment. [21] However, each framework serves its own purpose with different level of digital skills (see Box 1) and uses, not only for curriculum design and digital talent development, but also for the digital skill assessment.

Box 1: Level of Digital Skill

Digital skills and competencies exist on a continuum from basic skills to higher level, specialist skills, which are refers to "different abilities, many of which are not only 'skills' per se, but a combination of behaviours, expertise, know-how, work habits, character traits, dispositions and critical understandings". [22] According to ITU[23], Digital Skill could be categorized into three level: *Basic Digital Skills*: the fundamental abilities required to operate digital devices such as smartphones or computers, navigate the internet, and use simple software applications; *Intermediate Digital Skills*: skills beyond basic digital literacy that includes the ability to perform work functions by using various software applications, perform online transactions, understand digital security, and engage in online communication and collaboration; and *Advanced Digital Skills*: the skills to "use digital technology in empowering and transformative ways"[24]. It is necessary for more specialized tasks includes the ability to create complex digital content, develop software, understand and manage complex IT systems, and utilize advanced digital tools for analytical purposes.



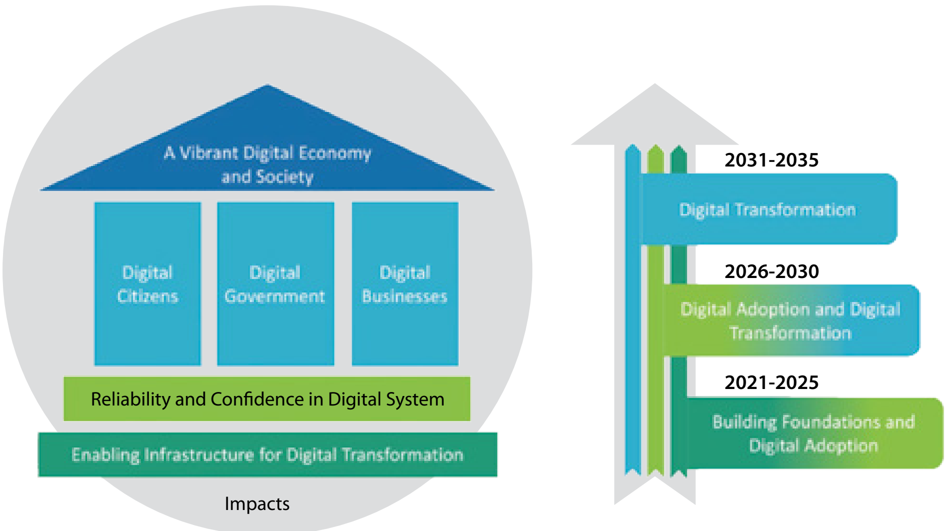
Continuum of Digital Skill[25]

4. A proposed co-created Cambodia's Digital Skill Competencies Framework

With the recognition of the importance of the digital skill competencies framework, the Cambodia Digital Economy and Society Policy Framework 2021-2035 and Digital Government Policy 2022-2035 outlined the policy measure to develop a comprehensive strategy to develop digital skills [26] and the development of a digital skills competencies framework[27]. The proposed design of the Digital Skill Competencies Framework in Cambodia is derived from the principle and framework for the development of Cambodia's digital economy and society, which is based on the two foundations and the three pillars that set the priorities of the Digital Economy and Society Policy Framework 2021-2035.[28]

The development of the framework adopted co-creation methods among policymakers, professors, lecturer, professional, and experts from relevant ministries, universities, private sectors, and development partners. In the process, it also incorporates the scientific study of the current digital skill development, focus groups, and consultative workshops, and benchmarking with the best practise and regional recommendation. The ASEAN ICT Standard[29] and Singapore's ICT Skills Framework[30] has been studied and used to benchmark the framework to ensure regional consistency and to enable regional digital talent mobility.

Figure 6: Principle and framework for building Cambodia's Digital Economy and Society[31]



The proposed Cambodia Digital Skill Competencies framework's design is closely aligned with these strategic elements of the Digital Economy and Society Policy Framework (see Figure 6) and the regional recommendation to ensure the development of key digital competencies, as well as corresponding to the demand of the industry. It encompasses 7 skill tracks, providing a comprehensive overview of the digital skill landscape and outlining the core competencies and skills required across various domains to address the diverse needs of the digital economy. As shown in Figure 7, the proposed Cambodia Digital Skill Competencies Framework consists of 7 skill tracks, 20 sub-tracks, and 62 occupations as follows[32]:

1. **Digital Infrastructure** derives from the foundation for establishing the necessary infrastructure for digital transformation. It emphasizes the importance of building a robust backbone, data center and cloud infrastructure to support digital transformation initiatives. It contains four sub-tracks: Transmission and Fiber Optical, Telecoms and

Networking, Data Center and Cloud Infrastructure, System and Virtualization, covering 20 occupations.

2. **Cybersecurity** derives from the foundation focused on fostering reliability and confidence in the digital ecosystem. It emphasizes the need for robust cybersecurity measures and to ensure trust in digital systems, which can be triggered by infrastructure vulnerabilities, network security, information security, operational security, application security, and the lack of awareness of users and firm on cybersecurity. It contains two sub-tracks: Governance, Risk and Compliance, and Cyber Operation, covering 8 occupations.

3. **Data Governance** derives from the foundation focused on fostering reliability and confidence in the digital ecosystem with emphasizes the need for effective data governance practices to safeguard sensitive information and ensure trust in digital systems. It contains two sub-tracks: Data Protection and Governance, and IT Audit, covering 5 occupations.

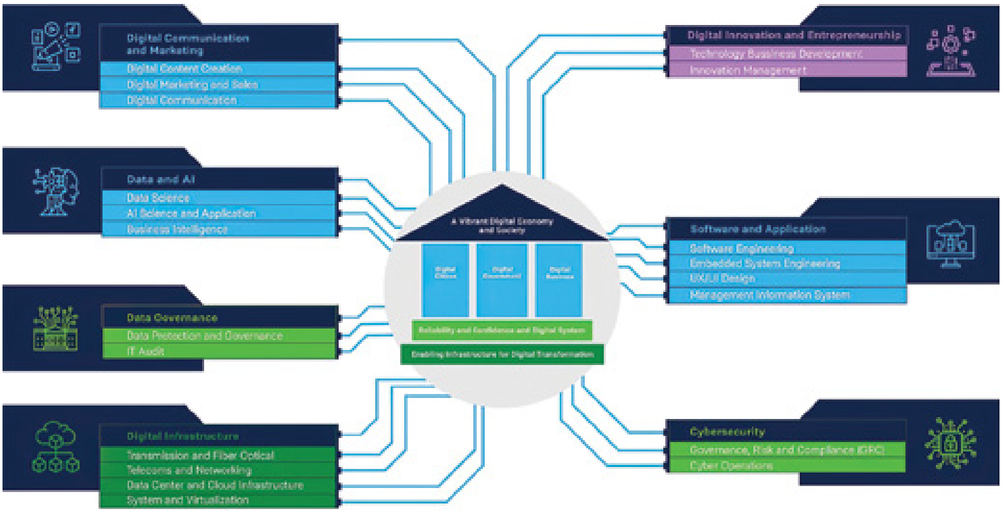
4. **Software and Application** derives from the three main pillars of Cambodia's digital economy and society in order to enable the digital adoption among government, businesses, and citizen. It encompasses the knowledge, abilities, and proficiencies required to develop, design, test, deploy, and maintain software and applications. It contains four sub-tracks: Software engineering, Embedded System Engineering, UX/UI Design, and Management Information System, covering 11 occupations.

5. **Data and Artificial Intelligence (AI)** derives from the importance of Data and AI in promoting the development of digital services and production for inclusive digital adoption and transformation of all stakeholders of the digital economy; especially, in education, healthcare, business and governance. It contains three sub-tracks: Data Science, AI Science and Application, and Business Intelligence, covering 7 occupations.

6. **Digital Sales, Communication and Marketing** derives from a crucial role of digital sales, communication, and marketing in driving digital adoption and transformation by creating awareness, facilitating internal communication and change management, enhancing customer engagement and experience, gathering market insights, promoting digital tools, measuring progress, building external relationships, and amplifying success stories. It contains three sub-tracks: Digital Content Creation, Digital Marketing and Sales, and Digital Communication, covering 5 occupations.

7. **Digital Innovation and Entrepreneurship** derives from the need to unlock the full potential of digitalization and reap its transformative benefits. This skill track drives technological advancements, seizes market opportunities, enhances economic growth, encourages digital disruption, focuses on customer-centric solutions, fosters collaboration, nurtures a culture of continuous improvement, and addresses societal challenges. It contains two sub-tracks: Technology Business Development, and Innovation Management, covering 6 occupations.

Figure 7: **Proposed co-created Cambodia Digital Skill Competencies Framework**[33]



In addition to the argument on the need of the reference framework for digital skill competencies, the framework will also serve as a comprehensive but not exhaustive guide to support students, firms, and training providers in stimulating their roles in digital skills development. For students and employees, the framework serves as a valuable resource helping them to identify and nurture their digital skills and competencies for career orientation. [34] Moreover, employees can gain insights into digital skills of their interest and it provides a structured pathway for employees to understand the skills required for different occupations in the digital realm, empowering them to make informed decisions about upskilling and reskilling in their career pathways. For firms, the framework offers guidance for their recruitment efforts and skills planning.[35] Firms can identify the specific digital skills and competencies required for different occupations, which helps firms align their recruitment processes and job descriptions with the skill sets outlined in the framework, ensuring that they attract candidates with the necessary digital skills to drive their digital transformation initiatives. Lastly, for training providers, the framework enables them to design and develop training programs that align with industry needs and emerging skill demands. Training providers can ensure that their programs cover the necessary digital competencies required by the job market. It provides guidance on the specific skill tracks, sub-tracks, and occupations that should be incorporated into the training curricula, enabling students to gain relevant and in-demand digital skills. [36]

5. Ways forward

The adoption of the Digital Skill Competencies Framework is not an end, but it is a steppingstone towards the development of digital skill in Cambodia. The framework could serve as a reference document and common language for key stakeholders in narrowing the differences between the supply side (students and universities), and the demand side (public and private sectors). It is to guide the design and development of training programs, and to ensure that digital training curriculums are aligned with industry requirements, promoting the acquisition of relevant technical and soft skills for students and employees, as well as preparing human resource need analysis for firms' advancement. However, the framework alone is not sufficient. It requires more efforts from all stakeholders; especially, the government, universities, and private sector to collectively work together to address the challenges. Based on the analysis of the current ecosystem of the Cambodia as presented in the above section, below are potential activities recommended to accelerate the development of digital talent in Cambodia:

First, all stakeholders have a unique role in attracting students to choose to pursue their studies in digital related fields or to improve attractiveness of STEM as the career of the future generation. It includes creating scholarship programs for student in the field of digital technology, student loans, and the development of attractive STEM curriculum or extra-curriculum activities. Second, the government should take a leading role in introducing policy interventions to improving quality and capacity of training providers, especially universities and TVET, in offering digital technology programs. It includes modernizing curricula in all levels of education, investment in broadband internet infrastructure and supporting digital infrastructure for teaching and learning, and the capacity building of lecturers, professors, and researchers. Third, the training providers should work to introduce more certification programs and testing to enable students and employee the opportunity to get international and regional certifications, as a mechanism for re-skilling and up-skilling of workforce and the promotion of digital talent mobility. Lastly, mapping the current status and skill need assessment are crucial to promote an evidence-based digital talent development intervention. It is fundamental that a routine assessment of skill demand is conducted and informs the revision of the skill development initiatives to ensure the relevance of the skill competencies framework and response to the need of digital talent in the country and region.

1 *World Bank, "The digital economy in Southeast Asia: Strengthening the foundations for future growth" (2019), https://documents1.worldbank.org/curated/en/328941558708267736/pdf/The-Digital-Economy-in-Southeast-Asia-Strengthening-the-Foundations-for-Future-Growth.pdf*

2 *MOEYS, "Education Congress," April 2022, https://planipolis.iiep.unesco.org/sites/default/files/ressources/cambodia_education_congress_report_2021-2022_eng.pdf, 101.*

3 *Unpublished data from the General Department of Higher Education of the MOEYS, 2023.*

4 *Author adaptation from the MOEYS, "Education Congress," April 2022, https://planipolis.iiep.unesco.org/sites/default/files/ressources/cambodia_education_congress_report_2021-2022_eng.pdf, 101.*

5 *Author adaptation from Unpublished data from the General Department of Higher Education of the MOEYS, 2023.*

6 *Unpublished data from the General Department of Higher Education of the MOEYS, 2023.*

7 *Author adaptation from Unpublished data from the General Department of Higher Education of the MOEYS, 2023.*

8 *CADT, Demand for and Supply of Digital Skills in Cambodia, 2021, https://www.cadt.edu.kh/resources/digital-skills-assessment-event-2021/demand-for-and-supply-of-digital-skills-in-cambodia-2021/, 23.*

9 *Ibid., 24.*

10 *Ibid., 23.*

11 *Accreditation Committee of Cambodia (ACC) is mandate to administer accreditation to all higher education institutions to ensure and promote the quality of higher education in Cambodia to meet the national and international standards, and to develop its standards, policies, procedures, management structures, roles, functions, and responsibilities in order to provide institutional accreditation to HEIs, offering degree programs ranging from Bachelor to Doctoral degrees in the Kingdom of Cambodia (ACC, "About Us", accessed 7 November 2023, at http://acc.gov.kh/about-us/.)*

12 *Ibid., 41.*

13 *Ibid.*

14 *Ibid.*

15 *Ibid.*

16 *Ibid., 22.*

17 *Ibid., x, and 22-26.*

18 *Broadband Commission for Sustainable Development, 2017, "Working Group on Education: Digital skills for life and work", https://unesdoc.unesco.org/ark:/48223/pf0000259013, 4.*

19 *ITU, 2020, "Digital Skill Assessment Guidebook", https://academy.itu.int/sites/default/files/media2/file/20-00227_1f_Digital_Skills_assessment_Guidebook_%2028%20May%20 2020.pdf, 5.*

20 *Riina Vuorikari and Yves Punie, "The use of reference frameworks to support digitally competent citizens– the case of DigComp." Digital Skills Insights (2019), https://www.researchgate.net/profile/Riina-Vuorikari/publication/336071434_The_use_of_reference_frameworks_to_support_digitally_competent_citizens_-the_case_of_DigComp/links/5d8ce81a299bf10cff12a70d/The-use-of-reference-frameworks-to-support-digitally-competent-citizens-the-case-of-DigComp.pdf, 1.*

21 *Ibid., 1.*

22 *Broadband Commission for Sustainable Development, 2017, 4.*

23 *ITU, 2020, 5-7.*

24 *Broadband Commission for Sustainable Development, 2017, 30.*

25 *Ibid., 7.*

26 *Royal Government of Cambodia, "Digital Economy and Society Policy Framework 2021-2035" (2021), https://mptc.gov.kh/en/documents/policies/31605/ , 35.*

27 *Royal Government of Cambodia, "Digital Government Policy 2022-2035" (2022), https://mptc.gov.kh/en/documents/policies/28365/, 24.*

28 *Royal Government of Cambodia, 2021, 27.*

29 *See Office of the National Digital Economy and Society Commission, Ministry of Digital Economy and Society, "Study on Crucial Soft Skills Required in Digital Transformation" (2021).*

30 *See TechSkills Accelerator (TeSA), "Skill Framework (SF) for ICT sector," SkillsFuture Singapore (SSG).*

31 *Royal Government of Cambodia, 2021, 27.*

32 *Ministry of Post and Telecommunications, 2023, "Draft Digital Skill Development Roadmap 2023-2035", Inter-ministerial version adopted on 13 July 2023, 11-16.*

33 *Ibid., 18.*

34 *Ibid., 1.*

35 *Ibid.*

36 *Ibid.*

Samboeun HEAN

Samboeun Hean has been working more than 13 years in Higher Education Sector and Research Works at laboratories of the Taganrog Institute of Technology, Southern Federal University, Russia in the Artificial Intelligence Field and at University of Namur, Belgium in the Data Security and Privacy. He has a comprehensive and advanced knowledge in Fuzzy Logic and Privacy-Role Based Access Control and recently he is doing research in accessing the digital skill development and talent in Cambodia.

Beside the Artificial Intelligent and the Data Privacy and Security Methods, He was interested in e-Learning Models (Flipped and Blended Learnings), and Strategic Partnership Development. Moreover, He has trained as Subject Mater Expert and Instructional Designer for Online Content Development and he became a director of e-Learning Center at Institute of Technology of Cambodia (ITC) from 2013 to 2018, In that period his mission was promoting the online model in Higher Education and providing e-Learning Contents to the university students.

From 2018 until now, Samboeun has been promoted as Vice President of the Cambodia Academic of Digital Technology (CADT), where is under the Ministry of Posts and Telecommunications. He leads the Education and Training Programs for Digital Talent, improving the graduated and under graduated Programs of Digital Technology, providing teaching and learning approaches to teachers, designing training models to maximize the learning outcomes.

Pisal CHANTY

Mr. Chanty Pisal is the Director of Digital and Innovation Policy Research Center of the Cambodia Academy of Digital Technology (CADT). He is also the project coordinator of the Assessing Internet Development in Cambodia using UNESCO Internet Universality Indicators. Prior to this, he also served as Vice Director of the ASEAN ICT Center of the ASEAN Digital Sectoral Body (ADGMIN/ADGSOM) and worked for Ministry of Post and Telecommunications as international cooperation officers in charge of ASEAN, Mekong Cooperation, WTO and trade.

Pisal has played an active role in formulating and providing inputs to digital related policies in Cambodia as well as in ASEAN. He is also a member of the drafting team of the Digital Skill Development Roadmap in Cambodia, commissioned by the Ministry of Post and Telecommunications. Pisal holds master's in public policy specialized in Economic Policy and Policy Analysis from Australian National University, and master's in International Law from University of Paris 8. He conducts research and study on digital economy, digital and internet policy, cybersecurity, ASEAN Law and integration, and public finance.

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Panharith In is a Business Development Coordinator at the Cambodia Academy of Digital Technology (CADT). He is passionate about helping organizations with their digital transformation, promoting digital startups, and promoting digital innovation. He has experience running different innovation projects, conferences, matchmaking, and incubation programs.

Prior to working at CADT, Panharith worked at a higher education institute in Canada, where he supported international students studying in Canada through different activities and programs such as engagement programs, cultural programs, educational programs, and mentorship.

Panharith is a highly motivated and experienced individual with a strong track record of success in the digital and education sectors. He is passionate about making a positive impact on the world and is always looking for new and innovative ways to do so.

Kunly SARAY

Mr. SARAY Kunly holds a degree in Telecommunications and Networking from the Cambodia Academy of Digital Technology (CADT). Before entering the field of education, he worked in industry and research institutions related to his background to complete his bachelor's degree. Currently, he has transitioned to various roles in the education sector, beginning as a teaching assistant and later assuming the position of program coordinator within the Department of Telecoms and Networking at the Institute of Digital Technology at CADT. Due to the advancement of technology, he remains dedicated to ongoing capacity building, with a particular focus on enhancing his skills in the field of cybersecurity.

Digital Literacy and Entrepreneurship in Cambodia: Assessing Gaps, Implications and Future Steps

Kimsorng SAN, Davy HEAB and Shane GLADWIN

1. Introduction

In 2021, Cambodia announced the implementation of its *Digital Economy and Society Policy Framework 2021-2035* and set out a vision to build "a vibrant digital economy and society by laying the foundations to promote digital adoption and transformation in all social actors [...] to accelerate new economic growth and promote social welfare in the new normal".[1] The framework outlines three core pillars of a vibrant digital economy and society, namely, a digital government, digital businesses and digital citizens. While these three pillars play unique roles in Cambodia's transformation towards a digital economy and society, this paper is interested in exploring the cross-cutting nature of these pillars, especially between digital businesses and digital citizens.

As digital technologies continue to disrupt traditional work operations, there has been a growing need for entrepreneurs and traditional human capital to adapt to digitally transforming business environments, especially since the pandemic. That being said, Cambodia has already shown signs of strong digital adoption over the last decade. In September 2022, there were approximately 18 million internet subscriptions[2] for a population of roughly 16.7 million[3], which potentially indicates the use of multiple internet subscriptions per consumer – highlighting a growing reliance on the internet. Additionally, across other aspects of everyday life such as for retail payments, there is a clear shift towards digital services as we see the number of KHQR payment transactions (QR Code Payments) rise to approximately 400,000.[4] In the past several years, there seems to be a clear shift online towards using Social Media platforms. Today, there are approximately 14.5 million Facebook users[5] in August; however, a clear indication remains that digital readiness as well as digital literacy (which is defined in the next section) is still low – especially in the context of the workforce. Research indicates that there is a skills gap within the ICT sector[6] and similarly a 2020 Global Digital Readiness Index rates Cambodia with a digital readiness score of 9.27/25 (well below the global average).[7]

For the purposes of this paper, we will be focusing in particular on *entrepreneurs* as they remain a core foundation to building a resilient digital economy. The positive impact of developing the entrepreneurial ecosystem is clearly highlighted in Cambodia´s Digital Economy and Society Framework[8], with further calls to action to enhance entrepreneurial ability through the incorporation of digital skills. In light of this, a necessary question to consider is what are the effective mechanisms to best achieve this?

The Digital Government Policy 2022-2035 has since outlined a strategic goal to further build digital capacity and innovation in the country, with a priority on developing the national digital competence framework and promoting the training of important digital professionals.[9] Under this goal, the framework outlines a strategy on building human capital which involves the promotion of digital literacy (through various means) across educational channels to build the capacity of the professionals through the uptake of digital skills.[10]

Critically, educational institutions – from primary through to higher education – have been identified as effective platforms through which skills development can take place and play an important role in developing digital literacy amongst the workforce. Across formal segments of education however, higher education institutes (HEIs) in particular stand out as a segment that is closest to the beginning of an individual's professional journey – and thus HEIs are an effective starting point for focusing on digital literacy initiatives.

In terms of entrepreneurship, the Royal Government of Cambodia considers the private sector as the engine of economic growth, and vital for promoting entrepreneurship. It is evidenced by many government initiatives to promote entrepreneurship such as the process for the Entrepreneurship Development Fund (EDF) and Techo Startup Centre for developing the ecosystem, initiated by the Ministry of Economy and Finance, as well as the establishment of SME banks to boost entrepreneurship.[11]

With this in mind, this paper attempts to further explore the linkages between digital literacy and entrepreneurship and examines how digital literacy initiatives can be improved within higher-education institutions to achieve better entrepreneurial outcomes.

2. Digital literacy and digital trends

Ensuring digital literacy nationwide is a necessary factor for the successful digital transformation of any developing nation. This section attempts to provide a high-level review of digital literacy in Cambodia, while outlining how emerging digital trends significantly increase the need to improve its outcomes.

2.1 Defining digital literacy

In order to remain consistent with the theme of digital literacy and its relation to entrepreneurship (especially in the context of a digital economy), this paper will use a particular definition that encompasses aspects of digital literacy that remain relevant to characteristics of digital entrepreneurship. As the definition has evolved significantly over the years with the advancement of digital technologies, today, digital literacy can be defined as the *"ability to access, manage, understand, integrate, communicate, evaluate and create informa-*

tion safely and appropriately through digital technologies for employment, decent jobs and entrepreneurship".[12] It includes various competences that are often referred to as computer literacy, ICT literacy, information literacy and media literacy.

2.2 Assessing gaps in digital literacy

According to the Cambodia Digital Economy and Society Policy Framework 2021-2035, approximately 30% of the population have foundational digital skills.[13] In September 2022, there were 18 million internet subscriptions, based on the Telecommunication Regulator of Cambodia.[14] In contrast to a population of 17 million, Cambodia demonstrates high internet user penetration but has a low digital literacy rate. This specific rate is reflected in standardized indices such as the Global Digital Readiness Index which is determined by examining seven components (such as basic needs, business and government investment, ease of doing business, human capital, start-up environment, technology adoption and technology infrastructure) to obtain an overall digital readiness score. Cambodia scored 9.27/25 which was well below the global average.[15] Additionally, based on the Cisco Digital Readiness Index 2021, Cambodia was ranked 92nd among 146 countries[16] and was classified in its 'Accelerate' category indicating that it would benefit from additional human capital development, basic human needs improvements and advancements in the ease of doing business in order to capitalize on the benefits of digitization on economic growth.

A 2021 Digital Skills Assessment that was jointly conducted by the Cambodian Academy of Digital Technology (CADT) and the Cambodia Development Resource Institute (CDRI) outlines that there are significant digital skills gaps for the general workforce, hindering the ability of individuals to adapt and adopt to changes in workplace environments – like when being introduced to new processes that require specific ICT skills.[17] In terms of professional skills gaps (specific to digital skills for ICT professions), the assessment indicated that a majority of the gaps to be present in the ability to innovate and create, predominantly in developing and repurposing content, creating and innovating using technology as well as for applications and programming.[18]

2.3 Emerging digital trends

With the onset of the COVID-19 pandemic, there has since been exponential growth in the usage of digital technologies – which has contributed significantly to the growth of the digital economy[19] as a whole. In Cambodia, the e-commerce market is projected to reach USD 979.90m in 2023 with an annual growth rate (CAGR 2023-2027) of 12.24%.[20]

The World Bank estimates that the digital economy contributes to more than 15% of global gross domestic product (GDP), and in the past decade it has been growing at 2.5 times faster than physical world GDP.[21] In Cambodia, the market size of the digital economy is estimated to be USD 1.45 billion in 2023 with e-commerce contributing a significant portion, around USD 1.28 billion.[22] In addressing the importance of the digital economy, the Royal Government of Cambodia identified the digital sector as a new model of economic growth in economic structure, development and international trade as outlined in the Digital Economy and Social Policy Framework 2021-2035.[23] Additionally, the newly adopted Pentagonal Strategy[24], a revision of the previous Rectangular Strategy, will strengthen the role of the digital economy in the country's development moving forward.

With the prevalence thus far that the digital economy has had in the development of Cambodia's strategic roadmap moving forward, there is ample opportunity for entrepreneurs and business owners to expand their existing businesses digitally. However, as outlined earlier in this paper, entrepreneurs need digital skills to grow their business, remain competitive, and keep up with the fast-changing world without being left behind. To address any gaps that may exist in their ability to operate within this space, having digital literacy is important for entrepreneurs to operate locally and internationally.

3. Digital literacy and its importance in the context of entrepreneurship

In the context of the entrepreneurial journey, digital literacy acts as a gateway to the broader ecosystem, aids in ease of doing business, efficiency and sustaining businesses in the long-term goal. This section expands on the cross-cutting benefits of digital literacy for entrepreneurs and business owners.

3.1 Digital literacy as a gateway to the entrepreneurial ecosystem

Over the last 5 years, there has been a significant rise in the number of activities promoting and supporting entrepreneurship in Cambodia such as startup competitions, startup incubation, investment and acceleration programs. These entrepreneurial activities have become mainstream and have attracted the attention of young tech-savvy individuals, especially fresh graduates and undergraduate students. Additionally, during and post pandemic, many entrepreneurship programs were conducted digitally and some of them remain their digital activities blended with physical activities such as Digital Platform Accelerator, Bandos Digital Startup, Cambodia Digital Award 2022 (CDA 2022) and Women's Digital Entrepreneurship (WDE).[25] As of September 2023, there are 153 active startups, 6 incubators and accelerators, 13 communities and associations, 13 institution investors, and 20 academic institutions who are engaging actively in entrepreneurship ecosystem in Cambodia.[26]

The growth of the entrepreneurship ecosystem digitally has unknowingly addressed the importance of digital literacy. People with digital literacy can easily explore, learn, and access the entrepreneurship ecosystem which drives their interest to begin their entrepreneurship journey.

3.2 Benefits of digital literacy in entrepreneurship

While the three R's (Reading, wRiting, and aRithmetic) remain the backbone of our education system, our ability to learn and communicate has evolved with society and technology.[27] Basic literacy and numeracy are important for everyone; however, digital literacy is an essential skill today considering the rapid digitalization of both the economy and society. Having digital literacy will enable us to navigate digital platforms easily and effectively, especially in the context of entrepreneurship. Ease of doing business is improved via digital platforms which bring more competitors into the market. Digital literacy can become a competitive advantage for businesses – if entrepreneurs can make use of it to their advantage – to survive and thrive in a highly competitive market.

Outlined below are several benefits of digital literacy to entrepreneurs.

- **Increased access to international markets:** With relevant digital skills, entrepreneurs can expand their businesses into new markets internationally by doing cross border e-commerce or connecting to business partners internationally. This allows businesses to increase their customer base, generate more sales, increase revenue, and remain sustainable. However, expanding business internationally is not easy and entrepreneurs need strong digital skills to effectively communicate with business partners and customers digitally through effective marketing practices.

- **Maintaining customer loyalty:** Entrepreneurs can engage and stay connected with customers via digital platforms such as social media. Many businesses in Cambodia nowadays have their online presence such as Facebook page or Telegram Channel to maintain relationships with customers. Moreover, digital marketing has become an important sales channel for businesses and there is an increasing amount of advertising on digital platforms. According to Statista, the Digital Advertising market in Cambodia is projected to reach a market volume of USD 121.39 million in 2027.[28]

- **Ease of recruiting talent:** Human capital is an important asset for every company. Entrepreneurs with digital literacy can connect and select potential employees who will help the business grow. Digital platforms do not only enable communication between companies and customers, but also companies and employees. Social media such as LinkedIn have become common places for job search globally and locally. Entrepreneurs can use such platforms to recruit talented employees.

4. How digital literacy initiatives can be further embedded into HEIs in Cambodia

Digital literacy initiatives play an important role in equipping individuals with the necessary skills and knowledge to thrive in the digital age. In Cambodia, higher education institutions (HEIs) serve as appropriate and relevant platforms to further embed these initiatives. By doing so, HEIs can empower students with the digital skills needed for academic success, future employment prospects and their potential entrepreneurial ventures.

4.1 Why are HEIs important education platforms for digital literacy?

A general education pathway of Cambodian students starts with kindergarten, primary school, high school, and higher education institutions (HEIs). The first three stages of the education journey (from kindergarten to high school) are mainly designed for basic literacy and numeracy. Although tech-savvy students can capture digital literacy during their high school years, HEIs are more specialized in nature, especially as platforms for improving specific skills including digital literacy. Moreover, HEIs are the closest education stage to the employment and entrepreneurship journey. As HEIs students must be ready for the job market which is essential for equipping them with digital literacy.

There are 130 HEIs in Cambodia, of which 82 are private and 48 are public with 209,059 students (95,619 females) enrolled in the school year 2021-2022.[29] Enrollment in higher education was measured by the overall education rate of the population aged 18 to 22. The female enrollment rate for HEIs was 13.2%, for males 15.5% in the Academic Year 2021-2022[30] and the overall enrollment rate increased by an average of 0.55% per year over the past decade. We can look further into STEM education in HEIs as it is closely related to digital skill education, where on average (between male and female students) the percentage of STEM training students was 25.6% in the Academic Year 2021-2022. There was an average annual increase of 0.66% over the past decade.[31] These increasing numbers in HEIs enrollment and STEM training enrollment address the importance of HEIs in Cambodia in developing future human capital for future workforce and entrepreneurship.

4.2 How digital literacy can be embedded further in HEIs

HEIs plays an important role in the education of digital literacy to students by providing digital learning experience through two main practices: using learning management systems (LMS)[32] and offering digital-related courses or majors. Some universities have implemented LMS such as third-party programs like Google Classroom and Canvas. LMS allows students to access class materials, view and submit assign-ments, connect with classmates and professors, collaborate with group members, take exams digitally, and more. These digital learning experiences help students cultivate digital literacy subconsciously. During the COVID-19 pandemic, HEIs were shut down and online classes were required which also increased the adop-tion of digital learning experiences among students and increased the number of universities using LMS.

Additionally, digital literacy can be embedded further in HEIs through the offering of digital-related courses or majors. Over the past decade, there has been a growing number of HEIs offering digital skill courses or majors significantly. In 2023, there are 53 HEIs offering digital skill programs with top programs being computer science, business information systems, and telecoms and networking.[33] Analysis conducted in the 2021 Digital Skills Assessment conducted by the CADT also outlines that HEIs have the potential to put more effort into introducing additional courses related to relevant technologies such as blockchain technologies, financial technology-related skills, and data science while incorporating core aspects of critical thinking, problem solving, communication, creativity and collaboration.[34] Additionally, opportunities exist to further implement digital literacy initiatives across non-ICT related courses as well. Blended learning serves as one potential method, which is a combination of traditional face-to-face education with online learning.[35] In the social sciences, and across many non-ICT related courses for example, it is the integrated use of technology as a learning strategy and as a tool to access greater resources meant to create a more personalized learning experience[36]. While there is little research supporting this in the Cambodian context, regional case-studies indicate that similar outcomes could be achieved through the implementation of more general blended learning models in HEIs. Research conducted on the implementation of blended learning in Social Sciences at Indonesian HEIs outlines that blended learning in social sciences have the potential to retain certain categories of students' competencies including knowledge & skills and thinking abilities there are retained digital literacy skills, critical thinking and problem-solving skills as well as creativity.[37]

Outside of improving and increasing digital literacy courses within HEIs, alternate channels to further incorporate digital literacy exist in collaborations between HEIs and the private sector. Company managers are keen on strengthening collaborations with HEIs to help address the skills gaps that exist.[38] This would involve periodic consultations, internships and conferences. Additionally, the 2021 Digital Skills Assessment indicated that there is also the potential for collaboration outside the aforementioned channels, in particular through a sector skills council for ICT which would help narrow down the necessary skills and qualifications in this sector to better inform curricula development and program delivery.[39] This form of public-private partnership will remain necessary if Cambodia is to focus on a driven digital literacy approach that seeks to solve specific gaps and challenges in this regard. Ultimately, only the private-sector can bring the necessary knowledge and lived-experiences necessary to inform greater digital literacy reform (in HEIs).

In light of this, however, it is important to keep in mind the reasons behind *why* attempts at incorporating these initiatives have been limited so far. The Digital Assessment study suggests that this may potentially be due to insufficient human resources and a lack of investment budgets.[40] The drive for digital literacy requires the necessary human capital *within* HEIs to facilitate the teaching of specific courses related to digital literacy. While the drive for upskilling the workforce has placed an importance on teaching the future generation of workers – more can be done to provide the necessary training to lecturers and teachers in this space. Additionally, with a growing number of HEIs in the country, there is generally high competition in terms of tuition fees. Over the last decade, there has only been a minimal increase in the tuition fees, which has been lower than the inflation rate, significantly hindering the abilities of HEIs to invest appropriately in courses that address the specific digital skills gap.[41]

5. Moving forward

This paper has attempted to highlight how digital literacy and entrepreneurship are crucial for fostering transformation in a digital economy. Through the use of digital technology, entrepreneurs are able to enhance their business operations better than before and increase productivity. HEIs remain important and necessary platforms through which skills can be learnt and developed through numerous initiatives. However, moving forward, we must keep in mind that the entrepreneurial journey and mindset is developed far before the transition into the workforce. In attempting to understand the practical implications of digital literacy initiatives then, we must also widen our scope to further understand the most effective ways to improve the prospects of entrepreneurship overall in the country.

To do so, we could consider what Khan et. al. describe as the development of "fusion skills".[42] Fusion skills in this context can refer to the combination of creative, entrepreneurial and technical abilities that ultimately help facilitate smoother transitions between different fields of work as the economy evolves.[43] So far, this paper has discussed the integration of improved digital literacy initiatives across HEI's but has done so with a particular focus on improving both entrepreneurial and technical abilities. In relation to this, efforts are also already in motion, with the announcement of the *Digital Skills Development Roadmap* – an initiative being led by the CADT with support from the Ministry of Post and Telecommunications (MPTC) and the Ministry of Education, Youth and Sport. The roadmap offers HEIs guidance on course development across several different skill tracks, including entrepreneurship.

The creative aspect of fusion skills on the other hand can largely be linked to the outcomes of an 'entrepreneurial mindset', which is something that will be critical in developing the future of entrepreneurship in Cambodia. An entrepreneurial mindset is best described as a "growth-oriented perspective through which individuals promote flexibility, creativity, continuous innovation, and renewal".[44] One way of categorizing this mindset involves viewing it as the promotion of creative and innovative problem solving which is something that can be addressed across pre-university levels of education.[45] A study conducted in Slovenia had success in teaching young students the entrepreneurial mindset by developing topic or thematic based courses that placed focus on decoding a local problem, breaking it down, and using evidence-based brainstorming (after speaking with local experts) to come up with solutions. The study fostered a positive result from the students, in that they were not only focused on the *process* of problem solving (as opposed to the final product) but did so creatively through interaction and collaboration with peers as well.[46] Keeping this in mind, there are significant prospects for the integration of digital aspects into such course design through the use of digital tools or digital solutions (designing presentations, flyers, infographics). This would allow us to bind outcomes for both entrepreneurship *and* digital literacy at early stages of development. Considering that each stage of education is complementary to the next, students would not only be better prepared for later stages of their educational journey but would also be better equipped to adapt to an evolving labor market.

Implementing such a curriculum, however, would take a significant amount of time and resources. Curricula in both national primary and secondary education in Cambodia is currently being revised to include basic aspects of digital literacy, however, is being developed over lengthy periods, requires significant funding and is being developed and implemented by segment (in order of high school, middle-school, and finally primary).[47] With the primary curriculum being at the end, there lies the risk of it already being far too late by the time it is implemented – which is something that departments responsible should take into consideration. Overall, however, perhaps a prioritization of short-term and long-term goals should be put into place to ensure that there is consistent effort to reform education at all levels. Implementing digital literacy initiatives further into HEIs could be categorized as a short-term goal, considering its achievability and progress so far, while pre-university reforms can be long-term.

1 *Royal Government of Cambodia, "Digital Economy and Society Policy Framework 2021-2035", May 2021, https://mptc.gov.kh/en/documents/policies/31605/, 20.*

2 *Telecommunication Regulator of Cambodia, "Internet Subscriptions," last modified September 2022. https://trc.gov.kh/en/internet-subscriptions/.*

3 *The World Bank, "Population, total – Cambodia,", accessed September 18, 2023, https://data.worldbank.org/indicator/SP.POP.TOTL?locations=KH.*

4 *Manoj Mathew, "KHQR Records 400K Transactions in One Year - Khmer Times," Khmer Times, August 2, 2023, https://www.khmertimeskh.com/501336016/khqr-records-400k-transactions-in-one-year/.*

5 *NapoleonCat., "Facebook Users in Cambodia,", last modified August, 2023, https://napoleoncat.com/stats/facebook-users-in-cambodia/2023/08/.*

6 *Royal Government of Cambodia, "Digital Economy and Society Policy Framework 2021-2035", May 2021, https://mptc.gov.kh/en/documents/policies/31605/ , 17.*

7 *UNDP, "Digital Literacy for Employability and Entrepreneurship among Cambodian Youth," 2020, https://www.undp.org/sites/g/files/zskgke326/files/migration/kh/UNDP-Assessment-Report_V11.pdf.*

8 "Cambodia Digital Economy and Society Policy Framework 2021-2035", 13.

9 "Cambodia Digital Government Policy 2022-2035", January 2022, https://asset.cambodia.gov.kh/mptc/media/Cambodia_Digital_Government_Policy_2022_2035_English.pdf.14.

10 Ibid., 24.

11 Sithika Sok, "Ecosystem to promote entrepreneurship, support SMEs," Khmer Times, October 20, 2022, https://www.khmertimeskh.com/501172189/ecosystem-to-promote-entrepreneurship-support-smes/.

12 UNESCO Institute for Statistics, "A Global Framework of Reference on Digital Literacy Skills for indicator 4.4.2," June 2018, https://unesdoc.unesco.org/ark:/48223/pf0000265403.locale=en.

13 Royal Government of Cambodia, "Cambodia Digital Economy and Society Policy Framework 2021-2035," May 2021, https://mef.gov.kh/news/cambodia-digital-economy-and-societypolicy/, 15.

14 Telecommunication Regulator of Cambodia, "Internet Subscriptions," last modified September 2022. https://trc.gov.kh/en/internet-subscriptions/.

15 UNDP, "Digital Literacy for Employability and Entrepreneurship among Cambodian Youth," 2020, https://www.undp.org/sites/g/files/zskgke326/files/migration/kh/UNDP-Assessment-Report_V11.pdf.

16 "Digital Readiness Index Cambodia," 2021, https://www.cisco.com/c/m/en_us/about/corporate-social-responsibility/research-resources/digital-readiness-index.html#/country/KHM.

17 CADT, Demand for and Supply of Digital Skills in Cambodia, 2021, https://www.cadt.edu.kh/resources/digital-skills-assessment-event-2021/demand-for-and-supply-of-digital-skills-in-cambodia-2021/, 23.

18 Ibid.

19 As per the Digital Economy and Society Policy Framework 2021-2035 the term digital economy refers to "advances in science and technology – which have been creating new business models, changing the production process, consumption, and distribution of goods and services, as well as gradually changing the way we work so as to expand digital product base and digital services, to modernize the production, and to increase productivity and economic efficiency in response to technological advances".

20 "eCommerce – Cambodia", Statista, August 2023, https://www.statista.com/outlook/dmo/ecommerce/cambodia.

21 Zia Hayat, "Digital trust: How to unleash the trillion-dollar opportunity for our global economy," World Economic Forum, April 17, 2022, https://www.weforum.org/agenda/2022/08/digital-trust-how-to-unleash-the-trillion-dollar-opportunity-for-our-global-economy/#:~:text=The%20World%20Bank%20estimates%20that.

22 "ASEAN's Digital Economy Growth Could Further Increase Cambodian Revenues," B2B CAMBODiA, September 5, 2023, https://www.b2b-cambodia.com/news/aseans-digital-economy-growth-could-further-increase-cambodian-revenues/.

23 Vanyuth Chea, "Cambodia's digital economic and society policy for 2021-2035 launched," Khmer Times, June 19, 2021, https://www.khmertimeskh.com/50877443/cambodias-digital-economic-and-society-policy-for-2021-2035-launched/.

24 Royal Government of Cambodia, "Pentagonal Strategy-Phase 1", August 2023. https://mfaic.gov.kh/files/uploads/1XK1LW4MCTK9/EN%20PENTAGONAL%20STRATEGY%20-%20PHASE%20I.pdf

25 Digital Economy and Business Committee - DEBC, "Key Initiatives or Programs in the Startups Ecosystem", accessed October 23, 2023, https://digitaleconomy.gov.kh/startup?lang=en.

26 "Startup Cambodia," Startup Cambodia, accessed September 18, 2023. https://startupcambodia.gov.kh/ecosystem/discover/category/startup.

27 YOTTABYTE, "Digital Literacy and its Importance,", March 6, 2023, https://www.linkedin.com/pulse/digital-literacy-its-importance-yotta-byte/.

28 "Digital Advertising – Cambodia", https://www.statista.com/outlook/dmo/digital-advertising/cambodia.

29 MOEYS, "Education Congress," April 2023, https://planipolis.iiep.unesco.org/sites/default/files/ressources/cambodia_education_congress_report_2022-2023_eng.pdf, 151-153.

30 Ibid., 154.

31 Ibid., 154.

32 LinkedIn, "How can LMSs help learners develop digital literacy and 21st century skills?," accessed September 18, 2023, https://www.linkedin.com/advice/0/how-can-lmss-help-learners-develop.

33 Tharum Bun, "Digital Skill Development Roadmap to Address Cambodia's Skills Shortage," Kiripost, June 12, 2023, https://kiripost.com/stories/cambodia-digital-skill-development-roadmap-to-address-skills-shortage.

34 CADT, "Demand for and Supply of Digital Skills in Cambodia," 50.

35 Raisa I. Platonova et al., "Blended Learning in Higher Education: Diversifying Models and Practical Recommendations for Researchers," Frontiers in Education 7 (July 5, 2022): 2, https://doi.org/10.3389/feduc.2022.957199.

36 Erond Litno Damanik, "Blended Learning: An Innovative Approach on Social Sciences at Indonesian Higher Education," Education Quarterly Reviews 3, no. 1 (March 30, 2020): 59, https://doi.org/10.31014/aior.1993.03.01.117.

37 Ibid., 60

38 CADT, "Demand for and Supply of Digital Skills in Cambodia," 50.

39 Ibid.

40 Ibid.

41 Ibid.

42 Nasreen Khan et al., "Connecting Digital Literacy in Higher Education to the 21st Century Workforce," Knowledge Management & E-Learning: An International Journal 14, no. 1 (March 26, 2022): 57, https://doi.org/10.34105/j.kmel.2022.14.004.

43 Ibid.

44 Blaž Zupan, Franc Cankar, and Stanka Setnikar Cankar, "The development of an entrepreneurial mindset in primary education," European Journal of Education 53, no. 3 (August 6, 2018): 428, https://doi.org/10.1111/ejed.12293.

45 Ibid., 428.

46 Ibid.

47 Private discussion with the Department of ICT at the Ministry of Education, Youth and Sports.

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Fostering Digital Pedagogy Among Pre-Service Teachers

Pichpisey SOVANN and Arunremfa LIM

Background

Digital technologies have intensified the digitalisation of the global economy. The use of information and technologies to transform business models, innovate new products and services, and facilitate transactions ushers in a digital economy. The digital economy could play a role in promoting economic growth through reiterations of digital dimensions in increased inclusion, efficiency, and scalability.[1] The digital economy encompasses a wide range of ideas including e-commerce, e-governance, e-banking, e-knowledge processing, payment wallets, and digital competency in labour markets[2] The digitalisation of the economy can be proliferated by the amplification of the digital competency of the said economy.[3] The majority of the fastest-growing jobs are technology-related roles. The ICT sector is expected to make up 2.5% of the global workforce and 1% of the workforce of developing countries.[4] Therefore, the economic gains from having access to digital technology are significant and it can be implied that digital skills are crucial for human capital.

Building human capital through education is a critical measure for social and economic development. To equip the workforce with digital skills, mandating digital literacy in education is a key measure. Mandating digital literacy in developing human resources is a priority in building the future of citizens in Cambodia, aligned with one of the three pillars of building a digital economy and society.[5] Like other professionals, teachers have experienced the integration of information and communication technologies (ICTs) in their professional journey. Digital technology has opened new possibilities and is also transforming the way we learn by making educational materials and resources more accessible and affordable than ever before.[6] Teachers are expected to utilise digital technologies to maximise learners' experience and develop learners' digital literacies.

The emergence of digital education is achieved by purposively incorporating technologies in the classroom. However, technologies can be perceived as beyond a delivery platform, but "as a pedagogical tool.[7]" It can help learners submerge into hands-on and meaningful experiences. Digital education is here to revolutionize education from 'transmissive' to 'transformative'[8], meaning learners and teachers have the ability to not just impart knowledge, but also be change agents. To meet this expectation, teachers need to practice integrating technology into teaching techniques and teaching content. This new way of teaching combining the use of technology known as 'Digital Pedagogy' can make learning more fun, rewarding, and effective.[9] While traditional classrooms allow the practice of hands-on learning activities, digital technology enables teachers to adopt appropriate technologies and design blended learning environments that leverage the strengths of both traditional and digital learning approaches.[10] It involves a strategic approach where teachers leverage digital tools to enhance both teaching techniques and teaching content. In this context, digital pedagogy emphasizes the creative and critical use of technology to facilitate active learning experiences.

While the use of digital technologies in Cambodian classrooms is not a new phenomenon, it is widely recognised that the preparedness of teachers to incorporate digital competencies into their teaching practices is crucial. Pre-service teachers' technology skill acquisition and experiences are primarily associated with their initial teacher education. It is indicative that teacher education develops teachers' professional competence by bridging theoretical knowledge and the practicality of pedagogy. Initial Teacher Education (ITE) refers to the foundation study in the teaching professional journey where pre-service teachers play a role as both teacher and learner to discuss, practice, and reflect on how to teach and how to facilitate their learners to learn.[11] Cambodia's Teacher Policy developed by the Ministry of Education, Youth, and Sport in 2013 also states the aim of equipping teachers with skills, professional competence, and morals to meet the requirements of their profession.[12] What does digital pedagogy entail? How do pre-service teachers perceive digital pedagogy? Do they perceive digital pedagogy as an important aspect of their professional confidence? How do teacher training institutions come into play in promoting digital pedagogy?

Objective

This paper seeks to understand the importance of digital pedagogy among pre-service and in-service teachers by assessing the perceptions regarding digital pedagogy of pre-service and in-service teachers through the theoretical basis – TPACK – technological, pedagogical, content knowledge. The findings are relevant for the government and standard-setting bodies to cultivate an effective mechanism to build teaching capacity and support Cambodia's pre-service and in-service teachers. Finally, this paper provides step-by-step recommendations that teacher training institutions could follow to enact digital pedagogy in pre-service teacher training.

Challenges of teaching with technology

Globally, the adoption of digital technology surges in almost all sectors, education included. COVID-19 intercepted face-to-face interactions and online learning replaced face-to-face interactions. Online learning is not entirely a new phenomenon. Online learning was often practised by higher education institutions to offer better flexibility and accessibility to a wider range of people.[13] Cambodia could not avoid online learning during the pandemic. COVID-19 has accelerated the adoption of online learning at an unprecedented rate. the Ministry of Education, Youth, and Sport (MoEYS) in Cambodia demonstrated resilience and adaptability during the COVID-19 crisis. Their efforts in ensuring the continuity of learning from pre-school to upper secondary school could be accessed only online, through platforms such as the MoEYS e-learning website, Facebook page, YouTube channel, Krou Cambodia and Komar Rien Koma Cheh, the Ministry's official Facebook page for early grade learning. MoEYS, with support from a variety of development partners, started to broadcast continuous or distance learning programs through a new dedicated education television channel (TVK2) and on radio[14] which played a crucial role in mitigating the impact of the pandemic on the education sector. Through these initiatives, the Ministry contributed significantly to the continuity of education for Cambodian students during these unprecedented times.

The greater potential the measures to ensure the continuity of learning have, the greater teacher capacity is needed. Factors including a shortage of digital devices and internet access, limited institutional support capacity, and student and teacher readiness for technology-based learning need to be considered to strengthen the capacity of teachers.[15] Teachers' readiness for technology in teaching has gathered great attention from many researchers. While technology adoption in Cambodia's education system ought to be given top priority[16], the practice of digital technology among Cambodian teachers is identified as a major challenge. Although most teachers have experienced online teaching during the time when the schools were closed, teachers switched back to physical classrooms the moment schools reopened, stating online classrooms are less engaging and effective.[17] This shows that the teacher did not feel comfortable delivering online teaching. As evidenced by the MoEYS and ESWG's assessment report (2021), only 13% of teachers and school directors were confident in performing their jobs effectively during the school closures, while other teachers stated they needed support with lesson planning and material development (57%), the use of social media for distance learning (55%), and the use of online platforms (40%).[18] In line with this, a World Bank report suggested that the majority of Cambodian teachers have voiced concerns about remote learning while only 18% said that they were provided with enough capacity support.[19] Addressing these challenges requires ongoing professional development for teachers, adequate infrastructure and resources in schools, and a thoughtful, well-planned approach to integrating technology into the classroom. Teachers must be equipped with the knowledge and skills to harness the potential of technology while mitigating its challenges effectively.

Teacher education in Cambodia

The Royal Government of Cambodia's long-term vision is to move Cambodia into an upper-middle-income country by 2030. Hence, one of the strategies to achieve that is to equip citizens with strong technical and 21st-century skills.[20] Those skills include but are not limited to, communication, critical thinking, collab-

oration, creativity, and information and communication technology (ICT). In the Cambodia Digital Economy and Society Policy Framework 2021-2035, developing a common framework to promote digital literacy including digital leadership development is set to be implemented. The Cambodian government has put priorities on reforming many sectors, education is one among those.[21] A significant measure to ensure the prioritization of technology adoption in Camdodia's educational system[22] is to equip the learners and teachers with sufficient skills to use digital tools effectively. For learners to acquire skills, teachers are also required to share the same knowledge and skills in those domains.[23] School is the best starting point.

The rapid pace of technological advancement poses a challenge. New tools and applications constantly emerge, requiring teachers to continuously upskill and adapt their teaching methods. Cambodia has made strides in revamping teacher education programs. Teacher training is one of the key priorities with policy in place with support from many international stakeholders.[24] Aligned to enhance teachers' capabilities to the fullest extent, MoEYS introduced comprehensive „Teacher Professional Standards" in 2010.[25] These standards, applicable to educators in licensed public and private educational institutions, encompass four vital components: (i) Professional Knowledge, (ii) Professional Practices, (iii) Professional Study, and (iv) Professional Ethics.[26] In contrast to teacher education being a key priority, most teachers have claimed to have never been trained to use technology in the classroom during their pre-service training.[27] In recognition of the significance of digital skills in ensuring high-quality education, MoEYS revised the standards in 2016. The standards facilitate the enhancement of teachers' skills, incorporating information communication technology (ICT) to meet the challenges of the digital era. The revised standards place an emphasis on teachers' professional practices – teaching methodology and teachers' self-learning.[28] To exercise the standards, teacher training centres (TTCs) are established to recruit and skill trainees with teaching as a career prospect.[29] Given the shortage of teachers in the education system, the bar of the requirement of the newly recruited teachers is lowered. The Teacher Policy Action Plan sets a requirement for new teachers to have passed grade 12 while the rural primary teachers only have to have passed grade 9 and obtain an extra two-year of teacher training (9+2). However, to teach at an upper-secondary school, a bachelor's degree is needed and the one-year National Institute of Education (NIE)'s post-graduate program (BA + 1).[30] Meanwhile, the completion of grade 12 plus 2 years at a teacher training centre (12+2) is required for lower secondary teachers and urban primary teachers.[31] Upper secondary teachers have to undergo a bachelor's degree and one more year of the National Institute of Education (NIE)'s post-graduate program (BA + 1).[32] However, the core competence offered in the mentioned teacher education programs is not available.

TPACK: A model for digital pedagogy

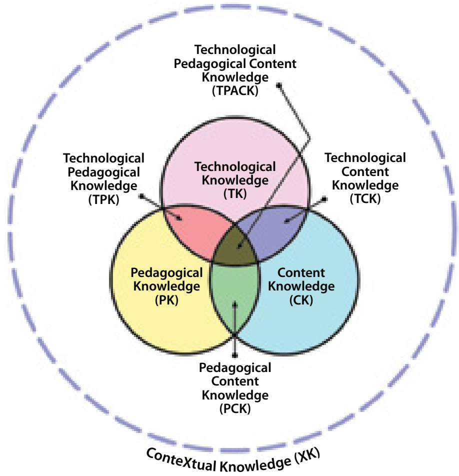
When discussing the digitalisation of education, the first notion that comes to mind is the use of technology equipment in teaching and learning. Digital tools and resources are recognised to play a crucial role in enhancing the quality and engagement of teaching material design, supporting teaching and learning processes, fostering networking and collaboration, and cultivating digital competencies, skills, and literacy.[33] Thus, integrating digital pedagogy into the preparation of pre-service teachers is crucial, not only to enhance the readiness of teachers to transfer knowledge for a digital generation but also to fulfil the demand for labour in the 21st-century economy.[34] These apprehensions, often rooted in low digital literacy, highlight the need for teachers to build confidence in utilizing technology effectively.

Before unravelling the case of digital pedagogy, an understanding of pedagogy must be established. Pedagogy refers to the bridge between learning methods and contexts in which learning takes place. The relationship also embeds a teacher's beliefs about how learning happens.[35] To further augment Dewey's view on learning through the repetition of hands-on experiences and adequate choices and Bloom's emphasis on actionable and measurable learning objectives, Nebrul looks at digital pedagogy through the lens of 4Ei, considering instructional methods, learning strategies, and learning goals, in the context of India.[36] The 4Ei model magnifies the utilisation of technology in teaching and learning as a value added to the learning goals through 4 components: 1. Explore; 2. Engage; 3. Enhancement; and 4. Extension and integration of digital pedagogy tools.[37] Howell (2012) advocates that technology influences the way teachers are perceived - teachers are expected to obtain digital proficiency and the capability of using techniques to meet the demands of learners. These demands stem from the novelty of a digitally enhanced environment exposed to the young generation, known as ***Digital Natives***.[38] This phenomenon is labelled ***Digital Expectant***.[39] To tend to this expectation, teachers turn to a new pedagogical approach that equips them with the capability to utilise digital tools and resources known as

Digital Pedagogy[40]. While technological support is often emphasized, it is also important to note that digital pedagogy involves a mixture of components such as content based in digital form, digital educational environment, technological methods and tools, and digital competencies of teachers.[41] In this paper, digital pedagogy is referred to the practice of purposive integration of digital tools to improve learning experiences through informed decision-making on instructional strategies, instructional delivery, content design, and teacher-learner relationship perpetuation.

Incorporating digital resources effectively in education requires teachers to possess some essential skills presented in the **TPACK** model. The TPACK model stands for 'Technology, Pedagogy And Content Knowledge' and was first conceptualised in 2016 by Punya Mishra and Matthew J. Koehler in "Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge.[42] The model is selected as the theoretical basis of this paper because it is one of the most prominent models of teacher competence for the effective use of digital technologies in teaching. The TPACK model introduced by Mishra and Koehler in 2009 emphasises how pedagogies, content, and technologies interact with each other to help teachers deliver lessons in a more meaningful manner.

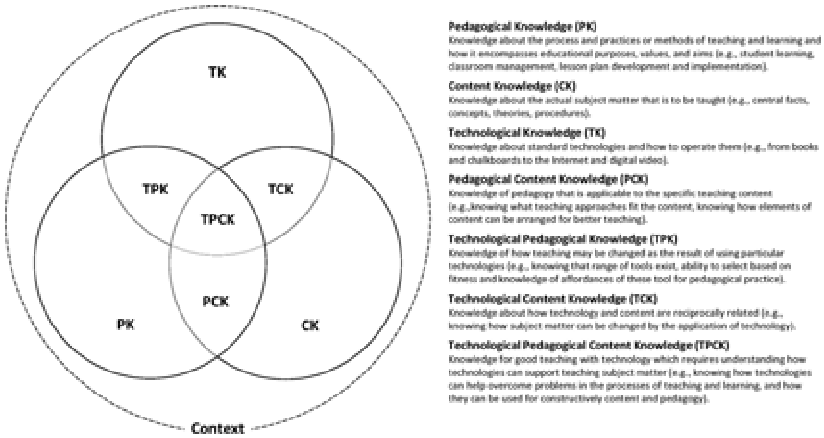
Figure 1: TPACK framework and components



Source: Mishra and Koehler 2009

TPACK is a model that describes the different types of knowledge that teachers possess to succeed in their teaching delivery. TPACK was, in fact, built on Lee S. Shulman's work in 1986 "Those Who Understand: Knowledge Growth in Teaching"[43] in which he challenges the traditional idea that teachers should integrate the content knowledge and pedagogical knowledge to effectively teach their subject matter rather than possess each knowledge separately. TPACK sheds light on the importance of Technological Knowledge of teachers in addition to their Content (CK) and Pedagogical Knowledge (PK). It has become a prominent framework among educational practitioners and researchers as a suggested approach to be applied in classroom teaching. There have been numerous studies on the production of TPACK. Suprapto et al. (2020) analysed the trend of research on TPACK between 2015 and 2019 and found that although the studies related to TPACK keep rising notably, the USA dominated the most research study followed by Australia and Turkey.[44]

Figure 2: TPACK framework and components explained



Source: Schmid, Brianza, and Petko 2020

TPACK consists of three foundation dimensions (CK, PK, TK), which are then transformed logically into seven factors through the interaction and overlapping process between the three dimensions.[45] TPACK also refers to teachers' ability to combine technology, pedagogy, and content and use them to appropriately plan lessons, develop classroom strategies, and deliver instructional methods through the means of technology.[46] TPACK is often considered to be an essential framework during this digital age. It is essential to include digital pedagogy in teacher training so that teachers can integrate the use of technology into their teaching, taking into account their pedagogy and content knowledge. [47] As is observed, the model is a widely used self-report instrument to assess teachers' competencies in adopting online learning or their use of technology in classrooms.

Method

This paper examined how pre-service and in-service teachers perceive and apply technological, pedagogical, and content knowledge (TPACK) through their teacher education and teaching practices. Data was collected by means of a questionnaire containing 56 items. Adapted from TPACK and TPACK.xs developed and validated by Schmid and her team, the survey on preservice teachers' self-assessment of the seven knowledge domains within the TPACK framework as a means of data collection. These knowledge domains include technology knowledge (TK), content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and finally, technological pedagogical content knowledge (TPACK). The questions in this study were used as participants' self-assessment of their TPACK perception. The majority of these were Likert items based on a scale from "strongly agree" to "strongly disagree." Other questions ask for factual information, highest education, age group, gender, and teaching experience. The questionnaire was contextualised to relate to Cambodian teachers in services or in pre-services. Google Forms was the medium of survey dissemination. Google Forms displayed both English and Khmer to minimise misunderstanding.

Table 1: Measures of TPACK

Source: Authors

Measures	Item Description
Pedagogical Knowledge	I can adapt my teaching based upon what students currently understand or do not understand.[48]
	I can adapt my teaching style to different learners.[49]
	I can use a wide range of teaching approaches in a classroom setting.[50]
	I can assess student learning in multiple ways.[51]
	I know how to assess student performance in a classroom.[52]
	I am familiar with common student understandings and misconceptions.[53]
	I know how to organize and maintain classroom management.[54]
Content Knowledge	I have sufficient knowledge about my teaching subject.[55]
	I can use a subject-specific way of thinking in my teaching subject.[56]
	I know the basic theories and concepts of my teaching subject.[57]
	I know the important theories and the historical events in the field of my teaching subject.[58]
	I have various ways and strategies of developing my understanding of my teaching subject.[59]
	I am familiar with recent research in my teaching subject.[60]
Technological Knowledge	I keep up with important new technologies.[61]
	I frequently play around with the technology.[62]
	I know about a lot of different technologies.[63]
	I have the technical skills I need to use technology.[64]
	I know how to solve my own technical problems.[65]
	I can learn technology easily.[66]
	I have had sufficient opportunities to work with different technologies.[67]

Measures	Item Description
Pedagogical and Content Knowledge	I know how to select effective teaching approaches to guide student thinking and learning in my teaching subject.[68]
	I know how to develop appropriate tasks to promote students complex thinking of my teaching subject.[69]
	I know how to develop exercises with which students can enhance their knowledge of my teaching subject.[70]
	I know how to evaluate students' performance in my teaching subject.[71]
	I can explain the essential content of my teaching subject in ways that students can understand.[72]
	In my teaching subject, I can identify from student errors where there are difficulties in understanding and give appropriate feedback.[73]
Technological and Pedagogical Knowledge	I can choose technologies that enhance the teaching approaches for a lesson.[74]
	I can choose technologies that enhance students' learning for a lesson.[75]
	I can adapt the use of the technologies that I am learning about to different teaching activities.[76]
	I am thinking critically about how to use technology in my classroom.[77]
	My teacher education program has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom.[78]
Technological and Content Knowledge	I know how technological developments have influenced the field of my subject.[79]
	I can explain which technologies have been used in research in my field and my teaching subject.[80]
	I know which new technologies are currently being developed in the field of my subject.[81]
	I know how to use technologies to receive and challenge the new knowledge of the field of my teaching subject.[82]
	I know technologies which help me understand my subject.[83]
	I know how to use essential technologies which are specific to my subject.[84]

Measures	Item Description
Technological, Pedagogical, and Content Knowledge	I can use strategies that combine content, technologies, and teaching approaches in my classroom.[85]
	I can choose technologies that enhance the content for a lesson.[86]
	I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn.[87]
	I can teach lessons that appropriately combine my teaching subject, technologies, and teaching approaches.[88]
	I can support others to coordinate the use of content, technologies, and teaching approaches at my school or community.[89]

Additionally, the survey was disseminated through various teacher networks, heads of departments and schools, and direct connections with teachers. Telegram was put into use to communicate with the respondents. Respondents were recruited from various private and public schools through a simple random sampling. The respondents were provided with detailed information about the study and asked to complete the questionnaire online voluntarily and allowed to skip any question that they were not comfortable answering. After having completed the questionnaire, the respondents were asked to refer the questionnaire to other pre-service and in-service teachers.

Data analysis

Our initial data is the responses collected from Google form as the form of Excel. Then, the collected data was transferred to Statistical Package for the Social Sciences (SPSS) software for statistical analysis purposes. An initial assessment of response validity was undertaken. This paper analyses teachers' perceptions of their teaching knowledge and practice in classrooms through the lens of TPACK. A descriptive analysis was employed to understand teachers' confidence in integrating TPACK and compare the level of TPACK employment between the three identified groups of teachers. Our analysis follows the calculation of Mean *(M)* and Standard Deviation *(SD)* in each of the domains in TPACK. Demographical factors such as areas of Cambodia from which they are, age group, gender, the highest education, teaching experience, school in which they teach, teacher education program which they are undertaking or have undertaken, and level they teach are also considered. Following the descriptive analyses, cross-tabulations were conducted to identify patterns of TPACK employment.

Results and discussion

Demographics

65 in-service and pre-service teachers participated in our survey. However, only 63 were validated through SPSS, which consists of 30 respondents who are female (44.4%) and 35 male (55.6%). Our survey

shows that the majority of respondents are young adults, with over half of respondents (56.5%) in the 20-29 age group. The 30-39 age group is the second largest group, accounting for 16.1% while the 40+ age group is the smallest group accounting for 27.4% of respondents. Approximately half of the respondents are from various provinces across Cambodia. Nevertheless, there are more female teachers (22) located in Phnom Penh than male teachers (13) while the same number of male teachers as females (22) are in the provinces. 47.6% of respondents possess at least a Bachelor's degree, 38.1% have already obtained a Master's Degree, 9.5% with a Doctoral Degree, and only 4.8% have completed high school. In regards to teacher education programs, the majority of respondents (53.2%) report having obtained a 'Bachelor's degree', while 25.5% of others with a 'Bachelor's Degree +1' and 4.3% with a 'Bachelor's Degree +2'. Only 12.8% have obtained an 'Associate Degree' and 4.3% responded 'Other'. Among them, around half of the respondents (48.8%) received their initial teacher training at a Higher Education Institution (HEI) while the other 32.6% attended the National Institute of Education (NIE) and 16.3% are from the Regional Teacher Training Centres (RTTC).

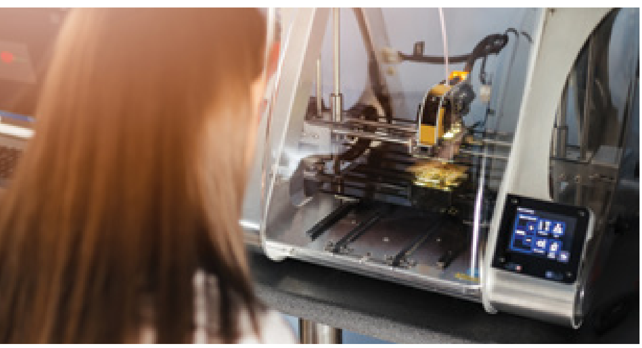
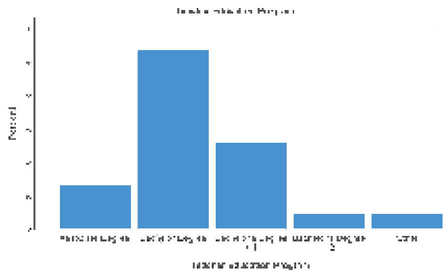
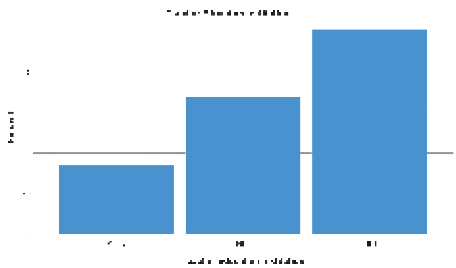


Figure 3: Teacher education program undertaken by the respondents



Source: Authors

Figure 4: Teacher education institutions and respondents



Source: Authors

In terms of teaching experiences, most of our respondents reported having extensive teaching experience of 5 years (46.8%) and above (21%). The remaining respondents report having four years (4.8%), three years (8.1%), two years (11.3%), or one year (8.1%) of experience. Respondents represented a variety of teaching institutions, including private schools (54%), public schools (36.5%), and NGOs (9.5%). Respondents also taught at a variety of levels ranging from Primary school (17.5%), Secondary school (42.9%), Higher education (34.9%), as well as Non-formal & TVET (1.6%).

Descriptive Analysis

Table 2: Descriptive statistics of the study variables and the TPACK domains total score (N=63)

Source: Authors

Domain	Mean	SD
Pedagogical Knowledge (PK)	4.09	0.68
Content Knowledge (CK)	3.98	0.74
Technological Knowledge (TK)	3.88	0.71
Pedagogical and Content Knowledge (PCK)	4.00	0.60
Technological and Pedagogical Knowledge (TPK)	3.95	0.71
Technological and Content Knowledge (TCK)	3.88	0.74
Technological, Pedagogical, and Content Knowledge (TPCK)	3.93	0.71

The general descriptive statistics of all variables are presented in Table 1. As depicted, teachers rated their competence highly in all domains with the lowest means score at only 3.86. This suggests that teachers are confident in their ability to integrate pedagogical, content, and technology knowledge into their teaching, considering the majority of the respondents (76.2%) had completed their teacher education. However, the top two domains with the highest means are consistently pedagogical domains (PK = 4.09; PCK = 4.01) whereas any technological constructs (e.i. TK, TPK, TCK, and TPCK), thus intersecting with pedagogical constructs (e.i. TPK and TPCK) are consistently rated low (TK = 3.87; TPK = 3.9; TCK = 3.86; TPCK = 3.92). Generally, the technological domains are lower than their counterparts. This is a reflection of teachers' lower confidence in integrating technology into their classrooms and the lack of preparedness for the use of technology in their teaching practices[90].

Table 3: Descriptive data (N=63)

Source: Authors

Domain	Variable	Item	Mean	SD
PK	PK1	I can adapt my teaching based upon what students currently understand or do not understand.	4.21	0.70
	PK2	I can adapt my teaching style to different learners.	4.02	0.81
	PK3	I can use a wide range of teaching approaches in a classroom setting.	4.11	0.68
	PK4	I can assess student learning in multiple ways.	4.11	0.68
	PK5	I know how to assess student performance in a classroom.	4.11	0.54
	PK6	I am familiar with common student understandings and misconceptions.	4.11	0.57
	PK7	I know how to organize and maintain classroom management.	3.97	0.80
	Total		**4.09**	**0.684**
CK	CK1	I have sufficient knowledge about my teaching subject.	4.17	0.69
	CK2	I can use a subject-specific way of thinking in my teaching subject.	3.94	0.69
	CK3	I know the basic theories and concepts of my teaching subject.	4.05	0.68
	CK4	I know the important theories and the historical events in the field of my teaching subject.	3.81	0.69
	CK5	I have various ways and strategies of developing my understanding of my teaching subject.	4.05	0.83
	CK6	I am familiar with recent research in my teaching subject.	3.78	0.94
	Total		**3.98**	**0.74**
TK	TK1	I keep up with important new technologies.	4.11	0.63
	TK2	I frequently play around with the technology.	4.02	0.78
	TK3	I know about a lot of different technologies.	3.89	0.60
	TK4	I have the technical skills I need to use technology.	3.94	0.67
	TK5	I know how to solve my own technical problems occurred while using technology.	3.61	0.78
	TK6	I can learn technology easily.	3.79	0.83

Domain	Variable	Item	Mean	SD
TK	TK7	I have had sufficient opportunities to work with different technologies.	3.79	0.72
	Total		**3.88**	**0.71**
PCK	PCK1	I know how to select effective teaching approaches to guide student thinking and learning in my teaching subject.	3.92	0.63
	PCK2	I know how to develop appropriate tasks to promote students complex thinking of my teaching subject.	3.94	0.62
	PCK3	I know how to develop exercises with which students can enhance their knowledge of my teaching subject.	3.98	0.61
	PCK4	I know how to evaluate students' performance in my teaching subject.	4.08	0.55
	PCK5	I can explain essential content of my teaching subject in ways that students can understand.	4.11	0.48
	PCK6	In my teaching subject, I can identify from student errors where there are difficulties in understanding and give appropriate feedback.	4.06	0.60
	Total		**4.00**	**0.60**
TPK	TPK1	I can choose technologies that enhance the teaching approaches for a lesson.	3.94	0.67
	TPK2	I can choose technologies that enhance students' learning for a lesson.	3.98	0.66
	TPK3	I can adapt the use of the technologies that I am learning about to different teaching activities.	3.94	0.80
	TPK4	I am thinking critically about how to use technology in my classroom.	3.89	0.81
	TPK5	My teacher education program has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom.	3.84	0.87
	Total		**3.95**	**0.71**
TCK	TCK1	I know how technological developments have influenced the field of my subject.	4.11	0.70
	TCK2	I can explain which technologies have been used in research in my field and my teaching subject.	3.73	0.81
	TCK3	I know which new technologies are currently being developed in the field of my subject.	3.56	0.88
	TCK4	I know how to use technologies to receive and challenge the new knowledge of the field of my teaching subject.	3.83	0.69

Domain	Variable	Item	Mean	SD
TCK	TCK5	I know technologies which help me understand my subject.	3.98	0.64
	TCK6	I know how to use essential technologies which are specific to my subject.	3.98	0.75
	Total		**3.88**	**0.74**
TPCK	TPCK1	I can use strategies that combine content, technologies, and teaching approaches in my classroom.	3.87	0.79
	TPCK2	I can choose technologies that enhance the content for a lesson.	3.97	0.65
	TPCK3	I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn.	4.02	0.64
	TPCK4	I can teach lessons that appropriately combine my teaching subject, technologies, and teaching approaches.	4.00	0.60
	TPCK5	I can support others to coordinate the use of content, technologies, and teaching approaches at my school or community.	3.78	0.79
	Total		**3.93**	**0.71**

To measure the confidence of teachers in using digital technologies in their classrooms, the descriptive results incorporated in Table 3 reveal that the means of most of the items of PK domain are around 4 (above the mean value of the scale), the means of most of the items of CK, PCK, and TPCK are more dispersed (between 3 and 4), the means of the majority of the items of TK and TCK are low (as the overall means are the two lowest of all domains) and the means of all the items of TPCK are below 3.95. In line with a study conducted by Castéra and team in 2019, this result clearly underlines that along with the need for teachers' ability to use technology (TK), they also need to be able to use this technology competence to aid their content and/or pedagogical knowledge (TCK, TPK, and TPCK). [91]

Within the **PK** domain, the item "I can adapt my teaching based upon what students currently understand or do not understand," scores the mean of 4.21 while the item "I know how to organize and maintain classroom management," obtains the lowest mean at 3.97. Within the **CK** domain, the item "I have sufficient knowledge about my teaching subject," scores the highest mean at 4.17 while the item "I am familiar with recent research in my teaching subject," with the lowest mean of 3.78. Within the **TK** domain, the item "I keep up with important new technologies," has the highest mean of 4.11 while the item "I know how to solve my own technical problems occurred while using technology," has the lowest mean of 3.61. Within the **PCK** domain, the item "I can explain essential content of my teaching subject in ways that students can understand," has the highest mean at 4.11 while the item "I know how to select effective teaching approaches to guide student thinking and learning in my teaching subject," has the lowest mean at 3.92. Within the **TPK** domain, the item "I can choose technologies that enhance students' learning for a lesson," scores the highest mean at only 3.98 while the item "My teacher education program has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom," relatively scores the lowest at 3.84. Within the **TCK** domain, the item, "I know how technological developments have influenced the field of my subject" has the highest mean of 4.11 while the item "I know which new technologies are currently being developed in the field of my subject," distinctly has the lowest mean of 3.56. Finally, within the **TPCK** domain, the item "I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn," obtains the highest mean at 4.02 while the item "I can support others to coordinate the use of content, technologies, and teaching approaches at my school or community" obtains the lowest mean at 3.78.

Teaching Experiences

Table 4: Compared means against years of teaching experience

Source: Authors

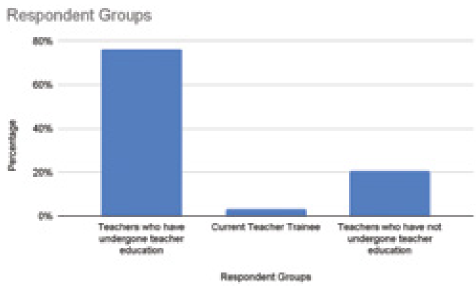
Domain	Variable	Teaching Experience											
		1 Year		2 Years		3 Years		4 Years		5 Years		> 5 Years	
		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
PK	PK1	4.00	0.71	4.00	0.00	3.80	0.45	4.00	0.00	4.62	0.65	4.18	0.82
	PK2	4.20	0.45	3.86	0.38	3.80	0.45	4.33	0.58	4.38	0.77	3.83	0.97
	PK3	4.00	0.71	4.00	0.00	4.20	0.45	4.00	0.00	4.31	0.75	4.03	0.78
	PK4	3.80	0.84	3.71	0.49	4.00	0.00	4.00	0.00	4.54	0.66	4.07	0.72
	PK5	3.80	0.45	3.86	0.38	4.20	0.45	3.67	0.58	4.15	0.69	4.24	0.51
	PK6	3.40	0.55	4.00	0.00	4.40	0.55	4.00	0.00	4.08	0.64	4.24	0.58
	PK7	3.60	0.55	4.00	0.00	4.20	0.45	4.33	1.16	4.08	0.86	3.86	0.92
Total		3.83	0.61	3.92	0.18	4.09	0.40	4.05	0.33	4.31	0.72	4.06	0.75
CK	CK1	4.00	0.00	4.00	0.58	4.00	0.00	3.67	0.58	4.46	0.66	4.21	0.82
	CK2	3.60	0.55	3.57	0.79	4.00	0.00	3.33	0.58	4.23	0.44	4.00	0.80
	CK3	4.20	0.45	3.71	0.49	4.00	0.00	3.33	0.58	4.31	0.63	4.07	0.80
	CK4	3.60	0.55	3.29	0.76	3.80	0.45	2.67	0.58	3.77	0.73	4.10	0.56
	CK5	4.00	0.71	4.00	0.58	4.00	0.71	3.67	0.58	4.23	0.44	4.00	0.96
	CK6	4.00	0.71	3.86	0.69	3.40	1.34	2.67	0.58	3.85	0.99	3.83	0.93

Domain	Variable	Teaching Experience											
		1 Year		2 Years		3 Years		4 Years		5 Years		> 5 Years	
		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Total		**3.89**	**0.51**	**3.76**	**0.58**	**3.90**	**0.41**	**3.34**	**0.54**	**4.17**	**0.66**	**4.04**	**0.80**
TK	TK1	4.40	0.55	4.00	0.00	4.00	0.00	4.33	0.58	4.38	0.51	3.93	0.75
	TK2	4.20	0.45	4.14	0.38	3.80	0.45	4.00	1.00	4.33	0.89	3.83	0.97
	TK3	4.00	0.00	3.71	0.76	4.00	0.00	3.67	0.58	4.17	0.72	3.79	0.62
	TK4	3.60	0.89	3.71	0.76	4.00	0.00	3.67	0.58	4.23	0.60	3.93	0.70
	TK5	3.40	0.55	3.57	0.54	3.60	0.55	3.00	1.00	4.00	0.74	3.55	0.87
	TK6	3.40	0.89	4.00	0.00	3.60	1.14	3.67	0.58	4.31	0.63	3.62	0.90
	TK7	3.80	0.45	4.00	0.00	4.00	0.00	3.67	0.58	4.08	0.95	3.62	0.78
Total		**3.83**	**0.54**	**3.88**	**0.35**	**3.86**	**0.31**	**3.72**	**0.70**	**4.21**	**0.72**	**3.75**	**0.80**
PCK	PCK1	3.80	0.45	4.00	0.58	4.00	0.00	3.67	0.58	4.00	0.71	3.90	0.72
	PCK2	4.00	0.00	3.86	0.38	4.00	0.00	4.00	0.00	4.08	0.76	3.86	0.74
	PCK3	3.80	0.45	4.14	0.38	4.00	0.00	3.67	0.58	4.15	0.80	3.93	0.65
	PCK4	3.80	0.45	4.00	0.00	4.00	0.00	4.00	0.00	4.23	0.73	4.10	0.62
	PCK5	3.60	0.55	4.00	0.00	4.00	0.00	4.00	0.00	4.38	0.51	4.14	0.52
	PCK6	3.80	0.45	4.00	0.82	4.00	0.00	4.00	0.00	4.25	0.62	4.07	0.65
Total		**3.80**	**0.41**	**3.98**	**0.36**	**3.98**	**0.04**	**3.87**	**0.26**	**4.19**	**0.69**	**3.96**	**0.67**
TPK	TPK1	4.20	0.45	3.86	0.38	4.00	0.00	3.67	0.58	4.15	0.80	3.83	0.76
	TPK2	4.20	0.45	3.86	0.38	4.00	0.00	3.67	0.58	4.15	0.69	3.90	0.77
	TPK3	4.00	0.00	3.86	0.38	4.20	0.45	3.67	0.58	4.23	0.73	3.76	0.99
	TPK4	4.00	0.00	4.00	0.82	3.80	0.45	3.67	0.58	4.00	1.00	3.79	0.86
	TPK5	4.00	0.00	3.86	1.35	3.40	0.55	3.33	0.58	4.31	0.63	3.76	0.91
Total		**4.00**	**0.25**	**3.92**	**0.64**	**3.91**	**0.21**	**3.70**	**0.45**	**4.18**	**0.74**	**3.87**	**0.80**
TCK	TCK1	4.00	0.71	4.00	0.58	3.80	0.45	3.67	0.58	4.54	0.66	4.03	0.73
	TCK2	4.00	0.71	3.43	0.98	3.20	1.10	3.00	1.00	4.00	0.82	3.76	0.64
	TCK3	3.40	0.55	2.86	1.07	3.00	1.00	3.00	1.00	3.77	0.93	3.76	0.69
	TCK4	3.80	0.45	3.71	0.76	3.60	0.55	3.67	0.58	4.08	0.86	3.76	0.64
	TCK5	4.00	0.00	4.14	0.38	3.80	0.45	3.33	0.58	4.38	0.65	3.83	0.66
	TCK6	4.00	0.00	3.71	1.25	4.00	0.71	3.67	0.58	4.23	0.73	3.93	0.70
Total		**3.89**	**0.38**	**3.68**	**0.81**	**3.62**	**0.64**	**3.43**	**0.68**	**4.17**	**0.77**	**3.85**	**0.69**
TPCK	TPCK1	3.80	0.45	3.86	0.38	3.60	0.55	3.00	1.00	4.23	0.60	3.83	0.93
	TPCK2	4.00	0.00	4.00	0.58	3.80	0.45	3.33	0.58	4.23	0.60	3.90	0.72
	TPCK3	4.20	0.45	4.14	0.69	3.80	0.45	3.67	0.58	4.23	0.60	3.90	0.67
	TPCK4	3.80	0.45	4.00	0.00	4.00	0.00	3.67	0.58	4.23	0.60	3.93	0.70
	TPCK5	3.60	0.89	3.71	0.95	3.60	0.55	3.67	0.58	3.92	0.95	3.76	0.74
Total		**3.90**	**0.37**	**3.87**	**0.67**	**3.77**	**0.48**	**3.49**	**0.65**	**4.18**	**0.69**	**3.87**	**0.74**
Total		**3.88**	**0.44**	**3.86**	**0.51**	**3.87**	**0.35**	**3.66**	**0.52**	**4.20**	**0.71**	**3.92**	**0.75**

Comparing teaching experience among the three identified groups, teachers, who possess 5 years of teaching experience score the highest in almost every sub-scale in the seven domains. The average of the means is above 4, which indicates a high level of competence for the teachers in that group. There are only a few sub-scales with the means less than 4; particularly the lowest means is 3.77. The second-highest range of means score is witnessed in the group of teachers with more than 5 years of teaching experience. They rate the highest scores in the domain of 'Pedagogy knowledge (PK)', 'Content Knowledge (CK)', and 'Pedagogical Content Knowledge (PCK)'.

Compared means of the three groups

Figure 5: Three groups of respondents



Source: Author

In this paper, we will predominantly examine teachers' knowledge of the three identified groups: 1. Teachers who have undergone teacher education (48); 2. Current teacher trainee (2); and 3. Teachers who have not undergone teacher education (13).

Table 5: Compared means across three groups

Source: Authors

Domain	Variable	Teachers who have undergone teacher education		Current Teacher Trainee		Teachers who have not undergone teacher education	
		Mean	SD	Mean	SD	Mean	SD
PK	PK1	4.27	0.57	4.00	0.00	4.00	1.13
	PK2	4.13	0.61	4.00	0.00	3.62	1.33
	PK3	4.17	0.56	3.50	0.71	4.00	1.00
	PK4	4.09	0.65	3.50	0.71	4.31	0.75
	PK5	4.17	0.60	3.50	0.71	4.00	0.00
	PK6	4.13	0.61	3.50	0.71	4.15	0.38
	PK7	4.02	0.76	3.50	0.71	3.85	0.99
Total		**4.14**	**0.62**	**3.64**	**0.51**	**3.99**	**0.80**

Domain	Variable	Teachers who have undergone teacher education		Current Teacher Trainee		Teachers who have not undergone teacher education	
		Mean	SD	Mean	SD	Mean	SD
CK	CK1	4.31	0.55	4.00	0.00	3.69	0.95
	CK2	4.00	0.62	4.00	0.00	3.69	0.95
	CK3	4.08	0.61	4.00	0.00	3.92	0.95
	CK4	3.79	0.77	4.00	0.00	3.85	0.38
	CK5	4.02	0.79	4.00	0.00	4.15	1.07
	CK6	3.67	0.88	4.00	0.00	4.15	1.14
Total		**4.00**	**0.69**	**3.95**	**0.07**	**3.92**	**0.89**
TK	TK1	4.10	0.66	4.50	0.71	4.08	0.49
	TK2	4.00	0.83	4.50	0.71	4.00	0.58
	TK3	3.96	0.55	4.00	0.00	3.62	0.77
	TK4	3.98	0.64	3.50	2.12	3.85	0.56
	TK5	3.64	0.82	3.50	0.71	3.54	0.66
	TK6	3.83	0.86	3.00	1.41	3.77	0.60
	TK7	3.85	0.74	4.00	0.00	3.54	0.66
Total		**3.91**	**0.73**	**3.86**	**0.81**	**3.77**	**0.62**
PCK	PCK1	3.96	0.65	4.00	0.00	3.77	0.60
	PCK2	3.96	0.68	3.50	0.71	3.92	0.28
	PCK3	4.04	0.62	3.50	0.71	3.85	0.56
	PCK4	4.15	0.58	3.50	0.71	3.92	0.28
	PCK5	4.15	0.46	3.50	0.71	4.08	0.49
	PCK6	4.09	0.58	3.50	0.71	4.08	0.64
Total		**4.04**	**0.62**	**3.62**	**0.62**	**3.91**	**0.49**
TPK	TPK1	3.98	0.73	4.00	0.00	3.77	0.44
	TPK2	4.00	0.72	4.00	0.00	3.92	0.49
	TPK3	3.96	0.77	4.00	0.00	3.85	0.99
	TPK4	4.04	0.68	4.00	0.00	3.31	1.03
	TPK5	3.85	0.95	4.00	0.00	3.77	0.60
Total		**3.99**	**0.72**	**3.87**	**0.19**	**3.80**	**0.67**

Domain	Variable	Teachers who have undergone teacher education		Current Teacher Trainee		Teachers who have not undergone teacher education	
		Mean	SD	Mean	SD	Mean	SD
TCK	TCK1	4.21	0.54	4.00	0.00	3.77	1.09
	TCK2	3.71	0.82	3.50	0.71	3.85	0.80
	TCK3	3.56	0.85	4.00	0.00	3.46	1.05
	TCK4	3.83	0.69	4.00	0.00	3.77	0.73
	TCK5	3.98	0.67	4.00	0.00	4.00	0.58
	TCK6	4.04	0.68	4.00	0.00	3.77	1.01
Total		**3.90**	**0.71**	**3.91**	**0.13**	**3.77**	**0.85**
TPCK	TPCK1	3.92	0.77	4.00	0.00	3.69	0.95
	TPCK2	3.94	0.70	4.00	0.00	4.08	0.49
	TPCK3	4.02	0.67	4.00	0.00	4.00	0.58
	TPCK4	3.98	0.67	4.00	0.00	4.08	0.28
	TPCK5	3.85	0.80	3.50	0.71	3.54	0.78
Total		**3.95**	**0.71**	**3.92**	**0.12**	**3.85**	**0.70**
Total		**3.99**	**0.69**	**3.82**	**0.35**	**3.86**	**0.72**

A disaggregated analysis of the three groups' scores revealed that teachers who had undergone teacher education programs consistently outperformed the other two groups in almost all domains, with the most outstanding score seen in Pedagogical Knowledge. Significantly, the mean scores for all of the sub-scales in the domain of pedagogical knowledge are above 4, which indicates a high level of confidence of teachers in the area. While the pedagogical domain, PK (4.09) and PCK (4.01), rank the highest, the sub-scales of the technological domains score the lowest at 3.86 for TCK and 3.87 for TK.

Teaching Schools Factors

Table 6: Compared means across teaching schools

Source: Authors

Domain	Variable	School					
		Public School		Private School		NGO	
		M	SD	M	SD	M	SD
PK	PK1	4.35	0.49	4.21	0.65	3.67	1.37
	PK2	4.13	0.34	4.06	0.85	3.33	1.51
	PK3	4.22	0.60	4.18	0.52	3.33	1.21
	PK4	4.17	0.72	4.12	0.70	3.83	0.41
	PK5	4.26	0.62	4.06	0.49	3.83	0.41
	PK6	4.26	0.54	4.09	0.57	3.67	0.52
	PK7	3.96	0.77	4.12	0.59	3.17	1.47
Total		**4.19**	**0.58**	**4.12**	**0.62**	**3.55**	**0.98**
CK	CK1	4.22	0.60	4.26	0.57	3.50	1.23
	CK2	4.00	0.67	3.97	0.58	3.50	1.23
	CK3	4.22	0.52	4.09	0.57	3.17	1.17
	CK4	4.09	0.60	3.65	0.73	3.67	0.52
	CK5	4.17	0.72	4.12	0.73	3.17	1.33
	CK6	3.91	0.85	3.88	0.84	2.67	1.21
Total		**4.11**	**0.65**	**4.01**	**0.66**	**3.32**	**1.09**
TK	TK1	3.96	0.64	4.26	0.51	3.83	0.98
	TK2	3.59	0.91	4.26	0.62	4.17	0.41
	TK3	3.82	0.50	3.91	0.71	4.00	0.00
	TK4	3.87	0.69	4.06	0.55	3.50	1.05
	TK5	3.55	0.80	3.71	0.76	3.33	0.82
	TK6	3.52	0.90	4.09	0.62	3.17	0.98
	TK7	3.65	0.83	3.88	0.69	3.83	0.41
Total		**3.71**	**0.75**	**4.02**	**0.64**	**3.69**	**0.66**
PCK	PCK1	3.91	0.79	3.94	0.55	3.83	0.41
	PCK2	4.00	0.74	3.94	0.55	3.67	0.52
	PCK3	3.96	0.71	4.03	0.58	3.83	0.41
	PCK4	4.26	0.54	4.03	0.52	3.67	0.52
	PCK5	4.17	0.39	4.15	0.50	3.67	0.52
	PCK6	4.14	0.56	4.12	0.59	3.50	0.55
Total		**4.02**	**0.64**	**4.03**	**0.56**	**3.69**	**0.51**

Domain	Variable	School					
		Public School		Private School		NGO	
		M	SD	M	SD	M	SD
TPK	TPK1	3.74	0.75	4.09	0.62	3.83	0.41
	TPK2	3.83	0.78	4.12	0.59	3.83	0.41
	TPK3	3.87	0.82	4.15	0.56	3.00	1.27
	TPK4	3.96	0.64	3.97	0.80	3.17	1.17
	TPK5	3.78	0.85	3.97	0.87	3.33	0.82
Total		**3.91**	**0.72**	**4.06**	**0.66**	**3.48**	**0.73**
TCK	TCK1	4.26	0.54	4.12	0.64	3.50	1.23
	TCK2	3.87	0.76	3.74	0.83	3.17	0.75
	TCK3	3.70	0.82	3.41	0.96	3.83	0.41
	TCK4	3.78	0.74	3.88	0.69	3.67	0.52
	TCK5	3.91	0.73	4.12	0.54	3.50	0.55
	TCK6	3.91	0.79	4.06	0.78	3.83	0.41
Total		**3.91**	**0.73**	**3.91**	**0.73**	**3.57**	**0.66**
TPCK	TPCK1	3.91	0.79	4.03	0.58	2.83	1.17
	TPCK2	3.83	0.78	4.12	0.54	3.67	0.52
	TPCK3	3.91	0.67	4.15	0.61	3.67	0.52
	TPCK4	3.91	0.67	4.15	0.44	3.50	0.84
	TPCK5	3.74	0.86	3.82	0.80	3.67	0.52
Total		**3.87**	**0.76**	**4.03**	**0.64**	**3.53**	**0.66**
TOTAL		**3.96**	**0.69**	**4.03**	**0.64**	**3.55**	**0.76**

Table 6 shows the mean (M) and standard deviation (SD) for different variables across various domains (PK, CK, TK, PCK, TPK, TCK, TPCK) and different types of schools (Public Schools, Private Schools, and NGOs and TVET Institutes). Across all domains, Private Schools (M=4.03) generally have higher mean scores compared to Public Schools (M=4.03) and NGOs (M=3.55). Generally, scores in Private Schools have lower variability (SD=0.64) compared to Public Schools (SD=0.69) and NGOs (SD=0.76). Public Schools and NGOs show higher variability, suggesting a dispersed level of confidence with teaching with technology within these school types. Teachers from Private Schools manifest a consistent level of confidence with TPACK employment, based on the scores. The TK and TPK domains consistently exhibit mean scores below 4.00.

Implications

The implications arise from the literature review and the results of the questionnaire survey. The following implications are:

- *Needs Assessment:* The TTCs can conduct a needs assessment to understand the digital proficiency levels of pre-service teachers and to possibly identify other areas where training is required. The finding of the study suggests a gap in applying technology not just in the classroom, but also considering pedagogy and content. The TTCs could adapt TPACK or 4Ei or other frameworks to design needs assessment tools when recruiting teacher trainees.

- *Curriculum Integration:* The TTCs should integrate and emphasise the use of digital pedagogy into the existing curriculum, ensuring it aligns with the national educational standards and goals. The content should also be tailored to focus on using digital pedagogy as a pedagogical tool such as interactive teaching methods, multimedia, digital platforms, content formats, and online assessment techniques.

- *Mentoring and Peer-Learning:* The TTCs can foster collaborative learning among pre-service teachers by fostering a community, where pre-service and experienced teachers can share resources, experiences, and best practices. The findings of the study suggest that teachers with 5 years or more of experience in teaching perceived their approaches to digital pedagogy very effectively. Best practices should be exchanged among teachers' educators, experienced teachers, and pre-service teachers to demonstrate effective digital teaching methods through model lessons, showcasing how to engage students using online resources and interactive activities. A mentoring program provided by the New Generation Pedagogical Research Center under Kampuchea Action to Promote Education Teacher (KAPE) mentoring also provides opportunities for pre-service teachers to undergo a 1-year training program to enhance their critical thinking, creative thinking, ICT, and many areas to apply their skills to their teaching practice.[92] Through this program, teachers are provided with an opportunity to enhance their skills through the mentoring program through which they are matched with another teacher to apply those skills as well, under their guidance. This will build teacher trainee's confidence in classroom management and their pedagogical skills. Practicum materials are widely appraised by many teachers' trainers and mentors in a similar report.[93]

- *Making teaching an attractive profession:* The policymakers and relevant organisations can take more measures to make teaching an attractive profession to attract more competent teacher trainees hoping to nurture more talents in the education sector. In order to achieve that, the standard-setting bodies can develop a professional development roadmap to build teaching capacity and promote the culture of lifelong learning. This could include providing teachers with access to high-quality professional development opportunities and developing and disseminating resources and guidelines. Establishing a teacher professional platform and learning hub for all teaching professionals to discuss and share best learning/teaching practices. The TTCs can conduct digital literacy workshops to familiarise pre-service teachers with basic digital tools, software, and online resources relevant to their subjects. Further studies on pre-service teacher's confidence and motivation. The survey showed lower scores of pre-service teachers' confidence in classroom management. The research could inform the development of targeted professional development programs and support mechanisms to help pre-service teachers develop their expertise in classroom management. In addition to teacher's skill competence, studies on teachers' motivation and career prospects are needed to understand the factors that contribute to the higher quality of teaching.

Limitations

This study was conducted as a self-report study based on teachers' voluntary responses to the online survey. Therefore, it contains three limitations: sampling bias, sampling size, and diversity of respondents that need to be taken into consideration in future studies on this topic. Firstly, there was a significant disparity number between each group of respondents: Current teacher trainees (2), teachers who have undergone teacher education (48), and teachers who have not undergone teacher education (13). Secondly, with the study using a self-assessment instrument, teachers rate each scale based on individual teachers' perceptions which might be an overestimation or underestimation of the respondents' competence. Lastly, the data collected was limited in terms of the number of responses and diversity of the respondents. Therefore, for validity purposes, future studies should address these limitations by using a larger and more diverse sample of teachers, including those from different age groups, experience levels, teaching subjects, and backgrounds. This study only represents the opinion of a certain number of teachers.

Conclusion

This paper seeks to understand the importance of digital pedagogy among pre-service and in-service teachers in Cambodia by assessing the teacher's perception using a theoretical basis - TPACK - Technological, Pedagogical, Content knowledge before providing offering recommendations using data provided by the survey. By grounding the study in TPACK, the findings provide not only valuable insights into how teachers perceive and engage with digital pedagogy but also to establish the foundation of the TPACK framework in Cambodia's initial teacher education. This study details the significance of digital pedagogy as well as underscores the collaborative efforts required from stakeholders in leveraging digital technology usage in Cambodia's educational landscape. It also suggests training institutions, policymakers, and standard-setting bodies to factor in developing and deploying all necessary technological infrastructures and capacity-building activities to maximize the effectiveness of digital pedagogy. Emphasising the importance of digital literacy, hands-on training, and the creative use of technology, these recommendations aim to empower future educators with the necessary skills and confidence to navigate the digital learning environment effectively.

1 *Theodore Gerad Lynn et al., "The Digital Economy and Digital Business", Digital Towns: Accelerating and Measuring the Digital Transformation of Rural Societies and Economies (February 2022): 69–89, https://doi.org/10.1007/978-3-030-91247-5_4.*

2 *Rumana Bukht and Richard Heeks, "Defining, Conceptualising and Measuring the Digital Economy", SSRN Scholarly Paper (August 2017): 68, https://doi.org/10.2139/ssrn.3431732.*

3 *Lisa J. Servon and Robert Kaestner, "Consumer Financial Literacy and the Impact of Online Banking on the Financial Behavior of Lower-Income Bank Customers", Journal of Consumer Affairs 42, no. 2 (2008): 271–305, https://doi.org/10.1111/j.1745-6606.2008.00108.x;*

Sumit Kumar Maji and Arindam Laha, "The Role of Digital Skill in Mitigating Digital Divide: Evidences from Asia-Pacific Region," Rajagiri Management Journal 16, no. 3 (January 1, 2021): 260–271, https://doi.org/10.1108/RAMJ-05-2021-0035; 42, no. 2 (2008): 271–305, https://doi.org/10.1111/j.1745-6606.2008.00108.x;.

4 *World Bank, "World Development Report 2016: Digital Dividends", (Washington, DC: World Bank, 2016): 14, https://documents1.worldbank.org/curated/en/896971468194972881/pdf/102725-PUB-Replacement-PUBLIC.pdf.*

5 *Royal Government of Cambodia, "Cambodia Digital Economy and Society Policy Framework 2021-2035", 2021, 23, https://mef.gov.kh/download-counter?post=7116#:~:text=%22Cambodia%20Digital%20Economy%20and%20Society,promote%20new%20economic%20growth%20and.*

6 *Mahatma Gandhi Institute of Education for Peace and Sustainable Development (MGIEP), "Digital Pedagogies for Building Peaceful & Sustainable Societies", Blue Dot, vol. 8 (2018), 82, https://unesdoc.unesco.org/ark:/48223/pf0000265758.*

7 *Ibid., 47.*

8 *Roy Saurabh, Nandini C. Singh, and Anantha K. Duraiappah, "The Alternate Education for the 21st Century", in IEEE 18th International Conference on Cognitive Informatics & Cognitive Computing (ICCI*CC) (July 2019): 266, https://doi.org/10.1109/ICCICC46617.2019.9146061.*

9 *Ibid.*

10 *Mahatma Gandhi Institute of Education for Peace and Sustainable Development, Digital Pedagogies for Building Peaceful & Sustainable Societies, 29.*

11 *Francesca Caena, "Initial teacher education in Europe: an overview of policy issues", European Commission, ET2020 Working Group of Schools Policy (February 2014), http://ec.europa.eu/education/policy/strategic--framework/expert--groups/documents/initial--teacher--education_en.pdf.*

12 *Ministry of Education, Youth, and Sport, Cambodia, "Teacher Policy", 2013, 3.*

13 *Claude Müller and Thoralf Mildenberger, "Facilitating Flexible Learning by Replacing Classroom Time with an Online Learning Environment: A Systematic Review of Blended Learning in Higher Education", Educational Research Review 34 (November 2021): 12, https://doi.org/10.1016/j.edurev.2021.100394.*

14 *MoEYS and ESWG, "Cambodia COVID-19 Joint Education Needs Assessment" (March 2021): 18, https://www.unicef.org/cambodia/media/4296/file/Cambodia%20COVID-19%20Joint%20Education%20Needs%20Assessment.*

15 *Phal Chea, Chankoulika Bo, and Ryuto Minami, "Cambodian Secondary School Teachers' Readiness for Online Teaching During the Covid-19 Pandemic", Cambodia Development Resource Institute (May 2022): 1, https://cdri.org.kh/publication/cambodian-secondary-school-teachers-readiness-for-online-teaching-during-the-covid-19-pandemic.*

16 *Ministry of Industry, Science, Technology & Innovation, "EduTech Roadmap" (June 2022): 7, https://www.misti.gov.kh/public/file/202206301656579124.pdf.*

17 *Chea Phal, Bo Chankoulika and Minami Ryuto, "Cambodian Secondary School Teachers' Readiness for Online Teaching During the Covid-19 Pandemic", 24.*

18 *MoEYS and ESWG, "Cambodia COVID-19 Joint Education Needs Assessment", 13.*

19 *World Bank, "Cambodia Is Now Living with COVID-19: World Bank" (December 2021): 51, https://www.worldbank.org/en/news/press-release/2021/12/08/cambodia-country-economic-update-december-2021-cambodia-is-now-living-with-covid-19.*

20 *Royal Government of Cambodia "National Strategic Development Plan 2019 - 2023" (2019), 168, https://data.opendevelopmentcambodia.net/dataset/national-strategic-development-plan-nsdp-2019-2023/resource/bb62a621-8616-4728-842f-33ce7e199ef3/view/ba44ac64-d773-4af4-bac7-cfc0df740d95.*

21 *Stephen J. Duggan, "Education, Teacher Training and Prospects for Economic Recovery in Cambodia," Comparative Education 32, no. 3 (November 1996): 361, https://doi.org/10.1080/03050069628768.*

22 *Ministry of Industry, Science, Technology & Innovation, "EduTech Roadmap", 7.*

23 *Novi Ratna Dewi et al., "Technological, Pedagogical, Content Knowledge (TPACK) Research Trends: A Systematic Literature Review of Publications Between 2010 -2020", Turkish Journal of Science Education (December, 2021): 590, https://doi.org/10.36681/tused.2021.92.*

24 *Stephen J. Duggan, "Education, Teacher Training and Prospects for Economic Recovery in Cambodia", Comparative Education (November 1996): 362.*

25 *Ministry of Education, Youth, and Sport , "Continuous Professional Development Framework for Teachers and School Directors" (August 2019): 39, http://cpd.moeys.gov.kh/documents/1635838377_cpd_framework_en.pdf.*

26 *Ibid.*

27 *Chea Phal, Bo Chankoulika, and Minami Ryuto, "Cambodian Secondary School Teachers' Readiness for Online Teaching During the Covid-19 Pandemic", 12.*

28 *Post Staff, "MoEYS Implements 'Teacher Professional Standards' to Boost Quality of Education", Phnom Penh Post, July 6, 2021, https://www.phnompenhpost.com/national/moeys-implements-teacher-professional-standards-boost-quality-education#:~:text=The%20Teacher%20Professional%20Standards%20are,and%20(iv)%20Professional%20Ethics.&text=Teachers%20have%20to%20know%20clearly,capacity%2C%20academic%20background%20and%20attitude.*

29 *Ministry of Education, Youth, and Sport, "Education Strategic Plan 2019-2023" (June 2019): 10, http://cpd.moeys.gov.kh/documents/1635838377_cpd_framework_en.pdf.*

30 Ministry of Education, Youth, and Sport, "Teacher Policy Action Plan 2015-2020", 2019, 6.

31 Ibid.

32 Ibid.

33 Senad Bećirović, "Digital Pedagogy: The Use of Digital Technologies in Contemporary Education", SpringerBriefs in Education (Singapore: Springer Nature Singapore, 2023), 3, https://doi.org/10.1007/978-981-99-0444-0.

34 Charles Kivunja, "Embedding Digital Pedagogy in Pre-Service Higher Education to Better Prepare Teachers for the Digital Generation", International Journal of Higher Education 2, no. 4 (October 28, 2013): 140, https://doi.org/10.5430/ijhe.v2n4p131.

35 K. G. Srinivasa, "Learning, Teaching, and Assessment Methods for Contemporary Learners: Pedagogy for the Digital Generation", Springer Texts in Education (Singapore: Springer, 2022): 2.

36 R. S. S. Nehru, "4Ei-Digital Pedagogy Model for Teacher Education", Digital Education Pedagogy (Apple Academic Press, October 2020), 238.

37 Ibid., 239.

38 Jennifer Howell, Teaching with ICT: Digital Pedagogies for Collaboration and Creativity (Melbourne, AUSTRALIA: Oxford University Press, 2013), 6, http://ebookcentral.proquest.com/lib/qut/detail.action?docID=1986003.

39 Ibid., 5.

40 Bećirović, "Digital Pedagogy", 1.

41 V. I. Toktarova and D. A. Semenova, "Digital Pedagogy: Analysis, Requirements and Experience of Implementation", Journal of Physics: Conference Series 1691, no. 1 (November 2020): 3, https://doi.org/10.1088/1742-6596/1691/1/012112.

42 Matthew Koehler and Punya Mishra, "What Is Technological Pedagogical Content Knowledge (TPACK)?", Contemporary Issues in Technology and Teacher Education 9, no. 1 (March 2009): 60–70.

43 Lee S. Shulman, "Those Who Understand: Knowledge Growth in Teaching", Educational Researcher 15, no. 2 (February 1986): 4–14, https://doi.org/10.3102/0013189X015002004.

44 Nadi Suprapto et al., "Research Trend on TPACK through Bibliometric Analysis (2015-2019)", International Journal of Evaluation and Research in Education (IJERE) 10, no. 4 (December 1, 2021): 1378, https://doi.org/10.11591/ijere.v10i4.22062.

45 Jérémy Castéra et al., "Self-Reported TPACK of Teacher Educators across Six Countries in Asia and Europe", Education and Information Technologies 25, no. 4 (July 2020): 3003–3019, 2, https://doi.org/10.1007/s10639-020-10106-6.

46 Prasart Nuangchalerm, "TPACK in ASEAN Perspectives: Case Study on Thai Pre-Service Teacher", International Journal of Evaluation and Research in Education 9, no. 4 (December 2020): 994.

47 Charles Kivunja, "Embedding Digital Pedagogy in Pre-Service Higher Education to Better Prepare Teachers for the Digital Generation", 2013.

48 Denise A. Schmidt et al., "Technological Pedagogical Content Knowledge (TPACK): The Development and Validation of an Assessment Instrument for Preservice Teachers", Journal of Research on Technology in Education 42, no. 2 (December 2009): 133, https://doi.org/10.1080/15391523.2009.10782544.

49 Ibid.

50 Ibid.

51 Ibid.

52 Ibid.

53 Ibid.

54 Ibid.

55 Mirjam Schmid, Eliana Brianza, and Dominik Petko, "Developing a Short Assessment Instrument for Technological Pedagogical Content Knowledge (TPACK.Xs) and Comparing the Factor Structure of an Integrative and a Transformative Model", Computers & Education (November 2020): 4, https://doi.org/10.1016/j.compedu.2020.103967.

56 Ibid.

57 Ibid.

58 Ibid.

59 Ibid.

60 Ibid.

61 Ibid.

62 Ibid.

63 Ibid.

64 Ibid.

65 Ibid.

66 Ibid.

67 Ibid.

68 Ibid.

69 Ibid.

70 Ibid.

71 Ibid.

72 Ibid.

73 Ibid.

74 Schmidt et al., "Developing a Short Assessment Instrument for Technological Pedagogical Content Knowledge (TPACK.Xs) and Comparing the Factor Structure of an Integrative and a Transformative Model", 134.

75 Ibid.

76 Ibid.

77 Ibid.

78 Ibid.

79 Schmidt et al., "Developing a Short Assessment Instrument for Technological Pedagogical Content Knowledge (TPACK.Xs) and Comparing the Factor Structure of an Integrative and a Transformative Model", 4.

80 Ibid.

81 Ibid.

82 Ibid.

83 Ibid.

84 Ibid.

85 Schmidt et al., "Technological Pedagogical Content Knowledge (TPACK.Xs) and Comparing the Factor Structure of an Integrative and a Transformative Model," 135.

86 Ibid.

87 Ibid.

88 Ibid.

89 Ibid.

90 Prasart Nuangchalerm, "TPACK in ASEAN Perspectives Case study on Thai pre-service teacher", International Journal of Evaluation and Research in Education (IJERE) 9, no. 4 (December 2020): 997, DOI: 10.11591/ijere.v9i4.20700.

91 Castéra et al., "Self-Reported TPACK of Teacher Educators across Six Countries in Asia and Europe," 3015.

92 "Evaluating the Effectiveness of Teacher Mentoring," 31, accessed November 3, 2023, https://policypulse.org/wp-content/uploads/2021/11/Evaluation-KAPE-research-report.pdf.

93 Fiona Ell et al., "Mapping a Complex System: What Influences Teacher Learning during Initial Teacher Education?," Asia-Pacific Journal of Teacher Education 45, no. 4 (August 8, 2017): 337, https://doi.org/10.1080/1359866X.2017.1309640.

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Future of STEM Education in Cambodia: Leveraging Generative Artificial Intelligence for Enhanced Learning and Innovation

Sodanid PHUONG

Executive Summary

This paper explores the potential of Generative Artificial Intelligence (Generative AI) to revolutionize Science, Technology, Engineering, and Mathematics (STEM) education in Cambodia and create new opportunities for enhanced learning and innovation. As the advancements in digital technology continue to shape the way we live, learn, and work, it is essential that education systems adapt to meet the demand for digital skills and harvest the fruits of new possibilities of teaching and learning, especially in STEM fields. Generative AI can enhance the learning and teaching experiences in STEM education and contribute to the development and innovation of the education field in Cambodia. It can foster creativity and innovation by generating new ideas, solutions, and designs in an impressively short amount of time. By leveraging generative AI, students in Cambodia can have access to more efficient and personalized learning experiences that promote critical thinking and problem-solving skills. Moreover, the integration of generative AI in STEM education can encourage students' interest and consequently inspire them to pursue careers in science, technology, engineering, and mathematics. This research paper also acknowledges the concerns and limitations surrounding the implementation of generative AI in STEM education in Cambodia. While concerns about generative AI in education are visible, such as potential overreliance on technology or ethical considerations, it is essential to view generative AI as a transformative resource that can be utilized for the benefit of education.

1. Introduction

Over the last few decades, the world has witnessed an exponential growth of digital technology, leading to transformative changes in both industries and societies. From big data to artificial intelligence, these digital and technological advancements have become a significant aspect of the way we live, learn, and work. While navigating the challenges and opportunities presented by this digital revolution, there has been a growing recognition of the importance of STEM education. Undoubtedly, STEM education plays a critical role in promoting long-term and sustainable growth, increasingly getting prioritized in the national development agendas of many countries worldwide, and Cambodia is no exception.

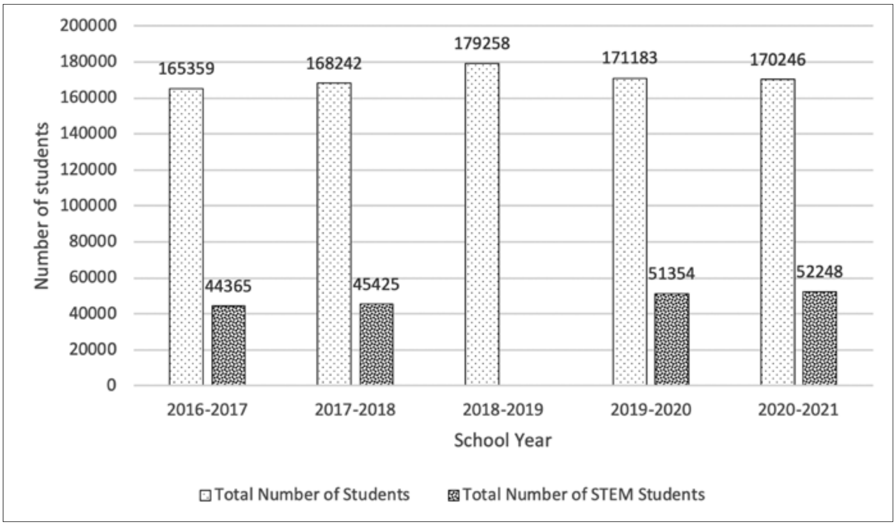
As Cambodia undergoes a shift in its economic development trends during the regional and global industrial revolution 4.0, there is an increasing emphasis on the need for graduates in STEM fields to meet the demands of a rapidly evolving job market. However, despite this recognition, Cambodia faces significant challenges in enhancing the enrollment and participation of students in STEM majors at the higher education level.[1] These challenges hinder the country's ability to produce a skilled workforce that can drive innovation, economic growth, and stay competitive. According to the National Policy on STEM Education developed by the Ministry of Education, Youth and Sports (MoEYS), it is crucial for the country's inhabitants to explore and develop 21st-century skills in STEM fields to drive the Cambodian economy forward.[2] To address these challenges and survive in the ever-changing global economy, Cambodia needs to strategically leverage emerging technologies.

This paper aims to promote the understanding of one promising technology that holds the potential to revolutionize STEM education in Cambodia which is Generative AI, followed by several key objectives, namely assessing the current state of STEM education in Cambodia; examining the potential benefits coupled with best practices and case uses of Generative AI in STEM education; identifying the opportunities and challenges associated with implementing Generative AI in Cambodian schools; and finally providing recommendations on the effective integration of Generative AI in Cambodian STEM education.

2. STEM education in Cambodia

Historically, the influence of the French educational system in Cambodia has resulted in a lack of emphasis on STEM education. Cambodia's educational system has focused more on administrative skills and other non-STEM subjects. As a result, there is a shortage of students pursuing science and engineering-related fields at the higher education level. According to the report of education congress published by the Ministry of Education, Youth and Sports (MoEYS) in 2022, interestingly, 69% of students pursuing a Bachelor's Degree in Cambodia majored in social studies which include business, law, foreign languages, and tourism among others. In comparison, only 31% majored in STEM.[3] This highlights an issue of imbalance in the tertiary education sector among social science and STEM fields. It is evident the current state of STEM education in Cambodia is insufficient to meet the demands of a rapidly evolving global economy and technological landscape.

Figure 1: **Number of students pursuing Bachelor's Degree**



Source: Author's compilation of data from MoEYS' annual reports of education congress[4]

Note: Data of the total number of STEM students pursuing Bachelor's Degree for the school year 2018-2019 is not available.

The current state of STEM education in Cambodia exhibits a combination of progress and challenges. While there have been commendable efforts to enhance the overall quality of education, particularly within the realm of STEM disciplines, disparities persist. In Cambodia, there have been significant endeavors aimed at promoting inclusive access to education and improving educational infrastructure nationwide. However, despite these efforts, discrepancies remain when it comes to accessing high-quality STEM education. Rural and remote regions face particular challenges such as limited resources and inadequate availability of specialized facilities dedicated specifically to STEM studies.

In addition, many Cambodian youth do not value STEM subjects, believing they are too difficult to study or not relevant. A study conducted by Sovansophal and Shimizu[5] sought to examine the factors that impact students' decision to pursue science and engineering majors in higher education in Cambodia, and to extract insights into both internal and external influences on students' choice of major. The findings revealed that individual academic performance in science-related subjects as well as personal preferences play a significant role in determining their preference for these fields, either positively or negatively. Moreover, family background factors such as parents' occupations and educators' influence were found to have a substantial impact on students' preferences. On the other hand, gender disparities and financial constraints emerged as barriers preventing students from selecting science and engineering majors. Additionally, Eng and Szmodis[6] contributed valuable insights to this matter by focusing specifically on gender discrepancies within STEM achievement levels. The discovery is rather unexpected. Their study reveals that there exists a minimal distinction between the academic performance of males and females in STEM subjects at the secondary school level, which goes against prevailing research[7] suggesting that males generally outperform their female counterparts and exhibit greater interest and participation rates in STEM-related areas.

Another prominent issue is the shortage of qualified instructors in STEM disciplines and a lack of quality STEM curricula.[8] This poses a significant challenge to providing students with comprehensive and well-rounded education in STEM. In addition to this, another challenge lies within the implementation of practical materials. The availability and effective utilization of hands-on resources are essential for fostering experiential learning among students. However, there have been obstacles encountered when it comes to effectively incorporating such materials into classroom settings. Moreover, it is worth noting that the concept of STEM itself is relatively new to Cambodia compared to other countries. Consequently, there exists a general lack of understanding about the importance and relevance of STEM education amongst various stakeholders including educators, parents, as well as learners themselves.[9]

Despite these challenges, certain steps toward improvement have been visible. For instance, the „Rectangular Strategy Phase IV"[10], a national strategic development plan, was formulated by the Royal Government of Cambodia, with building and developing human resources, which include fostering STEM education, as one of the central goals. Additionally, the Cambodian government established its first STEM education model in 2014, the New Generation Schools (NGS). These schools aim to improve the quality of public schools, particularly in STEM education, and have been set up in ten locations across five provinces/cities throughout the kingdom.[11] New pedagogical approaches are becoming more common in STEM schools, encouraging students' active participation and fostering critical and creative thinking skills. The government is also pushing for more transparent governance within schools and an improvement of teacher capabilities.[12]

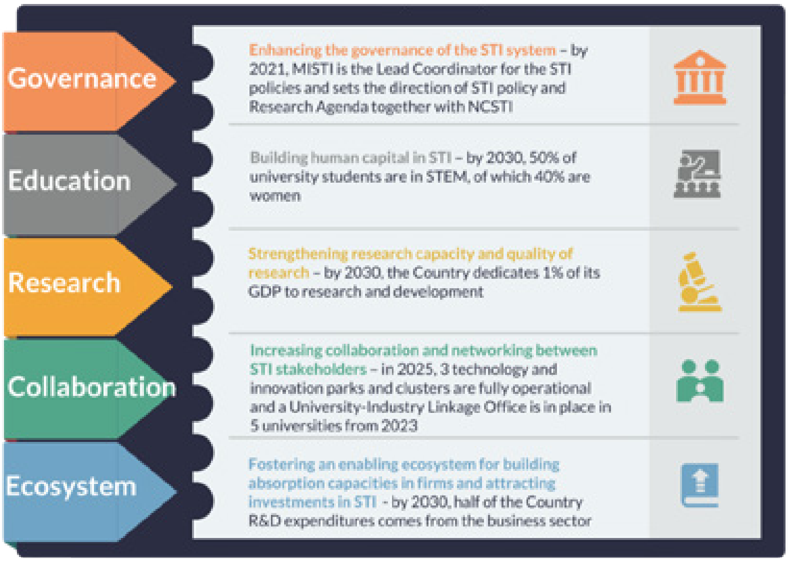
In 2010, MoEYS introduced the tracking/streaming policy with the intention of guiding students into STEM fields. By grade 11, students are required to choose either a science track or social track, with science and mathematics becoming elective courses for the former.[13] On top of that, MoEYS launched the Education Strategic Plan (ESP) 2014-2018[14] which identified STEM education as a major priority. The objective is to close the gap with more developed neighbors, highlighting the country's current lag in these fields, while the main focus is to expand access to higher education to meet Cambodia's economic, social, and market needs in areas of intellectual development and human resource provision. Key efforts to achieve these objectives include ensuring access to science labs for all schools, implementing computer training, preparation for future participation in international assessments like TIMSS (Trends in International Mathematics and

Science Study) and PISA (Programme for International Student Assessment) as well as the development of higher education programs with a strategic focus on STEM fields.[15]

To foster STEM interest, STEM Education Organization for Cambodia (STEMEOC), a locally registered NGO in Phnom Penh, hosted its 17th Annual STEM Festival in February 2023, drawing more than 13,000 attendees, including 48 visiting schools and 4,000 public school students.[16] This high turnout indicates changing attitudes of stakeholders towards STEM education. Another extracurricular activity that aims to foster young students' curiosity in STEM subjects, the STEM Bus Cambodia[17], was also initiated. The STEM Bus Cambodia brings science experiments to students and raises public awareness of STEM. Furthermore, the British Embassy in Phnom Penh initiated several programs to mitigate challenges faced in STEM education, including STEM activity days, road illustrations in provinces, teacher training sessions, and the publication of the STEM Career Guide Book (SCGB), a booklet listing the top 20 STEM careers.[18] The Cambodian government has also made plans to increase the number of sectors that require skilled labor. This means that young learners and professionals are being encouraged to make career choices that will help secure their future.[19]

In 2019, Cambodia put out the National Policy on Science, Technology & Innovation (STI) 2020-2030[20], and a year later, in March 2020, the Ministry of Industry, Science, Technology & Innovation (MISTI) was established along with the National Council of Science, Technology & Innovation (NCSTI). Shortly after, the Cambodia's STI Roadmap 2030[21] was developed under the purpose of guiding government ministries and relevant stakeholders on actions to take in the short and medium terms until 2030 and as well as for the implementation of the National STI Policy. The roadmap highlights five main pillars (see figure 2) for the effective implementation of the National STI Policy, namely governance, human capital, research and development (R&D), collaboration, and ecosystem. The second pillar, human capital, is intended to produce human resources of both quality and quantity in STEM for prioritized sectors for socio-economic development in Cambodia. This particular pillar sets the ambitious goal that by 2030, 50% of university students should be enrolled in STEM subjects, of which 40% shall be women.[22]

Figure 2: Five Pillars of the Cambodia's STI Roadmap 2030



Source: MISTI[23]

4. Generative Artificial Intelligence (Generative AI)

The field of Generative AI has reaped considerable attention and recognition in recent times. This branch of artificial intelligence focuses on training models using specific datasets, subsequently utilizing these trained models to generate completely novel data.[24] In contrast to traditional tasks like classification and regression, generative AI showcases the ability to autonomously generate novel data across different modalities including images, music, and text. The central element of generative AI is the generative model that captures the underlying distribution of data and generates new instances that closely resemble the original data.[25] Generative AI operates by training models utilizing extensive datasets to uncover patterns, structures, and attributes. As a result of this training process, these models are capable of generating novel content that closely resembles the input data. The advent of Generative AI has introduced numerous opportunities and applications across various domains such as education, communication, creativity, and problem-solving. The potential uses for generative AI span an array of fields including image generation, natural language processing, and music composition.[26] Generative AI has gained significant popularity with the emergence of online platforms that enable users to produce content in various artistic styles. For instance, individuals can now generate their own portraits resembling the iconic style of Van Gogh or create videos featuring a person's appearance while speaking provided words. The advancement and widespread utilization of Generative AI have led to its establishment as a popular research domain within the broader field of artificial intelligence. This is primarily due to its extensive array of practical implementations and potential applications across various sectors.[27]

Table 5: Top Generative AI Tools

Top Generative AI Tools			
Visual Generative AI	***Image Generators***	***DALL-E***	Produces, modifies, or alters visuals and grants the exclusive permissions to use the produced material for commercial purposes.
		Midjourney	Generates digital artwork from text descriptions.
		starryai	Allows users to create artwork with various choices in terms of style, aspect ratio, and more. Additionally, it provides complete ownership of the produced content.
		Craiyon	Converts text into images, but is not designed for creating larger-sized images.
		NightCafe	Generates art with various styles and options for resolution.
	Video Generators	***Synthesia***	Allows for converting text into videos, provides over 70 avatars, and offers its services in more than 65 different languages.
		Pictory	Generates video based on articles or scripts and creates video highlight reels.
		Deepbrain AI	Generate videos using basic texts.
		Veed.io	Creating videos, modifying them by including captions, eliminating unwanted background sounds, and adjusting the size of the visuals
	Design Generators	***Khroma***	Enables the development of a customized algorithm to generate authentic color schemes
		Uizard	Creates visual layouts for mobile apps, websites, or landing pages using initial drawings as a starting point.
		Colormind	Enables the generation of color schemes by extracting colors from various sources such as movie scenes, artwork, or other images whenever necessary.
		Fronty AI	Enables the creation of mobile-friendly websites that are optimized for search engine optimization requirements.

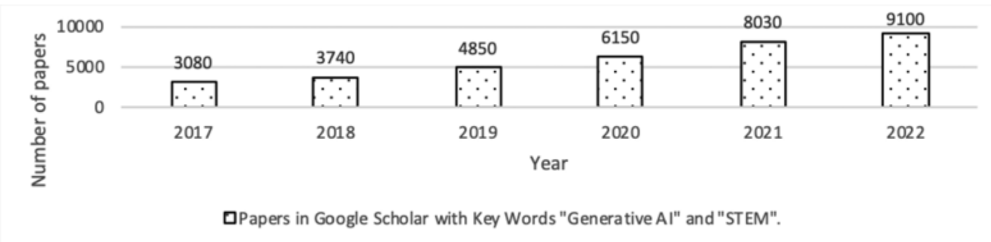
Top Generative AI Tools			
Audio Generative AI	Voice Generators	*Replica*	Allows for converting text into spoken words and provides artificially generated voices.
		Speechify	Enables the conversion of text into speech while providing the ability to customize the speed of reading and delivering natural-sounding voices generated by AI.
		Murf	Provides voiceover services for various contexts, allows the inclusion of punctuation, and grants commercial usage rights to the content.
		Play.ht	Offers AI-generated voices that are valuable for a wide range of commercial applications, providing services in over 140 languages and facilitating the conversion of text to speech.
		Lovo.ai	Allows for the conversion of text to speech, resulting in the creation of AI-generated voiceover that is not only convincing but also evokes genuine emotions.
	Music Generators	*AIVA*	Produces original music according to your chosen genre and grants you full ownership of the created content.
		Amper AI	Creates copyright-free music according to the desired musical style, duration, instruments, and grants an everlasting license.
		Jukebox	Generates genuine music by utilizing AI-generated lyrics and offers users a variety of genres to choose from.
Text Generators		*ChatGPT*	Generates texts and code based on short input prompts.
		Jasper AI	Specializes in creating SEO content.
		Copy.ai	Allows users to create various types of content, such as blog posts, social media updates, and emails. It offers a wide range of language options for content creation and can be used by multiple users simultaneously.
Code Generators		*PyCharm*	Offers users the ability to autocomplete code, identify and highlight errors, and facilitate automated refactoring.
		Kite	Offers users the ability to autocomplete multi-line code and supports over 16 languages.

Source: Author's compilation

5. Generative AI in STEM education

Bridging AI and education, there is an emerging interdisciplinary field known as Artificial Intelligence in Education (AIEd) that harnesses the potential of AI technologies to enhance and transform the design, process, and assessment of teaching and learning.[28] Within that field exists a sub-branch called, AI in STEM education (AI-STEM), focusing on the design and implementation of AI to support STEM education.[29] Further down this sub-branch, Generative AI has received increased interests year after year for its significant applications in enhancing STEM education. As evidence, figure 3 illustrates an increasing trend of numbers of papers in Google Scholar with key words "Generative AI" and "STEM".

Figure 3: Papers in Google Scholar with key words "Generative AI" and "STEM"



Source: Author's compilation of data from Google Scholar

5.1. Potential and case uses

Personalized learning experience

The utilization of generative AI presents an opportunity to enrich the field of STEM education by offering personalized and adaptive learning experiences to students. Through its revolutionizing capacity to adapt to individual student's learning preferences and pace, generative AI has the potential to address challenges in STEM education within Cambodia, specifically brought by the high student-to-teacher ratio, including limited hands-on learning opportunity and individualized attention, difficulty in addressing diverse learning needs, and limited feedback and assessment opportunity among others. By analyzing students' data such as their learning styles, strengths, and weaknesses in different subjects, generative AI can generate customized learning content and explanation that align with each student's unique needs. This way, each student has their own virtual teacher that is always there, providing guidance and support to ensure their academic success. On top of personalized learning materials, generative AI can also help adjust content of teachers' assessment tools based on each student's unique capacity. This ensures that our education

system will no longer judge a fish by its ability to climb a tree and therefore everyone will be empowered to believe that we all are a genius. An illustration of this potential of generative AI is CanopyLAB[30], a Danish educational technology (EdTech) company that provides a platform for online learning and education. CanopyLAB specializes in offering digital solutions for educational institutions, organizations, and businesses to create and deliver online courses, training programs, and educational content. CanopyLAB's AI engine, AICATO, demonstrates the transformative potential of generative AI in STEM education:
It streamlines content creation through automated content generation using Natural Language Processing (NLP), reducing the time and effort required for educators to develop course materials. AICATO also offers personalized learning by analyzing individual learners' historical data, preferences, and areas of struggle, suggesting supplementary resources or activities tailored to each learner's unique needs. Another innovative use case is Khan Academy's latest addition, Khanmigo[31]. Khanmigo is a platform that leverages the capabilities of Generative AI to offer customized and individualized learning experiences. The platform provides personalized guidance and mentorship utilizing AI-powered historical figures as well as literary characters. For instance, students who struggle with complex physics concepts can seek support from an AI-powered simulation of Isaac Newton. This does not just enable students to learn in a more effective and innovative way, but also entertains and encourages their interest in learning, especially in complex subjects like STEM. Moreover, it equips students with critical thinking abilities and analytical skills through engaging in debates and collaborative exercises. Teachers also benefit from this platform as it offers tools for developing lesson plans and generating progress reports on student performance.[32]

Interactively immersive educational experience

Another potential of generative AI in STEM education is its ability to provide an interactively immersive educational experience to learners. This represents a quantum leap from traditional classroom methods and opens up new horizons for students. Through this technology, students are no longer passive recipients of information but active participants in their learning journeys. The integration of generative AI introduces a dynamic and interactive dimension to education, one that transcends the limitations of physical classrooms. By means of virtual simulations and experiments facilitated by generative AI systems, learners are able to explore complex scientific concepts more effectively and practically. These simulations replicate real-world scenarios and scientific experiments with remarkable precision. They enable learners to delve into intricate scientific concepts, theories, and phenomena in a risk-free and controlled virtual environment. This immersive experience fosters a deeper understanding of complex subjects by allowing students to witness firsthand the cause-and-effect relationships that underpin scientific principles. This potential of generative AI promotes engagement, curiosity, and creativity among students, ultimately preparing them to tackle real-world STEM challenges with confidence. Furthermore, it aligns with the evolving demands of the job market, where problem-solving, adaptability, and technological proficiency are highly valued. A use case of this revolutionary feature of generative AI can be illustrated by the work of PraxiLabs.[33] PraxiLabs is an educational platform that offers students access to 3D interactive and immersive online science laboratories. Its primary objective is to enhance students' practical skills while also enabling them to do experiments that are typically hindered by financial, time, or safety constraints. To achieve this, PraxiLabs provides four main features to its users including immersive 3D interaction, instantly unlimited access, practice-centric simulations, and all-time virtual labs partner (named Oxi). Noteworthy results of this transformative platform are visible in experimental research conducted by Alsaif et al.[34] using PraxiLabs virtual labs in 2020, producing the following findings and recommendations. Virtual labs have a positive impact on student learning outcomes, including enhancing laboratory skills, achievement, and creativity, offering better learning opportunities, and reducing cognitive load. While virtual labs cannot replace traditional laboratories, they address challenges, optimize learning, and are vital in medical education and science literacy, requiring teachers' exposure to promote active learning and skill development in students.

Innovative curriculum and pedagogical approach

Generative AI has the potential to introduce an innovative curriculum and pedagogical approach within the realm of STEM education. The personalization feature of generative AI as discussed previously fosters more effective learning by dynamically adjusting the curriculum to ensure that students can progress at their own pace and focus on areas where they need the most support. In addition, generative AI's ability to generate adaptive learning content and interactive simulations, provides educators with a versatile toolkit that can be utilized to suit the specific objectives of STEM courses, making it easier

to align curriculum with the ever-changing industry needs and emerging scientific discoveries. Furthermore, generative AI can analyze vast amounts of data related to student performance and learning patterns. This data-driven approach can help educators make informed decisions about curriculum adjustments and pedagogical strategies. For example, if the AI identifies a common stumbling block for students, it can suggest modifications to the curriculum to address this challenge proactively. On top of that, an innovative curriculum should be adaptable and responsive to changes in the STEM field and industries. Generative AI can continuously update and refine the curriculum based on the latest advancements and best practices, ensuring that students receive the most up-to-date and relevant education, necessary for their future success in the real world. An example of this is how

Processica[35] leveraged the power of Generative Pre-trained Transformer (GPT) and database technology to effectively drove curriculum innovation for the education sector in USA. The GPT model, well-known for its capacity to comprehend context and produce cohesive content, served as the primary catalyst for their AI-powered solution. The generation of comprehensive and customized curriculums was facilitated by the utilization of vast quantities of multi-dimensional data processed by the third-party vector database. The GPT approach considered the distinct educational requirements of every student within the district, converting intricate data into significant and tailored content.

Enhanced creativity and innovation

Generative AI has the potential to significantly enhance creativity and innovation in STEM education through its ability to produce diverse learning materials, create a real-world-problem-based learning environment, and instant feedback and iteration. Generative AI can produce a wide range of learning materials, including text, images, videos, and interactive simulations. This diversity of content provides students with various ways to explore STEM concepts, encouraging creativity in their approach to learning and inspiring innovative thinking. Furthermore, generative AI can create authentic, real-world problem scenarios for students to solve. These problems require creative thinking and problem-solving skills, mirroring the challenges they may face in their future STEM professions. By working on these scenarios, students develop their innovative capabilities while gaining practical knowledge. Last but not least, generative AI can provide immediate feedback on assignments and projects, allowing students to iterate and improve their work. This iterative process is a fundamental aspect of innovation. By encouraging students to refine their solutions and ideas, generative AI supports the development of creative problem solvers.

Collaboration and inclusivity

Incorporating generative AI into STEM education creates an environment that values collaboration and inclusivity. Generative AI can analyze students' profiles, including their strengths, weaknesses, and interests, to form collaborative groups. These groups can comprise students with varying skill levels and backgrounds, promoting inclusivity and ensuring that every team member can contribute meaningfully. On top of that, generative AI can generate learning materials with alternative formats for students with disabilities. This ensures that all students, regardless of their abilities, have equal access to educational content, fostering a more inclusive learning environment.

5.2 Challenges

While the potential of generative AI in transforming STEM education in Cambodia is undeniable, challenges in its integration still persist.

Technological infrastructure

One of the primary challenges is the readiness of Cambodia, especially her educational institutions, to embrace and adopt advanced technologies. Many households and schools, particularly those in rural areas, lack the necessary technological infrastructure, including reliable internet access and up-to-date hardware, to effectively make the best use of generative AI application. According to the International Telecommunication Union, in Cambodia, in 2017, there were only 30% of households with internet access at home (rural), and only 8% of households with a computer at home in 2019.[36] Narrowing this digital gap is essential to ensure beneficiaries' equal access to the potentials of Generative AI.

Digital literacy

An essential ingredient for effectively utilizing Generative AI is digital literacy among both educators and students. Ensuring that teachers and students are adequately trained to navigate and leverage this technology is a significant challenge. Only 30% of Cambodians possess a basic understanding of digital literacy and are able to use digital platforms and the internet to search for and share information, according to Minister of Post and Telecommunication Chea Vandeth, who was speaking at the launch of the Development of the National Media and Information and Digital Literacy (MILD) program.[37]

Financial accessibility

Effectively harnessing Generative AI requires substantial resources, including access to powerful computing systems and specialized software, that are financially out of reach for many Cambodian schools and educational institutions, especially public ones, raising concerns about feasibility and equity in technology-related education. In this regard, insufficient domestic revenue had been reported in countries like Cambodia, Laos, and Myanmar to fund education, leading to a reliance on foreign investment.[38] This highlights the financial limitations faced by these countries in providing adequate funding for general education, let alone sophisticated-technology-enabled education.

Data privacy and security

Generative AI relies heavily on data, which raises questions about data privacy and security. According to Cybersecurity Ventures, worldwide cybercrime expenditures would increase by 15%, from USD 3 trillion in 2015 to USD 10.5 trillion annually by 2025.[39] This indicates alarming concerns about cybersecurity and data protection, and therefore safeguarding students' personal information and ensuring compliance with data protection regulations are of utmost importance in this vast digital world.

Coupled with these challenges, there are also many others that hinder this endeavor of harnessing generative AI's potential, including difficulty in curriculum integration, need of faculty training, system localization, overcoming resistance to change from relevant stakeholders, innovative assessment and accountability, and ethical considerations around generative AI usage. Addressing these challenges will require a concerted effort from various stakeholders, including government bodies, educational institutions, private sector, and the broader Cambodian society. An inclusive and forward-thinking approach, guided by a clear vision for the role of Generative AI in Cambodian STEM education, will be crucial to navigate these obstacles successfully. By proactively addressing these challenges, Cambodia can unlock the full potential of Generative AI to enhance STEM education, empower students, and prepare them for the demands of the 21st-century workforce.

6. Conclusion and recommendations

Generative AI holds great promise for revolutionizing STEM education in Cambodia. Its potential to provide personalized, interactive, and innovative learning experiences can address the challenges in Cambodia's current education system and equip Cambodian students with the required 21st-century skills needed to ensure a bright digital future. However, the effective implementation and integration of Generative AI into Cambodia's education sector requires a joint effort to address the aforementioned challenges, including technological infrastructure limitations, the need for digital literacy, financial accessibility, data privacy concerns, curriculum integration issues, resistance to change, innovative assessment methods, and ethical considerations. And all these call for a thorough attention and strategic planning.

Based on the analysis of potential and challenges provided above, several recommendations can be made as follows:

Government Bodies

- Put out government initiatives and implement public-private partnerships to expand reliable internet access throughout Cambodia, especially in rural areas.
- Seek funding opportunities (foreign aid, investments…) for schools to acquire modern hardware and software.
- Prioritize the increase of domestic revenue allocation for education,

especially budget for technology-enabled education.

- Strengthen collaboration with development partners and private tech companies to provide schools with affordable access to Generative AI tools and infrastructure.
- Produce data protection legal frameworks or regulations specific to AI and the education sector.
- Equip schools with qualified ICT personnel and train them on cybersecurity and data protection, with support from certified training agencies or internationally recognized experts in relevant fields.
- Establish national ethics committees to oversee and ensure the ethical use of AI in education.
- Include 'Generative AI in Education' in the National Research Agenda's list of prioritized research areas.

Educational Institutions, Educators and Learners

- Develop training programs for educators to effectively use Generative AI in their teaching with support from certified training agencies or internationally recognized experts in relevant fields.
- Organize workshops and seminars, develop campaign, and/or partner with development partners to implement projects to enhance educators and students' digital literacy.
- Strengthen collaboration between government bodies, educators, and AI developers to ensure effective localization of Generative AI and its alignment with Cambodia's educational goals.
- Initiate pilot programs to test Generative AI's integration with monitoring and evaluation mechanisms in place for accountability and improvements.
- Establish school-based ethics committees to oversee and ensure the ethical use of Generative AI in education.

Private Sector

- Foster collaboration with schools to provide updated hardware and software.
- Seek international investors to supply affordable Generative AI tools and infrastructure.
- Provide internship or apprenticeship opportunities to students in the area of digital competency development.
- Help share best practices of cybersecurity and data protection with school's ICT personnel.
- Devise strategies to attract AI developers into the kingdom.

1 *Kao Sovansophal and Kinya Shimizu, "A Review on STEM Enrollment in Higher Education of Cambodia: Current Status, Issues, and Implications of Initiatives", ResearchGate, (March 2020): https://www.researchgate.net/publication/339815574.*

2 *Ministry of Education, Youth and Sport "Policy on STEM Education", March 2016, 1.*

3 *Ministry of Education, Youth and Sport "Report of Education Congress." April 2022, http://Moeys.Gov.Kh/En/Media-Center/Education-Congress/Education-Congress-the-Education-Youth-and-Sport-Performance-in-the-Academic-Year-2020-2021/.*

4 *Ministry of Education, Youth and Sport | The government ministry responsible for promoting and regulating education, youth and sport development, in Cambodia, n.d. http://moeys.gov.kh/.*

5 *Kao Sovansophal, and Kinya Shimizu, "Factors Affecting Students' Choice of Science and Engineering Majors in Higher Education of Cambodia", International Journal of Curriculum Development and Practice 21, no. 63 (August 2013): 69–82, https://doi.org/10.18993/jcrdaen.21.1_69.*

6 *Sothy Eng, and Whitney Szmodis, "Stem Learning Achievement among Cambodian Middle School Students: An Examination of Gender and Psychosocial Factors", International Perspectives on Education and Society (January 2016): 279 - 305, https://doi.org/10.1108/s1479-367920150000028018.*

7 *Gail Jones, Ann Howe, and Melissa J. Rua, "Gender Differences in Students' Experiences, Interests, and Attitudes toward Science and Scientists", Science Education 84, no. 2 (February 2000): 180-192, accessed September 18, 2023, https://doi.org/10.1002/(SICI)1098-237X(200003)84:2<180::AID-SCE3>3.0.CO;2-X.*

Wahiba Sayed Saeed Alawi, and Muneer Mohamed Al Mubarak, "Gender Gap in Science, Technology, Engineering and Mathematics (STEM): Barriers and Solutions", International Journal of Economics and Financial Issues 9, no. 6 (November 2019): 225-231, https://www.econjournals.com/index.php/ijefi/article/view/8908;

Aaron M. McCright, "The Effects of Gender on Climate Change Knowledge and Concern in the American Public," Population and Environment 32, no. 1 (June 2010): 66–87, https://doi.org/10.1007/s11111-010-0113-1.

8 *Sopheap Kaing, "How can STEM education help stimulate economic growth in Cambodia" (unpublished Master's Thesis, Vrije Universiteit Brussel, 2016), https://www.researchgate.net/publication/308725757_How_Can_STEM_Education_Help_Stimulate_Economic_Growth_in_Cambodia.*

9 *Ibid.*

10 *Royal Government of Cambodia, "Rectangular Strategy Phase 4 of the Royal Government of Cambodia - OD Mekong Datahub", https://data.opendevelopmentcambodia.net/laws_record/rectangular-strategy-phrase-4-of-the-royal-government-of-cambodia.*

11 *"Annual Report 2022", Kampuchea Action to Promote Education (KAPE), (February 2023): https://www.kapekh.org/files/report_file/380-en.pdf.*

12 *Chanphalla Ban. "The Current State of Cambodia's STEM Education: A Case Study of the Preah Sisowath New Generation School." Future Forum Working Papers, 2020.*

13 *Ibid.*

14 *Ministry of Education, Youth and Sport, "Education Strategic Plan (ESP) 2014-2018", March 2014.*

15 *Ibid.*

16 *Sophoanreak Kov, "17th Annual Cambodia STEM Festival (ACSF)", STEM Cambodia, last accessed November 3, 2023, https://stemcambodia.ngo/17th-annual-cambodia-stem-festival-acsf/.*

17 *"រថយន្តស្ទែម STEM Bus Cambodia," Facebook, https://www.facebook.com/STEMBusKH/.*

18 *Post Staff, "Cambodia and the UK, Securing the Workforce of the Future", Phnom Penh Post, February 15, 2019, https://www.phnompenhpost.com/supplements-special-reports/cambodia-and-uk-securing-workforce-future.*

19 *Sopheap Kaing, "How Can STEM Education Help Stimulate Economic Growth in Cambodia", ResearchGate (July 2016): https://www.researchgate.net/publication/308725757_How_Can_STEM_Education_Help_Stimulate_Economic_Growth_in_Cambodia.*

20 *"National Policy on Science, Technology and Innovation 2020-2030 - OD Mekong Datahub," https://data.opendevelopmentcambodia.net/laws_record/national-policy-on-science-technology-and-innovation-2020-2030.*

21 *Ministry of Industry, Science, Technology & Innovation (MISTI), "Cambodia's Science, Technology & Innovation Roadmap 2030", 2021.*

22 *Ibid.*

23 *Ibid.*

24 *Ian Goodfellow, Jean Pouget-Abadie, Mehdi Mirza, Bing Xu, David Warde-Farley, Sherjil Ozair, Aaron Courville, and Yoshua Bengio, "Generative adversarial nets", Advances in neural information processing systems 27 (June 2014), https://doi.org/10.48550/arXiv.1406.2661.*

25 *Hao Yu, and Yunyun Guo, "Generative Artificial Intelligence Empowers Educational Reform: Current Status, Issues, and Prospects." Frontiers in Education 8 (June 1, 2023), https://doi.org/10.3389/feduc.2023.1183162.*

26 *Weng Marc Lim, Satish Kumar, Sanjeev Verma, and Rijul Chaturvedi, "Alexa, What Do We Know about Conversational Commerce? Insights from a Systematic Literature Review", Psychology & Marketing 39, no. 6 (March, 2022): 1129–1155, https://doi.org/10.1002/mar.21654.*

27 *Benjamin Beltzung, Marie Pelé, Julien P. Renoult, and Cédric Sueur, "Deep Learning for Studying Drawing Behavior: A Review", Frontiers in Psychology 14 (February 2023): https://doi.org/10.3389/fpsyg.2023.992541.*

28 *Lijia Chen, Pingping Chen, and Zhijian Lin, "Artificial intelligence in education: A review." Institute of Electrical and Electronic Engineers (April 2020): 75264-75278, https://ieeexplore.ieee.org/abstract/document/9069875.*

Kenneth Holstein, Bruce M. McLaren, and Vincent Aleven, "Co-designing a real-time classroom orchestration tool to support teacher-AI complementarity", Grantee Submission (2019).

Gwo-Jen Hwang, Haoran Xie, Benjamin W. Wah, and Dragan Gašević. "Vision, challenges, roles and research issues of Artificial Intelligence in Education", Computers and Education: Artificial Intelligence 1 (2020): https://doi.org/10.1016/j.caeai.2020.100001.

29 Weiqi Xu and Fan Ouyang, "The Application of AI Technologies in STEM Education: A Systematic Review from 2011 to 2021", International Journal of STEM Education 9, no. 1 (September 2022): https://doi.org/10.1186/s40594-022-00377-5.

30 Christian Jensen, "CanopyLAB – Social Learning Powered by AI", CanopyLAB, May 19, 2023, https://canopylab.com/.

31 "Khan Migo Education AI Guide | Khan Academy," Khan Academy, n.d., https://www.khanacademy.org/khan-labs.

32 K. Sabreena, "Generative AI in Education: A Case Study of Khan Academy." Analytics Vidhya, last accessed June 22, 2023, https://www.analyticsvidhya.com/blog/2023/05/generative-ai-in-education-a-case-study-of-khan-academy/.

33 PraxiLabs (2022), https://praxilabs.com/.

34 Bandar Alsaif, Usama M. Ibrahem, Munthir Alblaihed, Sameh S. I. Ahmed, Haisam A. Alshrif, Rabab A. Abdulkader, and Hanan M. Diab, "Interaction between Cognitive Styles and Genders When Using Virtual Laboratories and Its Influence on Students of Health College's Laboratory Skills and Cognitive Load during the Corona Pandemic." Heliyon. Elsevier BV (April 2022): https://doi.org/10.1016/j.heliyon.2022.e09213.

35 Processica Inc, "Custom Generative AI Development & Implementation Services," Processica, https://www.processica.com/.

36 "Digital Development," International Telecommunication Union ITU, https://www.itu.int/en/ITU-D/Statistics/Dashboards/Pages/Digital-Development.aspx.

37 Ngay Nai, "Cambodia Lags in Digital Literacy", Kiripost, accessed March 7, 2022, https://kiripost.com/stories/cambodia-lags-in-digital-literacy.

38 Fatharani Taqisa Nadhira, "Promoting investments in education in Asean: inclusive education, cross-border education programs, and ict capabilities", Center for Indonesian Policy Studies 45 (December 2021): https://doi.org/10.35497/353775.

39 Steve Morgan, "Cybercrime To Cost The World 8 Trillion Annually In 2023", Cybercrime Magazine (October 2022): https://cybersecurityventures.com/cybercrime-to-cost-the-world-8-trillion-annually-in-2023/.

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Revolution and Readiness through AI-Driven Learning in Cambodia's Higher Education

Soklay HENG and Dr. Sopheap SENG

1. Introduction

Cambodia's education system has experienced a significant transformation over decades. Education in Cambodia has evolved from traditional methods, where knowledge inscribed on palm leaves was directly imparted to students in pagodas, to the establishment of formal schools, ranging from kindergarten to university. Despite this transformation, teachers remain crucial in imparting knowledge to students within classroom settings. Today, with the advent of technology, numerous resources are available online for students to engage in self-paced learning, complementing traditional learning methods. Additionally, the COVID-19 pandemic highlighted the vital role of technology in education, and teachers across the country quickly adopted online classrooms to ensure continuous learning for students during this challenging time. Despite the end of the pandemic, many educational institutions have adopted a blended learning approach by combining traditional face-to-face classroom teaching with online instruction, providing students with a more flexible learning experience.

In today's rapidly digitalizing world, digital literacy is essential for emerging economies striving to align with global standards. For a nation like Cambodia, integrating digital literacy at the core of its higher education framework becomes pivotal to ensure that students acquire the required skills for Industry 4.0. This encompasses not just the ability to use digital tools, but also the understanding and leveraging of them for innovation, problem-solving, and knowledge creation. In addition, rapid advancements in artificial intelligence, known as AI, have led to the creation of powerful AI tools that have been proven to assist in various aspects of learning, from personalized tutoring to real-time feedback. With the emergence of AI-driven tools, Cambodia's higher education system has the opportunity to revolutionize teaching methods and equip students with the knowledge and skills necessary to excel in an increasingly technology-driven future. Integrating AI-driven tools in Cambodia's higher education could bridge the gap between traditional teaching methods and the dynamic demands of a digital future; however, powerful AI tools such as ChatGPT have yet to be publicly available in Cambodia. Furthermore, Cambodians need more awareness about accessing and utilizing these tools. The lack of awareness is restricting them from experiencing these innovative technologies and valuable learning resources.

This research paper investigates the potential, challenges, and readiness for integrating cutting-edge AI tools into Cambodia's higher education system. This paper is divided into four sections. The first section introduces artificial intelligence. The second section shows state-of-the-art generative AI tools for education. The third section discusses the potential and challenges of integrating AI tools in Cambodia's higher education. Conclusion and some recommendations are included in the last section of the paper.

2. What is Artificial Intelligence?

There are different definitions to describe artificial intelligence. John McCarthy, a pioneer in this field, coined the term "Artificial Intelligence" in 1956 at the Dartmouth conference, marking the inception of AI as a formal discipline. He defined it as "the science and engineering of making intelligent machines."[1 2] Elaine Rich stated that artificial intelligence is the study of how to make computers perform tasks at which, at the moment, people are better.[3] Artificial intelligence can also be described as a field of study to design systems that machines simulate or mimic human cognitive capabilities, which encompasses tasks such as image or object recognition, understanding and generating natural language, learning from past experience, adapting to a new environment, problem-solving, and decision-making. Artificial intelligence is achieved by teaching machines like humans, which involve recognizing patterns and acquiring knowledge from data. The machines' ability to perform tasks that typically require human cognitive skills is realized by following sets of instructions known as "algorithms". The algorithms include rule-based instructions which explicitly define a set of rules to guide the system's decision-making, machine learning that learns statistical relationships within data without the need for explicit programming, and deep learning which is a subset of machine learning and is inspired by the structure of the human brain. Deep learning uses "artificial neural network" comprising interconnected layers, such as input, hidden, and output layers to automatically extract complex features from data, making it more suitable for handling complex tasks like image and speech recognition.

Artificial intelligence, based on capability, can be divided into three main categories.[4] The first category, known as "Artificial Narrow Intelligence or ANI", simulates human intelligent behavior and is designed for specific tasks, lacking the broad cognitive abilities found in humans.[5] Many of the current state-of-the-art AI applications fall under this category, which can perform efficiently in a specific task, yet without the ability to generalize beyond their designated tasks. For example, a speech recognition system designed to transcribe spoken language into text cannot recognize objects or faces handled by object or face recognition systems. Similarly, while a machine translation system has the capability to translate languages, it cannot synthesize speech which can be accomplished by a text-to-speech system. The next level, "Artificial General Intelligence or AGI", aspires to replicate the general intelligence of humans, allowing machines to perform any intellectual task that a human being can. AGI would genuinely understand, learn, and apply knowledge in different domains on its own.[6] At the current stage, AGI remains a theoretical concept and aspirational goal to achieve despite ongoing significant research and discussions. The ultimate phase of AI evolution is "Artificial Superintelligence or ASI" which has self-awareness and consciousness and can surpass human capabilities.[7] The pursuit of ASI, which remains hypothetical and goes beyond even the not-yet-realized capabilities of AGI, introduces a dilemma to achieve it, given many controversial ethical concerns.

3. Introduction to Generative Artificial Intelligence

While generative artificial intelligence (Generative AI) has seen significant advancements in recent years and can produce impressive results, it still falls under the category of artificial narrow intelligence as it is still limited by the data it was trained on and lacks the general intelligence and adaptability of human intelligence. Generative AI is a subset of artificial intelligence that is designed to produce new content, ranging from text to image generation, based on trained data.[8] It can accept input in various formats, including text, image, audio, video, and code, and is capable of generating new content in any of these forms.[9] It generates different contents based on generative AI models, each with its own method. Generative AI models, a type of machine learning model, use neural networks to learn complex patterns in data without being explicitly programmed. Once trained, these models can generate new content that is similar, but not identical, to the original data. DALL-E, for example, is a text-to-image generative AI model that can generate images given text description as an input.[10] Another example is MusicLM which is capable of generating high-quality music from text.[11] In the field of generative AI for text content creation, Large Language Models (LLMs) are adept at producing coherent and contextually relevant text based on user prompts. Each of these shows the extensive benefits of generative AI, which contributes to content generation in various disciplines such as education, art, entertainment, and more. Although its potential is extensive, the integration of generative AI into various sectors requires careful consideration and robust safeguards. As our paper mainly focuses on AI tools integration in higher education, benefits and risks of textual content generated by AI models will be further illustrated in more detail.

3.1. Potential Generative Artificial Intelligence tools for higher education

With the evolution of large language models (LLMs) trained on a huge amount of textual data from articles, books, and websites, generative AI has made remarkable progress in producing human-like text. Before delving into what a large language model is, it is essential to first comprehend the concept of a language model. A language model (LM) is a type of artificial intelligence model designed to predict the next word in a sequence based on the words that have occurred in a sentence. Language models can be categorized into two types, statistical language model and neural language model.[12][13] Neural language model exploits deep neural networks, thanks to significant advancements in computing power and the availability of vast amounts of training data. This model can predict the next word or phrase based on the current input and generate coherent text sequence, yielding better performance compared to the statistical language model. Language models are used in various applications, including machine translation, speech recognition, text summarization, chatbot, spellchecking, etc. As an example of how a language model predicts, consider the phrase "I am going to the". The model might suggest several word options such as "eat", "store", or "I". However, given the context, "store" is the most appropriate continuation, so the model is likely to select "store" as the next probable word.

A large language model comes with a large size due to the vast amount of trained data.[14] LLMs have been used for a wide range of applications, including information retrieval, content creation, text classification, machine translation, question answering, document summarization, sentimental analysis, code generation, and text generation. The foundation of LLMs primarily lies in transformer model architecture which was introduced by Vaswani et al. in 2017.[15] The self-attention mechanism empowers this model to decide which words in a sentence are most relevant to another word. This mechanism helps the model to understand the relationships between words in a long sequence. It is similar to humans understanding the connection between words in a long sentence according to the context. Generative Pre-trained Transformer (GPT) models, developed by OpenAI, made extensive use of the transformer architecture in their models. For example, the GPT-2 large model was built in 2019 using around 40 Gigabytes of text data with 1.5 billion parameters.[16] In the following year, the GPT-3 model, which was developed by extending the size of text data up to 570 Gigabytes and the size of model architecture up to 175 billion parameters, has further improved the model performance to generate human-like text.[17] OpenAI's most advanced GPT series, known as GPT-4, was released in 2023 and is a large multimodal which can accept image and text as inputs.[18]

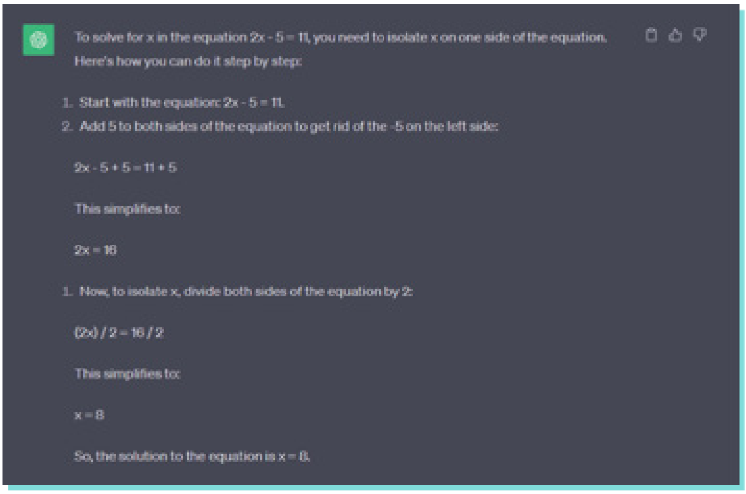
The model was evaluated with a range of tests created for human assessment, and the results indicate that GPT-4 performs exceptionally well and often surpasses the majority of human test takers and other models in many cases. While it offers capabilities on par with humans across various applications, such as question-answering, virtual assistants, language translation, text summarization, etc., it still has limitations and produces errors. Besides OpenAI's LLMs, there are other LLMs, for example "BigScience Large Open-science Open-access Multilingual Language Model or BLOOM" which was released by Hugging Face in 2022.[19] The model was developed by over a thousand AI specialists and is capable of producing text in 46 languages and 13 coding languages. Google released "Language Model for Dialogue Applications or LamDA", a transformer-based LLM with 137 billion parameters, in 2022.[20] The model is developed to provide more natural and dynamic conversations on an extensive range of subjects. Google later introduced another transformer-based LLM, known as "Pre-training with Abstracted Language Modeling or PaLM", to support multilingual content generation and coding. There are two versions of PaLM series – PaLM-1[21], which has 540 billion parameters and PaLM-2[22], which provides improvement of multilingual, reasoning and coding capabilities. Many state-of-the-art AI tools have been developed as interactive chatbots by leveraging Large Language Models (LLMs) as mentioned above. These chatbots offer users the ability to engage in conversations and perform a variety of tasks across multiple domains. We will highlight three popular AI tools that primarily utilize LLMs to generate human-like textual content, which have shown many benefits in the field of education.

3.1.1 Chat Generative Pre-Trained Transformer (ChatGPT)

A product by OpenAI, ChatGPT has received a boom in its popularity since the publicly official release in November 2022.[23] ChatGPT was developed using GPT-3.5 and GPT-4 as its foundation and was specifically fine-tuned to excel at conversational interactions. While ChatGPT is available for free, a premium version called ChatGPT Plus is also offered at a monthly subscription rate of $20. ChatGPT Plus is powered by GPT-4 which enhances the generated responses by offering greater reasoning and accuracy, along with faster response times. This 24/7 conversational assistance tool has been utilized in diverse professional domains such as research, programming, content creation, and business. For personal tasks, individuals can benefit from entertainment to developing applications without knowing code. In higher education, the quality of text generation with knowledge of various subjects makes ChatGPT a beneficial educational assistant tool. Its ability to generate human-like text enables it to explain complex topics in simplified terms and give real-time feedback, making it an effective tool for virtual tutoring of various subjects. Those subjects include mathematics, sciences, computer science, history, literature, languages, economics, geography, philosophy, and art and music. To utilize ChatGPT effectively, users primarily interact with the model through prompts. These prompts can come in various forms, such as direct questions ("What is an earthquake?"), requests for elaboration ("Tell me a story."), instructional directives ("Translate this English sentence to Khmer: "Hello, how are you?"), or even more open-ended stimuli ("Imagine a conversation between a robot and human."). It is worth noting that the structure of the prompt heavily influences ChatGPT's response. The more precise and clear the prompt, the more targeted the answer will likely be. Conversely, vague or broad prompts might lead to more generalized and undesired responses. We will illustrate some interesting cases of how students and educators can benefit from ChatGPT for their educational purposes.

Solving Arithmetic

Prompt for ChatGPT: "Solve for x in the equation 2x−5=11"


To solve for x in the equation 2x - 5 = 11, you need to isolate x on one side of the equation. Here's how you can do it step by step:

1. Start with the equation: 2x - 5 = 11.
2. Add 5 to both sides of the equation to get rid of the -5 on the left side:

2x - 5 + 5 = 11 + 5

This simplifies to:

2x = 16

1. Now, to isolate x, divide both sides of the equation by 2:

(2x) / 2 = 16 / 2

This simplifies to:

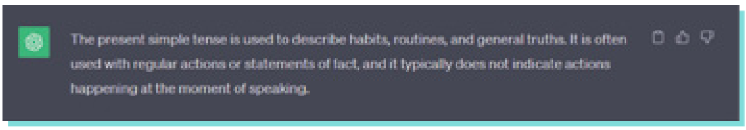
x = 8

So, the solution to the equation is x = 8.

Response from ChatGPT

Language Learning

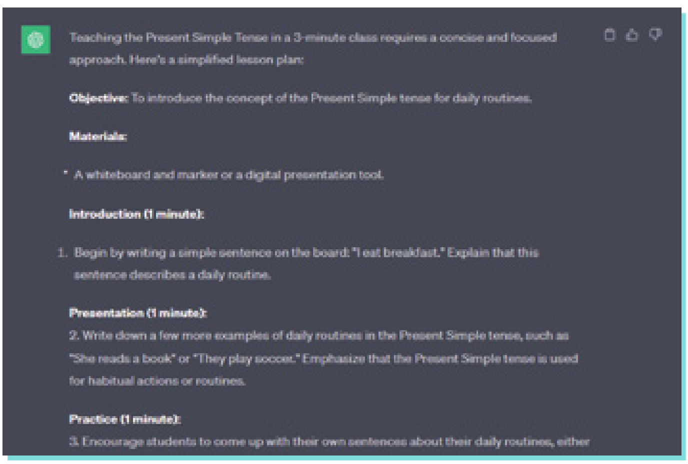
Prompt for ChatGPT: "Act as an English teacher and tell me the usage of present simple in 2 lines only"


The present simple tense is used to describe habits, routines, and general truths. It is often used with regular actions or statements of fact, and it typically does not indicate actions happening at the moment of speaking.

Response from ChatGPT

Lesson Plan Design

Prompt for ChatGPT : "Draw a lesson plan for my 3 minutes class to teach Present Simple"


Teaching the Present Simple Tense in a 3-minute class requires a concise and focused approach. Here's a simplified lesson plan:

Objective: To introduce the concept of the Present Simple tense for daily routines.

Materials:

- A whiteboard and marker or a digital presentation tool.

Introduction (1 minute):

1. Begin by writing a simple sentence on the board: "I eat breakfast." Explain that this sentence describes a daily routine.

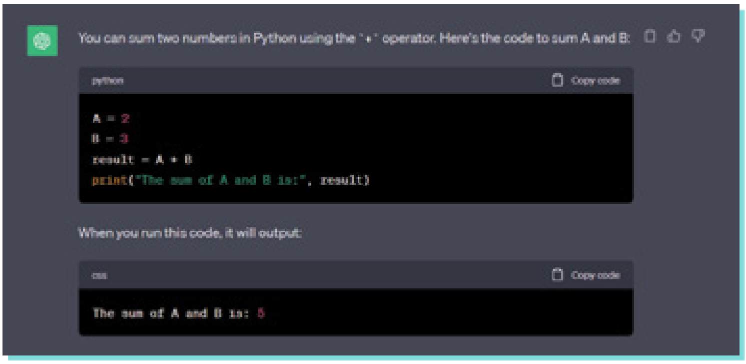
Presentation (1 minute):
2. Write down a few more examples of daily routines in the Present Simple tense, such as "She reads a book" or "They play soccer." Emphasize that the Present Simple tense is used for habitual actions or routines.

Practice (1 minute):
3. Encourage students to come up with their own sentences about their daily routines, either

Response from ChatGPT

Solving Computer Programming Task

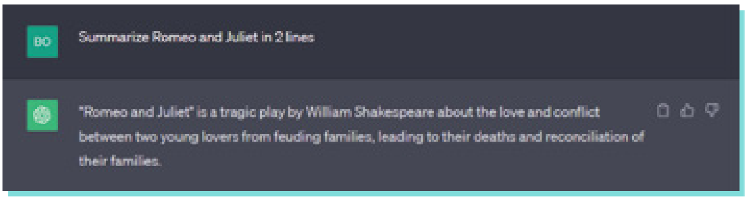
Prompt for ChatGPT: "Write a Python code to sum A=2 and B=3"



Response from ChatGPT

Summarizing Text

Prompt for ChatGPT: "Summarize Romeo and Juliet in 2 lines"



Response from ChatGPT

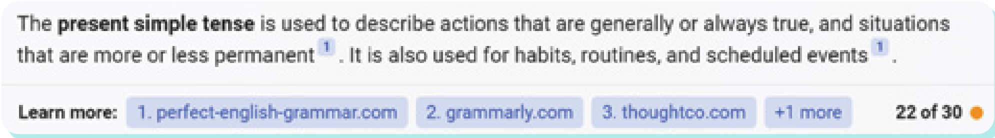
3.1.2 Bing Chat

Bing Chat, integrated into Microsoft Edge, enables users to interact with the chatbot within the browser's sidebar for various tasks similar to ChatGPT.[24] It uses GPT-4 language and real-time information available on the internet to generate answers. It leverages the power of Bing search engine to provide up-to-date and relevant information to users. Unlike ChatGPT, Bing Chat also provides references for its responses, allowing users to explore further and verify the information. Like ChatGPT, prompts act as a crucial medium for users to interact with Bing Chat.

We will use one of the prompts above to illustrate the differences between ChatGPT and Bing Chat.

Language Learning

Prompt for Bing Chat: "Act as an English teacher and tell me the usage of present simple in 2 lines only"



Response from Bing Chat

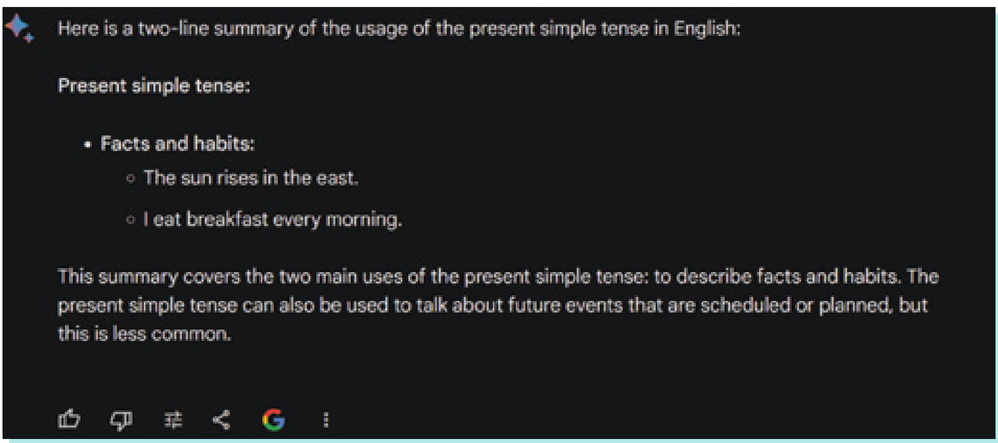
3.1.3 BARD

BARD is another conversational AI tool, based on PaLM 2.[25] It was introduced by Google in March 2023 and is seen to be a competitor to ChatGPT. Although BARD has been officially released to the public, it is still under development. As with ChatGPT and Bing Chat, prompts are used as a medium to ask and get responses from the interactive chatbot. Bard generates responses using real-time information on the internet. Although BARD does not attach references to its responses, it does provide verification options that users can utilize to check the reference against the BARD's response.

We will use one of the prompts above to illustrate the differences between ChatGPT, BARD and BARD.

Language Learning

Prompt for BARD: "Act as an English teacher and tell me the usage of present simple in 2 lines only"



Response from BARD

4. Potential and challenges of AI tools integration in Cambodia's higher education

While these technologies offer extensive benefits, they also come with many challenges of which not everyone is aware since they are quite new. We will delve into the potential and challenges posed by such technologies below.

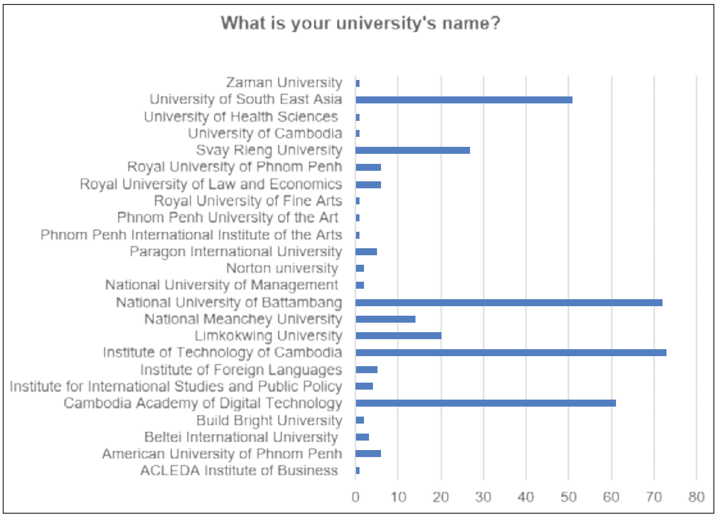
4.1 Potential of AI tools integration

Educators and students can exploit the benefits of these cutting-edge AI tools in the field of higher education as follows.

- **Personalized learning:** AI-driven chatbots empower students to study at their individual pace, catering to their unique learning styles. Serving as a virtual tutor with expertise in various domains, these chatbots are available 24/7. This accessibility allows students to seek answers to diverse questions without solely depending on in class teachers for knowledge dissemination. This innovative approach promotes autonomy and tailored educational experiences for learners. Moreover, the integration of such AI tools into the education sector has shown a significant step towards achieving digital transformation, bridging the gap between traditional teaching methods and modern, tech-driven pedagogies.[26]
- **Instant feedback:** Owing to the fact that a generative AI model can understand human language and context, it can generate detailed responses according to the input it receives. This function makes it a more interactive and dynamic learning experience which helps to motivate students to learn more. Instead of waiting for periodic assessments or teacher feedback, they can get immediate responses to their queries, test their understanding of a topic, or clarify doubts immediately, accelerating the learning process and ensuring that questions are answered promptly.
- **Promoting creativity:** When brainstorming or conceptualizing ideas, students can engage with generative AI to refine, expand, or even challenge their initial thoughts. AI can provide alternative perspectives, suggest related concepts, or even challenge students to think deeper and wider.
- **Cost saving:** In a traditional context, acquiring expertise often requires enrolling in specific courses. Each new skill or subject area typically incurs additional costs, be it in the form of tuition fees, course materials, or even the associated time and travel expenses. However, with generative AI, a wide knowledge is consolidated into a single platform where it is equipped to provide insights, guidance, and feedback.

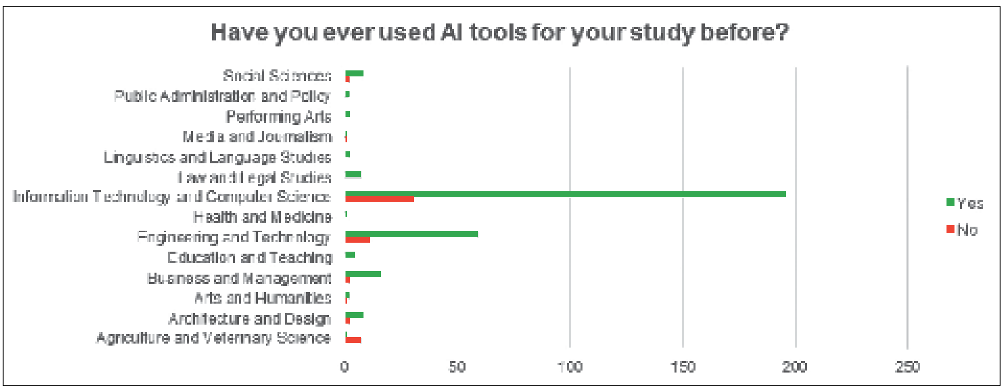
We conducted a survey among students from 24 different universities, of which twenty are from Phnom Penh and four are provincial universities such as National University of Battambang, Svay Rieng University, National Meanchey University, and University of Southeast Asia (Figure 1).

Figure 1: **Names of universities of the respondents who participated in the survey**



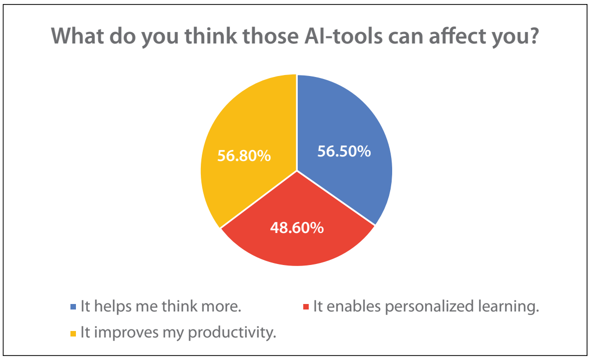
According to our survey result shown in Figure 2, students in the fields of Information Technology and Computer Science, and Engineering have used AI tools the most for their study.

Figure 2: **The top-ranked domains of students who have used AI-tools.**



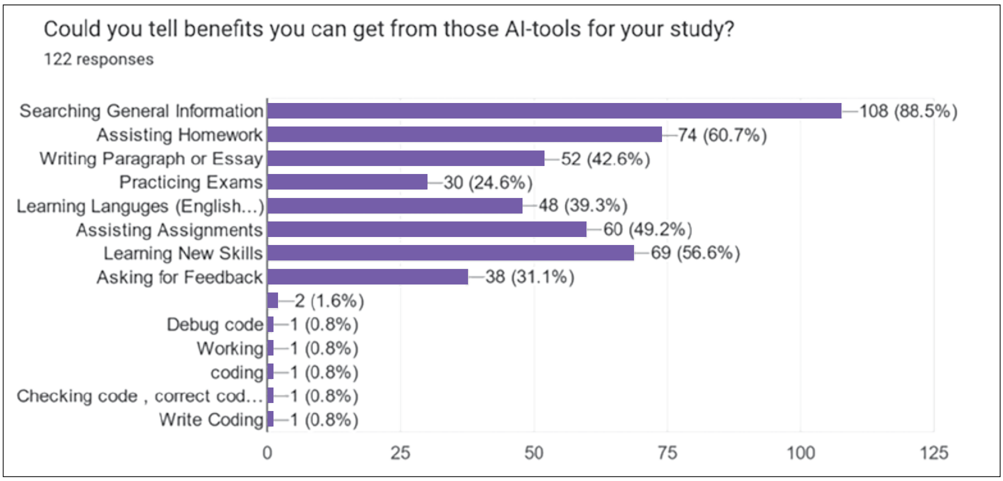
Out of 353 students surveyed, 56.5% believe that AI tools enhance their critical thinking, 56.8% feel that these tools boost their productivity, and 48.6% are of the opinion that AI facilitates their personalized learning (Figure 3).

Figure 3: Perspectives of respondents towards positive impacts of AI tools on their studies



The results of the survey show that students primarily use AI tools for general information searches, assistance with their homework, and acquiring new skills (Figure 4). Another significant use is in writing paragraphs and essays. Additionally, students utilize AI for learning foreign languages, seeking feedback, practicing for exams, debugging, and coding lessons.

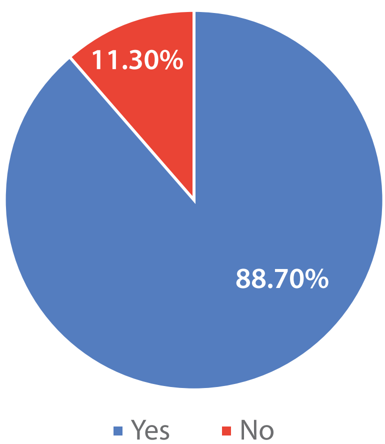
Figure 4: Different tasks students ask AI-tools to assist with for their studies



Students have utilized a variety of AI tools, such as ChatGPT, Microsoft Bing, Bard, Ask AI, DeepAI, pind.ai, YouAi, Codium AI, Bito AI, BAI Chat, SteveAI, Monica Chatbot, tabine Chat, Claude, GoodAI, GPTZero, Khmergpt, Grammarly, Quillbot, AI Essay Writer, CopyAI, Notion, Math ai, Tome, Perplexity, Citefast, and Poe. 62 lecturers from various universities in provinces and 43 lecturers from universities in Phnom Penh took part in the survey. 79.5% of lecturers in Phnom Penh and 65.2% in provinces have used AI tools to aid their teaching. They use them to search for general information, generate quizzes and exams, design course syllabus and lessons, create classroom content, generate code, and detect plagiarism. They use various AI tools, such as Chat-GPT, Microsoft Bing, Bard, and Poe. 88.7% think that AI tools should be allowed for use in higher education (Figure 5). They also mention that students should use tools for searching general information, assisting assignment or homework, and asking for feedback.

Figure 5: Lecturers' perspectives regarding the allowance of AI tools usage for students

Do you think AI-tools shoul be allowed for students to use?



4.2 Challenges of AI tools integration

The integration of AI tools in the educational field requires careful consideration of challenges.

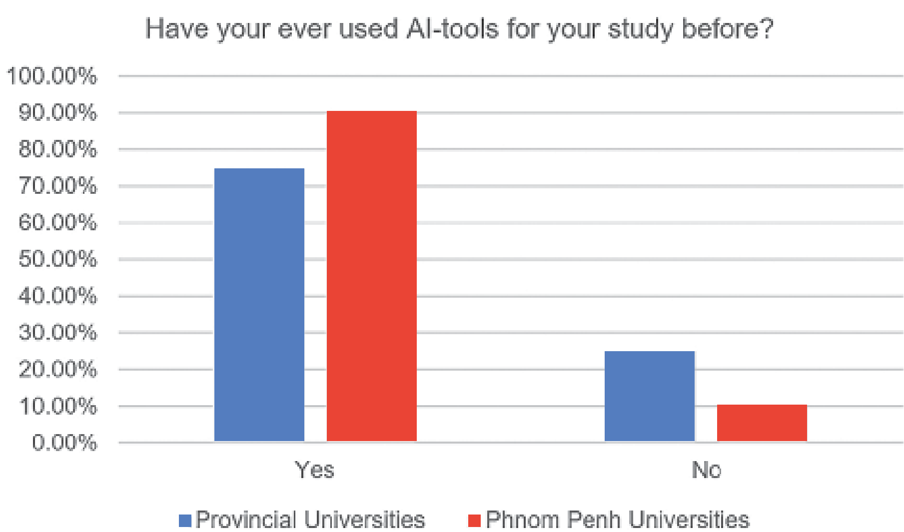
- **Reliability and Accuracy:** Generative AI models cannot always produce entirely accurate information. The developers of the generative AI tools have clearly addressed that the model cannot generate entirely accurate output. Therefore, ensuring and being aware of the limitations of AI-generated content in this field is crucial for educational purposes.
- **Data Privacy:** Using generative AI tools means user data has been collected by the product's company to process and can be kept and controlled by them. Therefore, understanding the terms and conditions of each AI tool is crucial to ensure data privacy and data protection.
- **Ethical Concern:** Although generative AI might produce answers that sound comprehensive, these answers often lack direct references or sources. This can become problematic in an educational setting as students and educators typically rely on references for further reading, validation, and citation purposes. In addition, as AI is trained by humans and if it is trained by biased datasets, it would result in algorithmic biases and therefore be unfair or discriminative against certain groups of students.
- **Language barrier:** The predominance of English datasets used to build AI tools enable these tools often perform optimally in English. This can make it challenging for these tools to be effectively integrated in non-English speaking regions, including Cambodia. Furthermore, not all Cambodian students have a good knowledge of English, limiting their ability to fully utilize and benefit from these AI tools.

- **Accessibility:** Inaccessibility to emerging technologies can lead to an exacerbating digital divide. Only a privileged group of people who have access to these AI tools benefit from the opportunities they offer. This divide is even evident in educational settings, where some students are aware of the potential of AI, while others are not. For example, ChatGPT has not been accessible in Cambodia. Only those who are aware of the method to utilize it through virtual private network (VPN) have the privilege of accessing such a sophisticated tool.

- **Over-reliance on AI:** There is a risk that students might become too dependent on AI, potentially suppressing critical thinking and problem-solving skills. This is due to the fact that the answer is always provided by the tool. Students tend to be lazy to produce ideas or solve the tasks by themselves.

25.2% of the 163 provincial students and 10% of the 190 students in Phnom Penh have never used AI tools for their studies (Figure 6). The primary barriers for the students are their limited knowledge about these emerging technologies and how to use these tools and accessibility issues related to AI service availability in Cambodia (ChatGPT) and internet connection. 37.7% of lecturers who have never used AI tools for their education reported the same challenges as the students. In addition to this, the survey shows 172 out of 354 students stated that the tools do not help their thinking but instead provide direct answers. The lecturers also raise concerns that these tools can make students lazy and disimprove their study and even encourage academic misconduct.

Figure 6: Percentage of students in the capital city versus provincial areas who have never used AI tools for their studies



5. Conclusion and suggestions

The advent of emerging technologies, particularly generative AI, shows many promising opportunities for digital transformation of education in Cambodia. With tools such as ChatGPT and BARD, students can get many benefits. From personalized learning experiences to enhancing cognitive skills, these platforms are set to revolutionize the way education is perceived and delivered. However, like the two sides of a coin, these advanced technologies carry both potential and challenges. Embracing them with awareness is essential to ensure that their advantages are harnessed while mitigating associated risks. Below are some suggestions proposed by the authors.

- **Regulation:** A framework of standardized rules is pivotal. Establishing clear guidelines and rules will help to ensure that students are aware of the consequences of their academic misconduct, such as using AI tools for plagiarism or cheating. These guidelines will provide students with a clear understanding of the expectations and unacceptable behaviors associated with using AI tools, thereby discouraging academic misconduct and enhancing students' learning experiences.
- **Teaching paradigm shift:** Instead of sticking to traditional comprehensive questions, teachers should design tasks which require critical thinking. Therefore, students can utilize the AI tools to refine their answers and challenge their ideas. With generative AI tools described above, the art of crafting effective prompts becomes essential. Teaching students how to utilize and formulate prompts can empower them to extract meaningful insights from AI, refine their answers, and challenge their ideas more deeply.
- **Ethics in AI:** The transition of AI tools integration in education should be the inclusion of courses on the ethics of AI usage. This is to ensure students are aware of limitations of AI tools and how to use them ethically.
- **Digital Literacy and Upskilling:** As technologies continue to shape almost every aspect of our daily lives, digital skills are essential for everyone in this technology-driven society. According to our survey, both students and lecturers miss opportunities to use new technologies, primarily because they are unaware of the potential of these tools and lack the skills to access them. Therefore, digital literacy is vital to ensure that all individuals have access to new opportunities provided by the latest technologies. It also plays an important role in bridging the digital divide, ensuring no one is left behind. The digital literacy can be fostered by incorporating it into school curricula, and collaborating with multi-stakeholders, including private sector, to provide digital skills training in educational institutions, especially those in remote areas.

1 John McCarthy, "What is Artificial Intelligence?" Stanford University (November 2007), http://jmc.stanford.edu/artificial-intelligence/what-is-ai/index.html.

2 Marvin Minsky, The Society of Mind (Simon and Schuster, 1986), 326.

3 Elaine Rich, "Artificial Intelligence and the Humanities", Computers and the Humanities 19 (2) (April-June 1985): 117–122, http://www.jstor.org/stable/30204398.

4 Paul Golata, The Ethics of Superintelligent Design: A Christian view of the theological and moral implications of artificial superintelligence, (Wipf and Stock Publishers, 2018).

5 Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, (3rd edition, 2010.)

6 Ben Goertzel, "Artificial General Intelligence: Concept, State of the Art, and Future Prospects", Journal of Artificial General Intelligence, 5, no.1 (November 2014): 1–48, https://doi.org/10.2478/jagi-2014-0001.

7 Nick Bostrom, Superintelligence: Paths, Dangers, Strategies, (Oxford University Press, 2014).

8 Elysse Bell, "Generative AI: How it Works, History, and Pros and Cons", Investopedia, (May 2023), https://www.investopedia.com/generative-ai-7497939#toc-what-is-generative-ai.

9 NVIDIA Glossary, "Generative AI – What is it and How Does it Work?", NVIDIA, accessed November 1, 2023, https://www.nvidia.com/en-us/glossary/data-science/generative-ai/.

10 OpenAI, "DALL·E 2", accessed November 1, 2023, https://openai.com/dall-e-2.

11 Google Research, "MusicLM", accessed November 1, 2023, https://google-research.github.io/seanet/musiclm/examples/.

12 Arun Jagota, "Neural Language Models", Towards Data Science (Medium, May 2021), https://towardsdatascience.com/neural-language-models-32bec14d01dc.

13 NVIDIA NGC Catalog. n.d. "Language Modelling." https://catalog.ngc.nvidia.com/orgs/nvidia/collections/languagemodelling.

14 NVIDIA Glossary, "What are Large Language Models?", NVIDIA, accessed November 1, 2023, https://www.nvidia.com/en-us/glossary/data-science/large-language-models/.

15 Ashish Vaswani et al., "Attention Is All You Need", (Preprint, submitted June 12, 2017), arXiv:1706.03762. https://arxiv.org/abs/1706.03762.

16 Jay Alammar, "The Illustrated GPT-2 (Visualizing Transformer Language Models)", accessed November 1, 2023, http://jalammar.github.io/illustrated-gpt2/#part-1-got-and-language-modeling.

17 Tom B Brown et al., "Language Models are Few-Shot Learners." (Preprint, submitted May 28, 2020), arXiv:2005.14165. https://arxiv.org/abs/2005.14165.

18 OpenAI, "GPT-4 Technical Report." (Preprint, submitted March 15, 2023), https://arxiv.org/abs/2303.08774.

19 Hugging Face, "Introducing The World's Largest Open Multilingual Language Model: BLOOM" (July 12, 2022), https://huggingface.co/blog/bloom.

20 Romal Thoppilan et al., "LAMDA: Language Models for Dialog Applications" (Preprint, submitted January 20, 2022), https://arxiv.org/abs/2201.08239.

21 Sharan Narang and Aakanksha Chowdhery, "Pathways Language Model (PALM): Scaling to 540 Billion Parameters for Breakthrough Performance" Google Research (April 4, 2022), https://blog.research.google/2022/04/pathways-language-model-palm-scaling-to.html.

22 Zoubin Ghahramani, "Introducing PALM 2." Google Blog, (May 10, 2023), https://blog.google/technology/ai/google-palm-2-ai-large-language-model/.

23 OpenAI, "Introducing ChatGPT" (November 30, 2022), https://openai.com/blog/chatgpt.

24 Mehdi, Yusuf, "Reinventing Search with a New AI-Powered Microsoft Bing and Edge, Your Copilot for the Web", Official Microsoft Blog (February 16, 2023), https://blogs.microsoft.com/blog/2023/02/07/reinventing-search-with-a-new-ai-powered-microsoft-bing-and-edge-your-copilot-for-the-web/.

25 Bard, "What Can Bard Do and Other Frequently Asked Questions", accessed November 1, 2023, https://bard.google.com/faq.

26 UNESCO, "Digital Learning and Transformation of Education", accessed November 1, 2023, https://www.unesco.org/en/digital-education.

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The Implications of ChatGPT on Media Education in Cambodia: A Plus or a Minus?

Ponleu SOUN

Introduction

While journalism is the process of acquiring, evaluating, creating, and presenting news and information, journalists gain facts about an event or issue and then clearly and accurately represent that knowledge to the public. Journalists must adhere to ethical norms such as truthfulness, accuracy, objectivity, and impartiality to maintain professional integrity.[1]

Traditionally, the intent of the journalism curriculum includes internships and laboratory experience, in addition to a professionally oriented program, to produce an individual who can effectively and efficiently work in journalism and mass media industries; however, presently, journalism schools have added training in broadcast, advertising, publication, program designing, and reporting.[2] This makes journalism and media education an interconnected and interdependent discipline in modern society. In the United States, accreditation rules have encouraged a journalism curriculum to incorporate technological advancements and embrace a multidisciplinary curriculum that nurtures critical thinking, analytical reasoning, and problem-solving skills.[3]

On the other hand, there may be more valuable guides for future journalism and media education than imitating the best practices of the preceding generation. Rather than reinforcing outdated patterns, journalism and media educators may do more to push students to learn how to improve their work in their contemporary environment.[4] In journalism colleges, the status quo is becoming increasingly untenable. Creating new models that are more relevant to today's needs than earlier media sectors is a motivating endeavor for journalism educators and experts.

In today's digital advancement society, where artificial intelligence is at the core of digital transformation, media institutions have applied AI technology in their professions. For example, the Associated Press, the world's largest news agency, has used AI technology in many areas of journalism, including image recognition and computer vision, robotics, machine learning, natural languages, and speech.[5] To provide interactive visuals for dozens of stories each day, AP teamed with Graphiq, using AI to automate infographic generation and match its output to news articles in real time.[6] The AP and an IA company, Agolo, use natural language processing to create news summaries for chatbots and news article summaries for spontaneous social media posts.[7] In addition to text-to-speech technology that newsrooms leverage to broadcast news content using a synthetic voice, speech-to-text technology is used as a reporting tool to transcribe interviews and conversations in real time.

Media and journalism education in Cambodia at a glance

The curriculum structure of a bachelor's degree in higher education is divided into two groups: foundation study and skills training, which the skills training shall consist of core major subjects, basic major subjects, or elective major subjects.[8]

At the time of writing, at least three universities offer higher education degrees in journalism and media studies in Cambodia, including the Department of Media and Communication of the Royal University of Phnom Penh (RUPP), Faculty of Communication and Media Arts of Pannasastra University of Cambodia (PUC), and College of Media and Communications of University of Cambodia (UC). The Department of Media and Communication offers various courses to prepare students to become professionals and practitioners.[9] The foundation courses include principles and practice of journalism and digital skills for media studies, which equips students with basic knowledge and skills in digital maneuver essential for their studies. At the same time, students are exposed to intensive journalism courses such as news writing and reporting, journalistic inquiry and commentary, and photojournalism in their sophomore year. In years three and four, students will receive training and disciplines in various practical courses such as broadcast journalism, radio production, TV/Video production, investigative reporting, multimedia and online journalism, documentary film production, newsroom management, and entrepreneurial journalism.

In the Faculty of Communication and Media Arts of PUC, the major of journalism uses English as a medium and also trains and develops highly skilled journalism through offering various courses such as Digital Media and Society, Introduction to Journalism, Introduction to Media Law and Ethics, visual communication, photojournalism, news reporting and writing, radio and television broadcasting, broadcast journalism, current issue in media, and advanced journalism workshop.[10]
Providing either a Khmer or an English language program, the College of Media and Communications of UC also aims to produce broadly educated and ethical professionals by offering a four-year higher education program. Like the other institutions, the College of Media and Communication journalism program also prepares students to be writers, reporters, and editors for various media.[11]

Problem statement

With the advent of ChatGPT, journalism and the media will undoubtedly adapt to their newfound possibilities. As a result, media education needs to transform itself to effectively prepare students to become practitioners in the constantly changing media industries. This paper uses secondary sources to examine the advantages and disadvantages of using ChatGPT in journalism and media education. It begins by identifying significant benefits that ChatGPT can provide, followed by the risks associated with using ChatGPT in media education in Cambodia. This paper concludes with recommendations and proposals for media education institutions to include this technical implication in future media education curriculum modification.

Benefits of ChatGPT on media education

ChatGPT offers media education distinct advantages by enhancing both the efficiency and effectiveness of content creation while encouraging independent thinking among media practitioners. Through this technological support, educational institutions can encourage students to delve deeper into media and journalism content, fostering analytical and critical thinking skills while automating repetitive tasks with machine learning. In contrast to the traditional lecture-based approach, which often necessitates constant supervision, ChatGPT promotes a self-reliant learning mindset among students.

Cost-effective and time-efficient in content creation

Given that content creation is the backbone of media education, ChatGPT can offer cost-effective and time-efficient AI-generated content for students and educators to use and practice in the educational setting. The AI-generated content has been referred to as the ability to use a large language model and the strength of producing convincing responses to the context of ChatGPT in support of educational causes.[12] More specifically, it can help with assessment design, essay writing, and language translation, allowing users to pose and answer various questions and summarize materials.[13]

In courses like news writing and reporting, these functions will assist educators and students to spend less time and resources on writing and producing vital yet repetitive content. With that, they can focus on new features and higher-impact journalism with quality and in-depth analysis that their society still needs to cover. For investigative reporting courses, media students and educators can use the well-function of ChatGPT as a news-gathering tool to generate relevant responses to break news and dig into investigative news. This support can encourage students to dedicate additional time to thoroughly analyze the collected information and investigate news stories more comprehensively to pursue public interest. Furthermore, ChatGPT can help educators and students automate video transcription and generate short lists and story summaries to streamline workflow for courses like broadcast journalism, radio production, and video production. This ability will push educators and students to focus on assignments with higher-order thinking skills and creative and analytical thinking, which are essential for students to develop to succeed in their future careers.[14] Armed with these essential skills, media organizations can centralize the standardization of pre-production procedures, including scripting, content creation, and storytelling, all while maintaining a commitment to delivering high-quality outputs.

Promotion of independent and self-reliant media practitioners

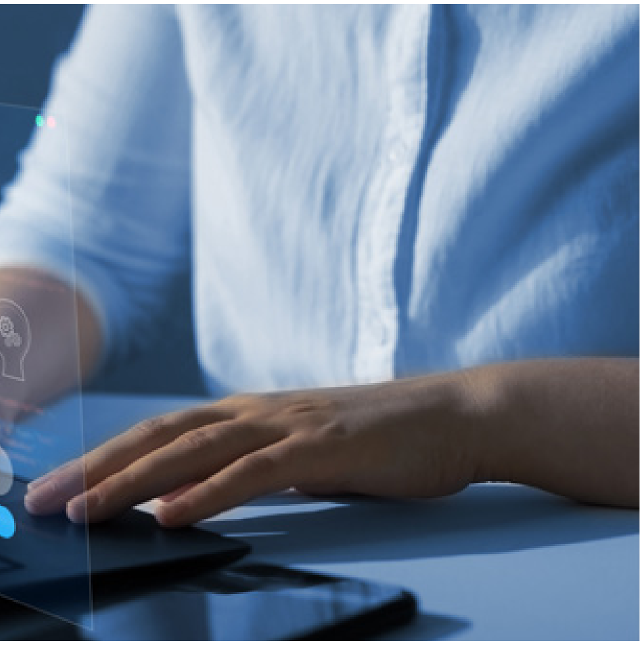
ChatGPT, in contrast to traditional class methods, is a potentially helpful technology that can be utilized as a personal tutor for media students, overshadowing human interaction, which deteriorates independent news writing and media creation. As previously said, in the education sector, students can benefit from experiential learning since ChatGPT can generate various problem-solving scenarios and provide students with personalized teaching.[15] From interaction with students, the AI could communicate and answer queries like humans, allowing students to stay curious and look for multiple approaches to solving assigned problems. With this strategy, the ChatGPT application has the potential to serve as a means of empowering students to become autonomous and self-directed learners to develop future independent media professionals. One of the critical strengths of ChatGPT in education is its ability to generate plausible personalized and real-time responses.[16] This would allow media students to be independent and free from supervisor's misjudgment and misperception. Instead of expecting supervisor feedback on the story they may need to gain expertise on, media students can now discuss with ChatGPT to have the assignment and story independently covered.

The main objective of journalism and media institutions is to create sufficient and independent journalists and media practitioners to serve the public interest. Adopting independent learning in the university can prepare students to contribute to the field. In courses like documentary film production, newsroom management, and entrepreneurial journalism, the personalized response tool of ChatGPT may help students find their purpose using their skills for long-term

personal development. The application of ChatGPT can help students become independent journalists free from influence by the government or other external sources. Journalists should feel no pressure to share or sanitize their reporting, even if it may negatively portray the government or other power entities, including the owners of the news outlets.[17] Through Chat-GPT's support, students can enjoy greater autonomy in their news writing, diminishing their dependence on mentors and peers, thereby equipping them to cultivate their individuality and self-reliance in media and journalism.

Costs of ChatGPT on media education

In addition to concerns surrounding academic integrity and cognitive bias that higher education institutions possessed



regarding the presence of ChatGPT in the education sector[18], information quality and accuracy and ethical consideration of media practitioners stand out as significant challenges posed by the integration of ChatGPT into the media education system. While troubled by the increased risks of plagiarism and cheating for courses that rely more on written outputs, the consequences of AI abuse in media education are relatively exacerbated, requiring constant skepticism and careful consideration.

Quality and accuracy of information

As an example of asking about health-related questions, the current version of ChatGPT did not consistently answer with suitable information when questioned about anatomical facts.[19] Given the fundamental limitation of ChatGPT, the primary concern of this application in media education is the creation of misinformation – information that is false but not intended to cause harm – that goes against the principles and standards of the media profession.[20] Even if the responses generated may sound plausible, it is a concern and danger that many ChatGPT-generated contents may lead to harmful information.[21]

Researchers in the news media have expressed concern about the material's accuracy, with incidences implying that ChatGPT made up content in the face of knowledge shortages and even created false resources.[22] Using ChatGPT in media education may risk that students generate text that is not based on facts but on false and misleading information. This is especially concerning when the model is utilized in courses requiring accuracy and truthfulness, such as news writing and reporting, journalistic inquiry and commentary, and investigative reporting.

A UNESCO report in 2023 illustrated that ChatGPT cannot distinguish right, wrong, genuine, and false since it only collects information from databases, texts, and online processes.[23] AI and chatbot models are frequently accused of prejudice and discrimination. ChatGPT can perpetuate biases in the data it was trained on, producing unfair or discriminatory outcomes.[24] Due to its underpinning mechanism, data trained on ChatGPT can be manipulated. As a result, it will give students misleading, irresponsible, and manipulated information.[25] Without proper verification and fact-checking, courses like radio, TV, and video production will likely base their narratives on false information and misinformation, leading to media integrity and transparency deterioration. In response, media educators and students need to stay skeptical and verify the information given by the ChatGPT.

Ethical considerations

Ethical consideration is another potential concern regarding the integration of ChatGPT in media education. It is a cause for concern if a media practitioner uses ChatGPT to generate false new content, such as text, audio, or images, to create misleading or malicious information that is difficult for people to distinguish from genuine content, resulting in the spread of disinformation and harmful news.[26] Without proper educator precaution, the same concern will appear for multimedia and online journalism courses if the students wish to manipulate the public, who may have no media literacy skills, through AI-generated content. As suggested by a researcher, the relevance of ethics in an online setting should be emphasized in approaches to social media reporting teaching.[27] Another ethical consideration revolves around the absence of references and sources from the ChatGPT.

In contrast to typical tools, ChatGPT furnishes and tailors immediate and natural responses without including sources or references. In this context, media students might seek to utilize prompted and modified responses generated by ChatGPT from online sources without securing permission or acknowledging the origin. Courses like multimedia and online journalism, video production, and documentary will face huge ethical concerns if the sources used in the students' content are not found or mentioned.

Way forward for the curriculum of media education institutions

Regardless of the drawbacks of the platform, it is inevitable to acknowledge and accept its impact on the education setting. As argued by one author, ChatGPT and similar tools will become a part of everyday writing in some shape or form, much as calculators and computers have become a part of math and science.[28] Similarly, another researcher recommends that instead of prohibiting students from utilizing AI technologies, they could be involved in molding and using them to promote learning.[29] This paper will offer a few suggestions for how journalism and media education, especially in Cambodia, should move forward on the heels of the development of AI.

Reinvention of media literacy in the curriculum

It is self-evident that media literacy has moved from reading and understanding traditional media frontiers to using sophisticated technological advancement to answer one's inquiry. In the age of ChatGPT, media education institutions shall reinvent and reintegrate media literacy with AI advancement in their curriculum, which would allow students to gain the ability to maximize the benefits and minimize the risks of using ChatGPT. As outlined by a research paper, reinventing media literacy in subdisciplines in which students in media and communication must be educated as responsible, ethical consumers and producers on digital platforms.[30] Designing a curriculum of AI media literacy would allow students to fully use the opportunities offered by ChatGPT for education, such as increasing the accessibility of information and facilitating personalized learning. Compulsory and elective courses like Digital Skills for Media Studies, Digital Media and Society, and Principles and Practice of Journalism should focus on media literacy skills and emphasize advancing responsible usage of ChatGPT by exposing students to different approaches to using this application and assessing its advantages and disadvantages in the media sector. For instance, educators can make it compulsory for students to critically analyze the results ChatGPT provides and compare them with other sources of information.

Integration of ethical components in the curriculum

Given the growth in AI's use across communication subdisciplines, its value to educators makes it an essential addition of ethical components to the media curriculum. Journalism and media educators should require students to take a course on the ethical and legal implications of using AI in journalism and media, such as the need to protect individual's privacy and rights, the importance of transparency and accountability in the use of AI, and the potential consequences of using AI in harmful or irresponsible ways. A finding suggests that applying journalism ethical standards such as responsibility, accuracy, impartiality, balance, objectivity, and truthfulness is essential to establishing a program to teach journalists.[31] Students in media education institutes must follow ethical norms on plagiarism, accuracy, and fairness in all assignments, especially news writing and reporting, radio production, TV/Video production, journalistic inquiry and commentary, documentary film production, broadcasting, and online journalism.

Conclusion

With set word limits, ChatGPT's answers and responses are precise and to the point if students correctly and properly phrase their first question and prompt questions. While offering extensive benefits to media education, the platform also has undesirable drawbacks and downsides that must be seriously considered and addressed. As suggested, higher education institutions should renovate media literacy skills and incorporate ethical components into the media education curriculum.
At the same time, it is recommended that future research emphasizes and explores the impact of this platform to direct stakeholders such as educators and students and the way forward to maximize the benefits and minimize the risks of such a tool in the media education setting.

1 John V. Pavlik, "Collaborating with CHATGPT: Considering the Implications of Generative Artificial Intelligence for Journalism and Media Education," Journalism & Mass Communication Educator 78, no. 1 (2023): 84–93, https://doi.org/10.1177/10776958221149577, 86.

2 Donica Mensing, "Rethinking [Again] the Future of Journalism Education," Journalism Studies 11, no. 4 (2010): 511–23, https://doi.org/10.1080/14616701003638376, 513.

3 Accrediting Council for Education in Journalism and Mass Communication, "Mission Statement," ACEJMC, August 23, 2013, http://www.acejmc.org/about/mission/.

4 Mensing, "Rethinking [Again] the Future of Journalism Education, 515.

5 Francesco Marconi and Alex Siegman, rep., The Future of Augmented Journalism: A Guide for Newsrooms in the Age of Smart Machines (New York, United States: Associated Press, 2017), 7.

6 Ibid., 8.

7 Ibid., 12.

8 JICA-HRD, trans., Decision On Implementation of Credit System and Credit Transfer into Curriculum (2004).

9 Department of Media and Communication, "About," DMC Department of Media and Communication, accessed July 25, 2023, https://dmc-cci.edu.kh/curriculumcourse-offered/.

10 "Curriculum," Paññāsāstra University of Cambodia, accessed September 7, 2023, http://www.puc.edu.kh/index.php/academics/communication-media-arts/curriculum.

11 "College of Media and Communications - Welcome to the University of Cambodia (UC)," UC, accessed September 7, 2023, https://cmc.uc.edu.kh/ucs/DegreePrograms/2/4.

12 Jianyang Deng and Yijia Lin, "The Benefits and Challenges of ChatGPT: An Overview," Frontiers in Computing and Intelligent Systems 2, no. 2 (2023): 81–83, https://doi.org/10.54097/fcis.v2i2.4465, 81.

13 Sarin Sok, "Opinion: Benefits and Risks of ChatGPT in Education," Cambodianess, February 15, 2023, https://cambodianess.com/article/opinion-benefits-and-risks-of-chatgpt-in-education.

14 "Higher-Order Thinking Skills," RSS, accessed September 7, 2023, https://www.structural-learning.com/post/higher-order-thinking-skills.

15 Jürgen Rudolph, Samson Tan, and Shannon Tan, "ChatGPT: Bullshit Spewer or the End of Traditional Assessments in Higher Education?," 16, no. 1 (2023): 342-363, https://doi.org/10.37074/jalt.2023.6.1.9, 354.

16 Mohammadreza Farrokhnia et al., "A SWOT Analysis of ChatGPT: Implications for Educational Practice and Research," Innovations in Education and Teaching International, 2023, 1–15, https://doi.org/10.1080/14703297.2023.2195846, 3.

17 European Liberties Platform, "Independent Journalism: Meaning, Value, Sources i Liberties.Eu," Liberties.eu, accessed September 7, 2023, https://www.liberties.eu/en/stories/independent-journalism/43789.

18 Sabzalieva Emma and Valentini Arianna, publication, ChatGPT and Artificial Intelligence in Higher Education: Quick Start Guide (United Nations Educational, Scientific and Cultural Organization, 2023), 11.

19 Sreenivasulu Reddy Mogali, "Initial Impressions of ChatGPT for Anatomy Education," Anatomical Sciences Education, 2023, https://doi.org/10.1002/ase.2261, 1.

20 Sylvia Braesel and Thorsten Karg, publication, Media and Information Literacy - A Practical Guidebook for Trainers (Third Edition) (DW Akademie), accessed September 7, 2023, https://akademie.dw.com/en/media-and-information-literacy-a-practical-guidebook-for-trainers-third-edition/a-42423367, 205.

21 Biyang Guo, et al., "How close is ChatGPT to human experts? Comparison corpus, evaluation, and detection," arXiv - CS - Computation and Language. Preprint posted online on 18 (2023), 1-20, DOI:arxiv-2301.07597, 2.

22 Hong, Wilson Cheong Hin. "The impact of ChatGPT on foreign language teaching and learning: opportunities in education and research." Journal of Educational Technology and Innovation 5, no. 1 (2023): 37 – 45, 39.

23 Sabzalieva and Valentini (n 19), 11.

24 Terry Yue Zhuo et al., "Red teaming ChatGPT via Jailbreaking: Bias, Robustness, Reliability and Toxicity." arXiv preprint arXiv:2301.12867 (2023).

25 Ahmed Tlili et al., "What If the Devil Is My Guardian Angel: ChatGPT as a Case Study of Using Chatbots in Education," Smart Learning Environments 10, no. 1 (2023), https://doi.org/10.1186/s40561-023-00237-x, 17.

26 John V. Pavlik, "Collaborating with CHATGPT: Considering the Implications of Generative Artificial Intelligence for Journalism and Media Education," Journalism & Mass Communication Educator 78, no. 1 (2023): 84–93, https://doi.org/10.1177/10776958221149577, 88.

27 Stephanie E. Bor, "Teaching Social Media Journalism: Challenges and Opportunities for Future Curriculum Design," Journalism & Mass Communication Educator 69, no. 3 (2014): 243–255, https://doi.org/10.1177/1077695814531767, 249.

28 Beth McMurtrie, "AI and the Future of Undergraduate Writing," The Chronicle of Higher Education, December 13, 2022.

29 Mike Sharples, "New AI Tools That Can Write Student Essays Require Educators to Rethink Teaching and Assessment," The London School of Economics and Political Science, May 17, 2022, https://blogs.lse.ac.uk/impactofsocialsciences/2022/05/17/new-ai-tools-that-can-write-student-essays-require-educators-to-rethink-teaching-and-assessment/.

30 Regina Luttrell et al., "The Digital Divide: Addressing Artificial Intelligence in Communication Education," Journalism & Mass Communication Educator 75, no. 4 (2020): 470–82, https://doi.org/10.1177/1077695820925286, 474.

31 Fergal Quinn, "Failing to Prepare? Journalism Ethics Education in the Developing World: The Case of Cambodia," Journal of Media Ethics 33, no. 2 (2018): 50–65, https://doi.org/10.1080/23736992.2018.1441031, 50.

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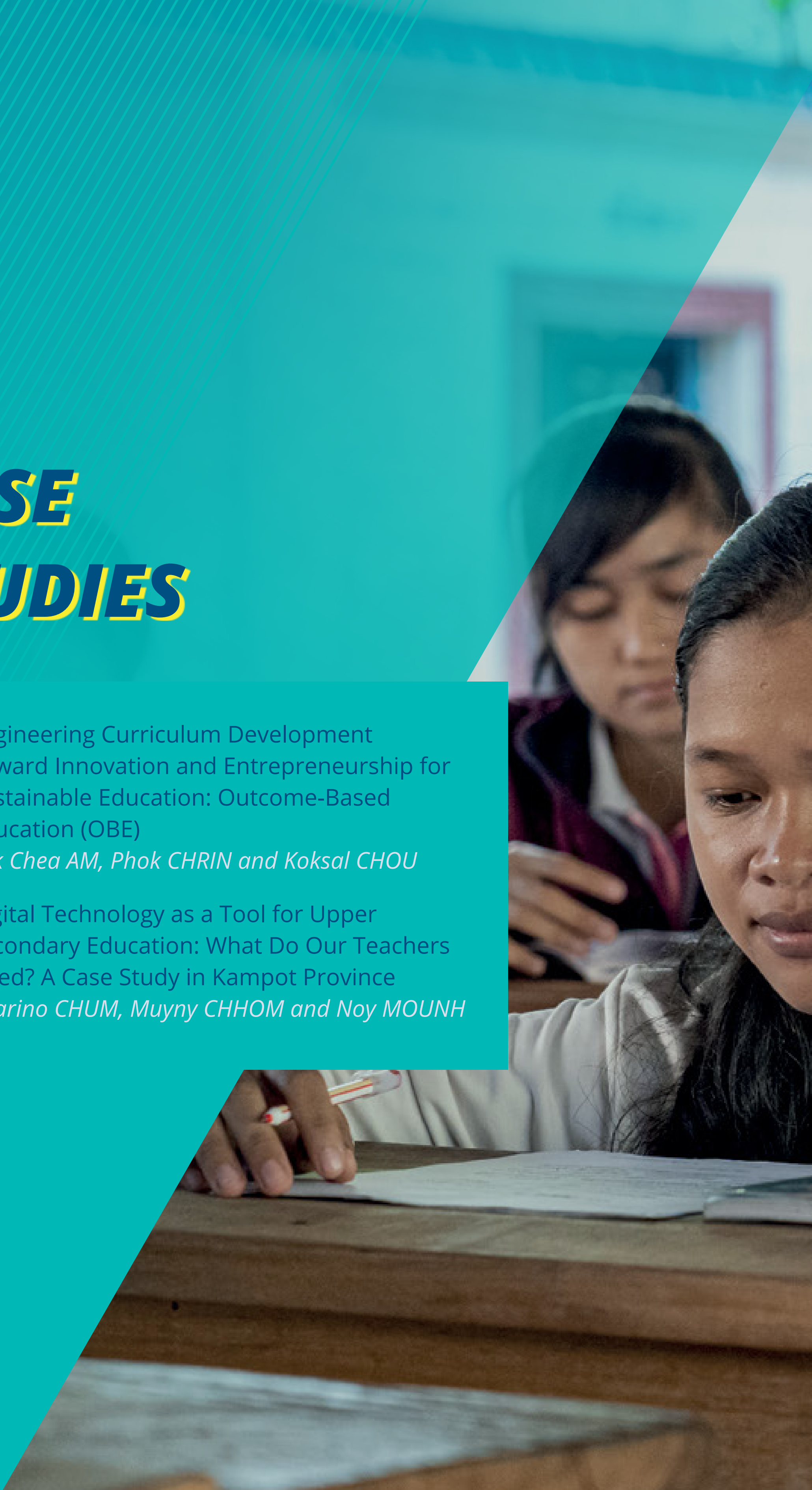


Engineering Curriculum Development Toward Innovation and Entrepreneurship for Sustainable Education: Outcome-Based Education (OBE)

Sok Chea AM, Phok CHRIN and Koksal CHOU

Abstract: This article examines how to design an innovation and entrepreneurship-integrated engineering education based on the concept of Outcome-Based Education (OBE). The objective of this work is to develop an Electronics and Automation Engineering curriculum associated with effective teaching and learning methods to ensure the achievement of students' outcomes in innovation and entrepreneurship. Three main outcomes of this program are defined: 1) Graduates who are qualified engineers, 2) Graduates who have lifelong learning skills and research skills, and 3) Graduates who are future techno-entrepreneurs. In order to obtain these outcomes, this academic program implemented Project-Based Learning (PBL) that drives each student to do a research project within the university or industry for about 2 years before graduation. Therefore, graduates expect to be equipped with 21st-century skills including higher-order thinking skills to be successful in their future careers. As a result, we implemented 22 applied research projects categorized into 12 university projects, 8 joint industry projects, and 2 joint collaboration projects with a partner university in the region. Among them, one final product (KHQR Vending Machine) is already commercialized to the local market. Three projects won the Techno Innovation Challenge Cambodia 2023.[1] One product from our research helped a local company to improve their productivity and increase revenue by USD 600 per hour compared to the previous operation.

Keywords: Curriculum design and alignment, Entrepreneurship, Assessment Rubrics, Project-Based Learning

1. Introduction

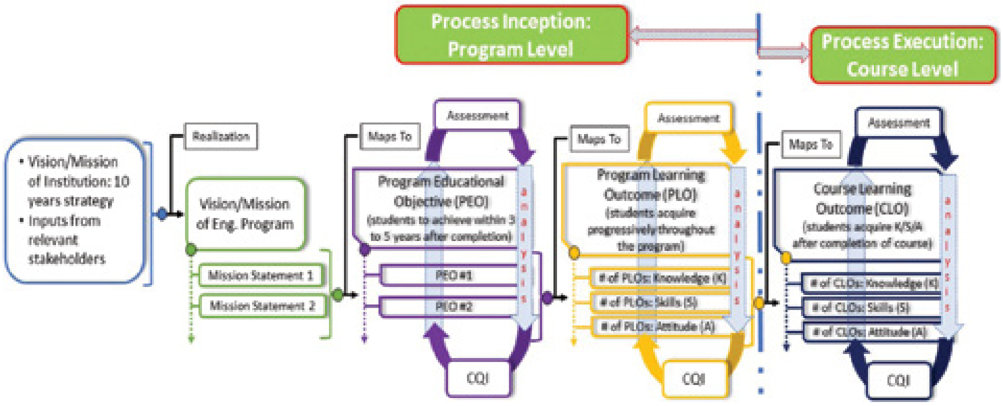
The traditional educational program and teacher-centered learning do not ultimately produce graduates with all skillsets required by the current and future work environment.[2] Currently, many companies seek candidates who have the technical skills and soft skills (21st-century skills) to complete the given task effectively. In response to those requirements, our institution has improved the engineering curriculum and applied Project-Based Learning (PBL) in order to produce graduates who have the important interdisciplinary skills, innovation skills, and entrepreneurship mindset essential in a modern market. The Electronics and Automation (EA) Engineering Program is designed for multidisciplinary skills and uses PBL as a driving force to fabricate graduates equipped with higher-thinking skills and the ability to become techno-entrepreneurs. Six subjects are introduced as project-based courses in the curriculum to provide the opportunity for each student to perform research in one project for 2 years before graduation. It covers a whole electronics and automation design and supply chain investment to connect the university, stakeholders, and market. The curriculum is developed based on the Outcome-Based Education (OBE) framework. OBE is a learner-centered learning philosophy that focuses on measuring students' outcomes.[3] In this framework, the outcomes are measured through the Program Educational Objectives (PEOs). Herein, the educational objectives of students for the next 3-5 years after graduation are pre-defined corresponding to the needs of stakeholders, i.e., the market requirements, and the ability to become techno-entrepreneurs and create jobs. The PEOs serve as the basis for designing the Program Learning Outcome (PLOs). PLOs define the outcome that students acquire during the program which is developed through the aggregation of the Course Learning Outcomes (CLOs). The relationship of this framework will be further discussed in this article, including the rubrics for assessing and evaluating the success of students' learning outcomes.

This paper is organized as follows. Section 2 elaborates in detail the OBE concept from PEOs to CLOs of curriculum development. Section 3 demonstrates a step-by-step on curriculum improvement of the EA Engineering Program. The detailed assessment and evaluation rubric is explained in this section. Section 4 summarizes the results of program implementation as well as potential products, from student projects, that are ready for commercialization in the local market. Finally, the conclusion is given in section 5.

2. Outcome-Based Education (OBE) Concept

OBE is a fit framework for establishing a performance-based education at the higher education curriculum. OBE builds an environment where students are navigated by what they can learn and apply to solve real-life problems. OBE is a method of planning, developing, delivering, and documenting instruction in terms of its intended goals and outcomes.[4] The outcomes are a principal value for curriculum development. Hence, OBE is a blend of three types of proficiencies: a) experimental: understanding how to experiment with things, and the ability to make a correct decision, b) fundamental: knowing and overcoming what you are doing and why, and c) reflective: learning and adjusting by way of self-reflection; use knowledge properly and responsibly. Learners take full responsibility for their learning and are motivated by feedback and affirmation of their worth.[5] Figure 1 shows the comprehensive OBE mandate that is linked from the vision/missions of the university to the CLOs of the program.

Figure 1: Dependency among vision/mission, PEOs, PLOs, CLOs, and CQI of an Eng. Program – own compilation[6]



2.1 The OBE Framework

Figure 1 proposes a comprehensive OBE framework, which is accurate and solid enough to address the key stake and activity that needs to be accomplished for the successful adoption of OBE within an Engineering Program. According to this framework, there should be 2 main processes that need to be executed in sequences. The first main part is the process inception (program level), which covers the program's visions and missions – program educational objectives (PEOs) – and program learning outcomes (PLOs), which have to be conducted. Once the task of program structure is accomplished, the process execution (course level) has to be developed to design the program curriculum for responding to the defined PLOs in the previous process. The assessment must be processed in every cycle and followed by the continuous quality improvement (CQI) plan. Table 1 details each step of curriculum development.

Table 1: The OBE mandates

No	OBE Mandate
1	Clearly define the vision and mission statements of an Engineering Program that are aligned with national policy and strategies. The vision and mission statements of the program must show the commitment and action preparing for success for all learners.
2	Clearly define PEO statements of a program that show what students will become after 3 to 5 years of graduation. Then, define PLO statements that students must demonstrate at the point of their graduation. PEOs & PLOs must be mapped to each other and support the engineering program's mission statements.
3	CLO statements of each course in a curriculum should demonstrate certain knowledge (K), skills (S), and attitudes (A) that students can obtain after completion of the course.

No	OBE Mandate
4	A system of instructional decision-making and delivery that employs a variety of methods, assures successful demonstration of all outcomes (CLOs) and provides more than one chance for students to be successful. Active teaching-learning methods should be applied for students to achieve targeted CLOs.
5	A criterion-referenced system (commonly known as Rubrics) of assessment. This ensures benchmark assessment practice that is transparent, focused, unbiased, and performance-driven.
6	An ongoing system of program improvement, commonly known as the CQI process includes academic process measurement and improvement, staff accountability, effective leadership, and staff collaboration.
7	A database of significant, visionary outcomes for all students, plus key indicators of program effectiveness, that is used and updated regularly to improve conditions and practices that affect student and staff success.

2.2 Program Level: Vision, Mission, PEO, and PLO Statements

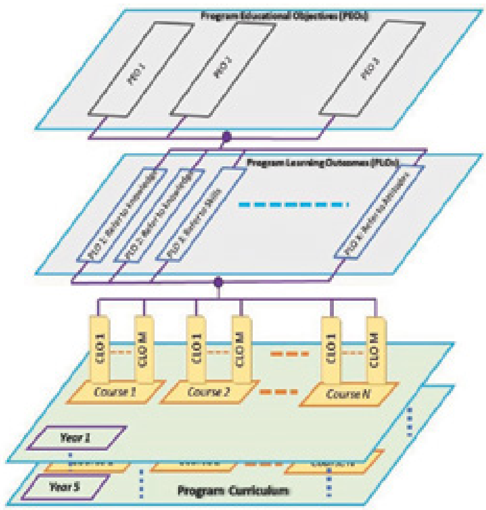
To define the vision and mission statements of an academic program, the program developers should collect and analyze the vision and mission statements from university and government strategies as well as the current and future labor markets in the field. As presented in Figure 1, in order to ensure the success of the defined vision and mission of an education program, the PEOs must be well-defined and must support that vision and mission.[7] In a short definition, PEO statements describe the career and professional accomplishments that the program wants graduates to achieve. The PEOs' assessment depends on the achievements of graduates who have worked for 3 to 5 years after graduation. An Engineering Program usually has 3 to 5 PEO statements. Additionally, for evaluating the effectiveness of the program, the PEO attainment should be measured periodically (3 – 5 years after the student's graduation, and the assessment can be performed in the form of a tracer study). Thus, the preparation and execution of the PEOs evaluation process should be developed. This process should comply with the guidelines detailed in Table 2.

Table 2: The definition and guidelines for PEO development and assessment

No.	Properties for PEO definition	Guideline for PEO assessment
(a)	Each PEO statement should be consistent with the vision and mission statements of the program	The PEO assessment tools should be indicated, and how these tools are used should be explained.
(b)	PEO must be supported by a well-defined curriculum and the teaching-learning process.	The PEO assessment tools should be indicated, and how these tools are used should be explained
(c)	A justification of how curriculum and academic process contribute to the attainment of the PEOs.	Adequate documentation of the evidence associated with the PEO assessment should be provided.

PLO statements of an academic program show what learners are expected to know and their ability to perform by the time of graduation. PLO statements demonstrate what are the crucial knowledge (K), technical skills (S), and attitudes (A) that the learners acquire within the program. The program curriculum and course structures must be designed and executed accordingly so that by the time of graduation students have achieved an acceptable minimum level of K-S-A addressed by the PLOs. The number of PLO statements of each program can be defined based on a well-known international qualification framework such as the Accreditation Board of Engineering and Technology (ABET: 7 PLOs), the Washington Accord (12 PLOs), the Engineering Accreditation Council (12 PLOs), etc.8 PLOs of this engineering program are designed according to the ABET guidelines. Figure 2 shows the alignment of PLOs towards the attainment of PEOs and support by course structure.

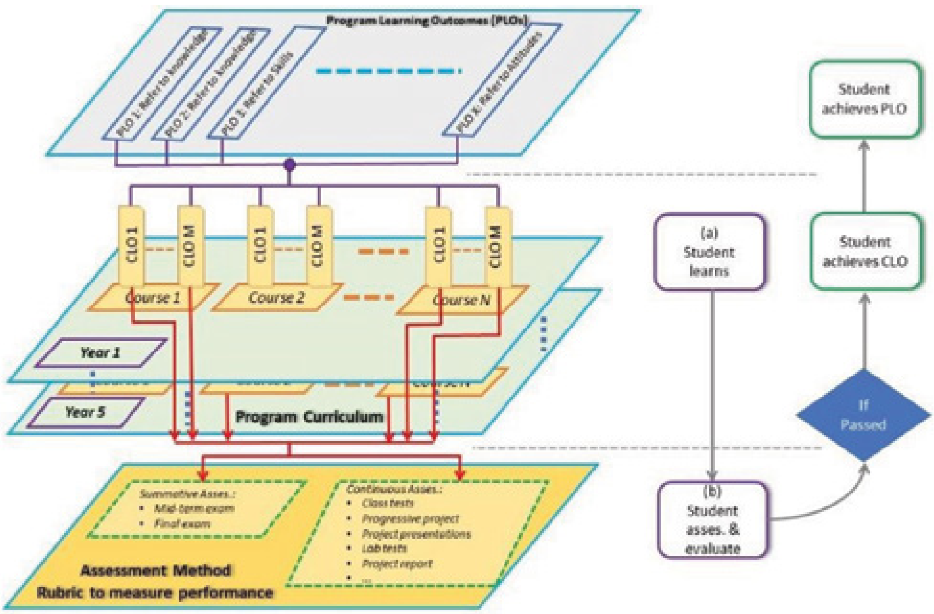
Figure 2: Mapping between PLOs-PEOs-CLOs of a program



2.3 Course Level: CLO Statements

At the course level, re-structuring each course outline/curriculum, developing the CLOs and mapping to PLOs, defining project-based teaching and learning methods, and evaluation and assessment tools should be developed. In the curriculum, one course must have a set of CLOs representing what is the knowledge (K), technical skills (S), and attitudes (A) the learners are expected to obtain after the completion of the course. A CLO should mention what students would know and ability to perform after the completion of the course. A revised Bloom's taxonomy proposed by Krathwohl D. R is used for defining each CLO of a course.[9] Furthermore, CLOs should be classified at the level in Bloom's Learning Domain (such as cognitive - C, affective - A, or psychomotor - P skills) and should correlate with more than one PLO of the program. For developing course content, in the format of a course syllabus, each course should outline the important points such as measurable and assessable CLOs, Lesson Learning Outcomes (LLOs) for weekly teaching and learning activities, appropriate teaching methods, design-based problems for appropriate learning activities, and evaluation methods for each proposed CLOs. An Active Learning System (ALS) is implemented in some courses to prepare students to be able to perform well in future project-based courses at the program level.[10] ALS method will teach students to be more active, have hands-on experience, self-evaluate, and teach others about their work. For assessing and evaluating each course for each student, according to the OBE concept, formative assessment and summative assessment strategies are recommended. Figure 3 shows the assessment and evaluation methods for the attainment of CLOs and corresponding PLOs for a student.

Figure 3: CLO Assessment Process and corresponding PLOs by a student



3. Case Study: Implementation of OBE for EA Engineering Program

The engineering degree in EA at our institution, the Institute of Technology of Cambodia (ITC), is a 5-year program with a 2-year foundation and 3-year specialization part. In 2019, the institution conducted a self-assessment of the program by reviewing the feedback from all stakeholders. Several main issues have been identified such as students' lack of communication skills, limited technical skills, limited interest and decision-making, and lack of entrepreneurship mindset. Since then, ITC has revised the curriculum to tackle these above issues by setting up a clear set of vision/mission statements, redefining the PEO and PLO statements, and integrating PBL and ALS learning approaches to improve the students' performances and outcomes required at the workplace.
In the new curriculum, each student has to complete a project for about 2 years before their graduation.

3.1. Vision, Mission, PEO, and PLO Statements of EA Engineering Program

In a 10-year strategy framework of the university, the vision and mission statements are 1) provide quality and equitable education in science and technology to become engineers with high professional ethics, entrepreneurial ability, creativity, innovation, virtue, morality, conscience, patriotism, social responsibility, and high awareness and 2) develop scientific research, and transfer technology to the national community to enhance production capacity and harmonize.[11] Therefore, the vision and mission statements of the EA Engineering Program must be developed to support the above statements of the institution. Table 3 highlights those statements (on the left side). According to this table, two main mission statements are highlighted. Moreover, to support these two mission statements, three PEOs are defined a) enhancement of technical skills for the betterment of society, b) improve lifelong learning skills, and c) development of entrepreneurship and leadership skills.

Table 3: **Vision, mission, and PEOs for the EA program**

Vision/Mission of the Program	PEOs of the Program
Vision: The vision is to become a prominent EA Engineering Program that produces graduates with 21st-century skills and innovation who will contribute to the technology-led vision of the country in electronics, smart automation, robotics, and emerging globalization.	PEO - 1: To produce graduates who are ***qualified engineers*** in electronics (design and fabrication) and automation (production line, applied AI in automation, automation in smart grid/building) to meet market needs nationally/internationally.
Mission - #1: Produce graduates with high skills (technical skills and soft skills) for innovation for the country's vision 2030/2050 as well as for the emergence of globalization in the related field.	PEO - 2: To produce graduates who have ***lifelong learning skills*** and ***pursue higher education*** which will increase the number of qualified managers level in the EA field.
Mission - #2: Produce graduates who are lifelong learners and entrepreneurs through applied research and development (R&D) projects.	PEO – 3: To produce graduates who are ***entrepreneurs*** in the field of electronics and automation or other sectors.

Table 4 presents the mapping between the PEOs and the mission statements of the program. Among those 3 PEOs, at least 2 PEOs are combined to support one mission statement. This program consists of 46 subjects for a duration of 5 years. Figure 4 shows the repartition of courses dedicated to supporting each PEO statement. Six subjects are invented for students to learn with a project-based approach that leads to creativity, confidence in themselves, and the ability to become entrepreneurs. These courses are crucial for measuring the success of all three PEO statements. PLO statements relate to the knowledge, skills, and attitudes that students acquire progressively throughout the program. For each engineering program, the ABET accreditation has defined seven mandatory PLOs. Table 5 and Table 6 detailed the PLO statements and their mapping to PEOs, respectively.

Table 4: **Mapping between the PEOs and mission statements**

Program Educational Objectives (PEOs)	Mission statements of the program	
	Mission #1	Mission #2
PEO - 1	✓	
PEO - 2		✓
PEO - 3	✓	✓

Figure 4: Course repartition dedicated to the attainment of each PEO statement

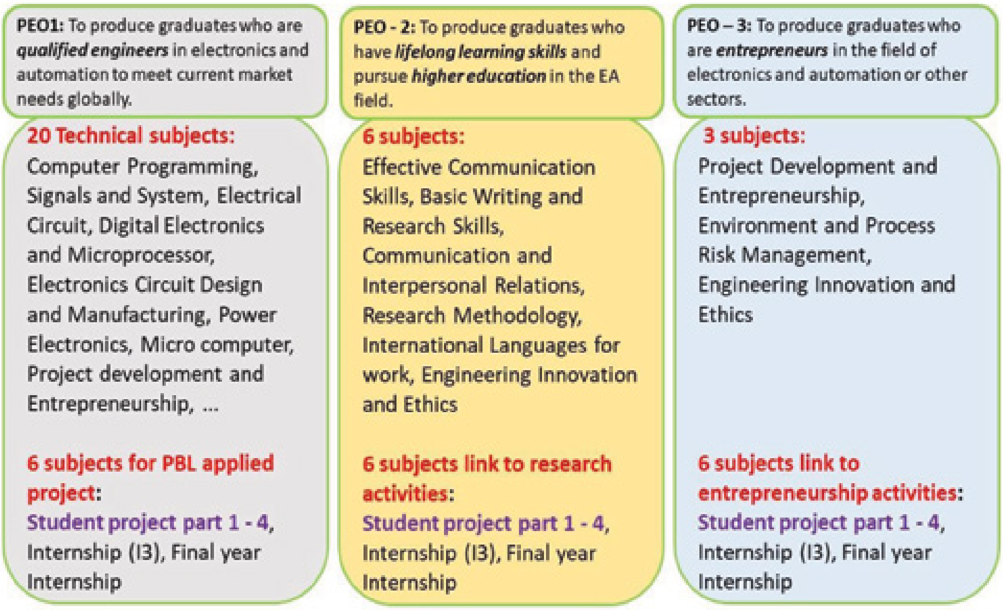


Table 5: Program Learning Outcomes (PLO) statements

Categories	Program Learning Outcomes (PLOs)
Knowledge (K)	PLO – 1: An ability to apply new knowledge as needed, using appropriate learning strategies, and research-based knowledge in the fields of Electronics and Automation.
Skills (S)	PLO – 2: An ability to solve complex EA engineering problems by applying principles of engineering, science, and mathematics.
	PLO – 3: An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, welfare, cultural, social, environmental, and economic factors in the field of Electronics and Automation.
	PLO – 4: An ability to conduct appropriate experimentation with data interpretation to draw conclusions in the scope of Electronics design and Automation development.

Categories	Program Learning Outcomes (PLOs)
Attitudes (A)	PLO – 5: Ability to apply written, oral, and graphical communication with appropriate usage of technical literature in broadly defined technical and non-technical environments.
	PLO – 6: An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
	PLO – 7: An ability to function effectively on a team whose members provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

PLO	Program Educational Objectives (PEOs)		
	PEO - 1: Qualified Engineers	PEO – 2: Lifelong Learning	PEO – 3: Entrepreneurship
PLO1	✓	✓	
PLO2	✓	✓	
PLO3	✓		✓
PLO4	✓	✓	
PLO5		✓	✓
PLO6	✓		✓
PLO7	✓		✓

3.2 Defining the curriculum

The next action is to develop the program curriculum including the adjustments in the existing courses and integrate the new 18 courses with draft content to address the comprehensive attainment of the PLOs. Most of those new courses are designed to train students on attitudes, research innovation activities, and upgrade their critical thinking skills. The main objective of those courses is to create a learning environment that can help students to be more active inside and outside classrooms.

After spending 2 years in the foundation stage, all students will be driven by PBL (courses: student project Part 1 to 4 plus a final year internship) for more than 2 years in the specialization of the EA program. The curriculum must provide both breadth and depth across the range of engineering, science, and ethical contents consistent with the PLOs. Thus, the curriculum designed for the EA Engineering program has comprehensive coverage of all required academic dimensions for adequate teaching and learning of the designated PLOs. Table 7 draws the overall curriculum with a mapping toward the attainment of PLOs. As presented in this table, twelve courses are combined to support PLO 4. PLO 3 mapped to 28 courses while the other PLOs aligned with the number of subjects ranging from 14 to 24.

3.3 OBE process implementation at course level

After the curriculum arrangements are set, the course-level process execution begins. This is the most important process in the OBE framework that shapes the actual learning of students. Therefore, the OBE framework (Figure 3) is adopted verbatim for defining the outline for each course, detailing the learning outcomes (CLOs), their association with the contents, and evaluation strategies towards the attainment of the mapped PLOs. All these necessary definitions for each course are documented in individual course files, titled Course Syllabus. A subject called "*Power Electronics*" was chosen for the course outline demonstration. This is one of the main courses for the EA Engineering program. The content is to teach students about power electronics conversion as well as the modeling of converter and simulation works with software (Matlab/ LTSpice) plus the preparations for prototype development which corresponds to the requirement of its suitable application. This subject requires 2 hours of lecture, 2 hours of tutorial, and 2 hours of Lab per week and continuous for 16 weeks to complete a semester. There are 60 students (2 groups) enrolled for this course. For developing a detailed course syllabus, the CLOs must be first defined and mapped to PLOs, as shown in Figure 5.

Table 7: CLOs of course "Power Electronics" with a mapping toward PLOs of program

Year	Course Title	PLOs						
		1	2	3	4	5	6	7
Y1	Effective Communication Skills					✓	✓	✓
	Engineering Mathematics I	✓	✓					
	Programming C++	✓		✓				
	Physic for Engineering I	✓	✓					
	Engineering Mathematics II	✓	✓					
	Chemistry for Engineering	✓	✓					
	Physic for Engineering II	✓	✓					
	Basic Writing and Research Skills					✓	✓	✓

		PLOs						
Year	**Course Title**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Y2	Calculus for Engineers	✓	✓					
	Engineering Mechanics			✓	✓			
	Fundamentals of Programming	✓		✓				
	Electrical Systems		✓	✓	✓			
	Engineering Foundations: Principles, Design and Communication			✓				
	Resource, Process, and Materials Engineering			✓			✓	
	Environmental Engineering						✓	✓
	Engineering Drawing and Computer Aided Design			✓				
Y3	Computer Programming	✓		✓				
	Signals and System			✓	✓			
	Electrical Circuit			✓	✓			
	Electronics Analog and Filter			✓	✓			
	Engineering Innovation and Ethics		✓			✓	✓	✓
	Feedback Control System							
	Digital Electronics and Microprocessor		✓		✓			
	Electrical Machine	✓			✓			
	Student Project Part 1	✓	✓	✓	✓	✓	✓	✓
	Communication and Interpersonal Relations					✓	✓	✓
	Numerical Method and Optimization		✓	✓				
Y4	Electric Drive		✓	✓	✓			
	Modern Control System		✓	✓	✓			
	Power Electronics	✓		✓	✓	✓		
	Research Methodology	✓					✓	✓
	Industrial Network Protocol		✓	✓	✓			
	Student Project Part 2	✓	✓	✓	✓	✓	✓	✓

Year	Course Title	PLOs 1	2	3	4	5	6	7
Y4	Sensors and Actuators		✓	✓	✓			
	Programmable Logic Controller		✓	✓	✓			
	Real-Time Embedded Systems		✓	✓	✓			
	Electronics Circuit Design and Manufacturing		✓	✓	✓			
	International languages for work					✓	✓	✓
	Student Project Part 3	✓	✓	✓	✓	✓	✓	✓
Y5	Industrial Automation		✓	✓	✓			
	Environmental and Process Risk Management						✓	✓
	Image Processing		✓	✓	✓			
	Micro Computer		✓	✓	✓			
	Project Development and Entrepreneurship					✓	✓	✓
	Student Project Part 4	✓	✓	✓	✓	✓	✓	✓
	Final Year Thesis	✓	✓	✓	✓	✓	✓	✓
	46 (with 18 new courses in Red)	17	24	28	23	12	15	14
Total		37%	52%	61%	50%	26%	33%	30%

Figure 5: CLOs of course "Power Electronics" with a mapping toward PLOs of program

Description of the course learning outcomes - CLOs		Matching PLOs/Definitions	
CLO1 (K)	Ability to *apply* basic *knowledge* of power electronics components, power electronics structure, and its application in the Electronics/Automation field. (C3)	PLO1,	**PLO1**: An ability to acquire and apply ***new knowledge*** as needed, using appropriate learning strategies, and research-based knowledge in the fields of EA field.
CLO2 (S)	Ability to ***design a suitable and economical*** power electronics converter for requirement specification. (C6, P7)	PLO1, PLO3	**PLO3**: An ability to apply ***engineering design*** to produce solutions that meet ***specified needs with consideration*** of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors in the field of EA.
CLO3 (A)	Ability to develop ***effective communication*** skills (presentation, writing, teamwork) of power electronics systems in scientific and non-scientific communities. (C6)	PLO3, PLO5	**PLO5**: Ability to apply ***written, oral, and graphical communication*** with appropriate usage of technical literature in broadly-defined technical and non-technical environments.

The next step in defining the course outline is to develop the course content that is tightly mapped toward the comprehensive CLOs. Additionally, effective teaching-learning strategies and CLO assessment methods must be equipped with the content. Figure 6 shows: a) A weekly course content/topic distribution for Power Electronics, b) Associated teaching methods, c) Effective learning methods and assessment strategies, and d) Maps of what weekly contents are relevant to which CLOs. This systematic detailing serves both the teachers and the students, alike to get a clear picture of what engineering qualities to be developed within the course, and how to deliver and acquire those qualities.

Active Learning System (ALS): As cited in vision/mission and PEO statements, this EA engineering program aims to equip graduates with 21st-century skills (from ways of thinking/communication to ways of creation/system thinking) who can serve as future human capital for tech-innovation and techno-entrepreneurship. Therefore, the learning method at the course level (e.g. subject "Power Electronics"), constructing a practical learning system, and setting up a practice platform for students are necessary for guiding students to conduct innovative practice activities and to have the required skill set at the workplace.[12] As shown in the weekly content and learning activity, the Power Electronics course is designed to train students to be more active by assigning them to a team to solve, simulate, report, and present case study problems in each lecture. Following the content definition, the assessment and evaluation strategy should be carried out in two strategic categories for a course, e.g., Continuous Assessment and Summative Assessment. There are several assessment tools within each of the categories that can be deployed for evaluation. Table 8 summarizes the assessment and evaluation method for this subject. Under the Continuous Assessment type, four distinct assessment tools are used, namely lab and assignment on modeling/hardware (25%), progressive report and presentation (25%), and tests (10%). Midterm exam (20%) and final exam (20%) are the two assessment tools for the Summative Assessment type. Another analysis, from this table, 50% of the score is planned for CLO1's assessment. 25% of the score is reserved for CLO2's assessment and 25% is used to evaluate the student's achievement of CLO3.
The student learning time (SLT) is 120 hours for 3 credits course.

Figure 6: A course syllabus of the subject "Power Electronics"

Week	hours (L/T/P)	CLOs	Lesson Learning Outcomes (LLOs)	Lecture	Teaching Method/activity	Learning Method/activity (ALS)	Assessment	T&L Resources
1	2/2/2	CLO1	- Ability to distinguish different PE devices. - Ability to select semiconductor devices for specific specifications of the converter. - Ability to select power electronics systems for suitable applications.	Lecture 1: Introduction to Power Electronics System: Devices, Structure, and Application	- Lecture on the passive device: the relationship between voltage and current (definition) - Lecture on the active device: switch ON/OFF - Lecture on conversion types of power electronics systems - Lecture on the example of power converter for suitable applications: challenges, and issues - Demonstrate how to perform Lab. #1: ON/OFF Diode/MOSFETs	- Review provided learning material - Review state-of-art of semiconductor devices - Work as a group of two students on provided topics/resources and research on the internet about active devices. - Presentation during Tutorial class - Work as a group for Lab. - Review Lab. topic before class.	–	- PPT - Completed document on active devices - Lab. #1: Topic - Safety guidelines for Lab. Class
2-3	4/4/4	CLO1 CLO2 CLO3	- Ability to compute the half-wave rectifier with Diode and with Thyristor - Ability to analyze the half-wave rectifier operation for different load types. - Ability to simulate the half-wave rectifier with a case study. - Ability to build a single-phase half-wave rectifier with 1 diode.	Lecture 2: Operation and Device Sizing for Half-Wave Rectifier	- Lecture on a single-phase half-wave rectifier with R load, RL load, RL+Vdc (DC motor) - Demonstrate how to use Matlab/Simulink for a case study rectifier - Provide 12-15 problems (case study) - Assign students as a group responsible for the oral presentation: 1 case study - Show the format of the report and the deadline to submit the report. - Monitor and follow up on Lab. #1 - Demonstrate how to perform Lab. #2: Half-wave rectifier for 10W - Lecture on using KidCad for PCB design of 10W half-wave rectifier	- Review provided learning material before class (Flip-Classroom) - Review on state-of-art of half-wave rectifier system and its various range of applications - Review how to use software (Matlab/Simulink, Spice) in the rectifier system. - Working as a group of two students on provided topic for the selected names. - Teach or instruct others in the class on the group findings (***only for assigned students***) - Submit a synthesis report of the case study. - Review Lab. #2 before class	- Progressive report and presentation according to lecture: ***Rubrics*** (devices, construct PE, Modeling PE, prototype, Report) 5 slides: intro → device → model → conclusion, 3 minutes presentation. - Lab & assignment: hardware and report	- PPT - Completed document of Half-wave rectifier - Lab. #2
4-5	4/4/4	CLO1 CLO2 CLO3	- Ability to compute the full-wave rectifier with Diodes/Thyristor - Ability to analyze the full-wave rectifier operation. - Ability to simulate the full-wave rectifier with a case study. - Ability to build a 1-phase full-wave rectifier	Lecture 3: Operation and device sizing for Full-Wave Rectifier	- Lecture on a single-phase full-wave rectifier with R load, RL load, RL+Vdc (DC motor) - Provide 12-15 problems (case study) - Assign students as a group responsible for the oral presentation for 1 case study - Recall the format of the report and the deadline to submit the report. - Monitor and follow up on Lab. #2 - Demonstrate how to perform Lab. #3: Full-wave rectifier for 10W	- Review provided learning material - Review how to use software (Simulink, Spice) in the rectifier system. - Working as a group of two students on the provided topic for the selected names. - Teach or instruct others in the class on the group findings (***only for assigned students***) - Submit a report of the case study. - Continuous working on Lab. #2 - Review Lab. #3 before class	- Progressive report and presentation according to lecture: ***Rubrics*** (devices, construct PE, Modeling PE, prototype, Report) 5 slides & 3 minutes presentation. - Lab & assignment: hardware and report	- PPT - Completed document of full-wave rectifier - Lab. #3
6	2/2/2	CLO1 CLO2 CLO3	- Ability to compute the 3-phase rectifier with 6 Diodes/Thyristor. - Ability to analyze the 3-phase rectifier operation for different load types. - Ability to simulate the 3-phase rectifier with a case study. - Ability to build a 3-phase rectifier.	Lecture 4: 3-Operation and device sizing for 3-phase rectifier	- Lecture on a 3-phase rectifier with R load, RL load, RL+Vdc (DC motor) - Provide 12-15 problems (case study) - Assign a pair of students as a group responsible for the oral presentation of only 1 case study during Tutorial class - Recall the format of the report and the deadline to submit the report. - Monitor and follow up on Lab. #3 - Prepare problems (Quiz #1)	- Review how to use software (Matlab/Simulink, Spice) in the rectifier system. - Working as a group of two students on the provided topic for the selected names. - Teach or instruct others in the class on the group findings (***only for assigned students***) - Submit a synthesis report of the case study. - Continuous working on Lab. #3	- Progressive report and presentation according to lecture: ***Rubrics*** (devices, construct PE, Modeling PE, prototype, Report) 5 slides & 3 minutes - Lab & assignment: hardware and report - Class Test #1 (Quiz1)	- PPT - Completed document of full-wave rectifier - Lab. #3 - Quiz #1
7	2	CLO1					Mid-term exam	Midterm doc.
8-9	4/4/4	CLO1 CLO2 CLO3	- Ability to compute the Buck / Boost Converter - Ability to analyze the Buck and Boost Converter operation. - Ability to simulate the Buck Converter and Boost Converter with a case study. - Ability to build Buck or Boost Converter.	Lecture 5: Operation and Device Sizing for DC-DC Non-isolated Converter Part 1	- Lecture on a Buck Converter and a Boost Converter - Demonstrate how to use Matlab/Simulink for a case study Buck/Boost converter. - Provide 12-15 problems (case study) - Assign students as a group responsible for the oral presentation for 1 case study - Recall the format of the report and the deadline to submit the report. - Demonstrate how to perform Lab. #4: Buck Converter and Boost Converter for 25W	- Review how to use software (Matlab/Simulink) in the converter system. - Working as a group of two students on the provided topic for the selected names. - Teach or instruct others in the class on the group findings (***only for assigned students***) - Submit a synthesis report of the case study. - Review Lab. #4 before class	- Progressive report and presentation according to lecture: ***Rubrics*** (devices, construct PE, Modeling PE, prototype, Report) 5 slides & 3 minutes presentation. - Lab & assignment: hardware and report	- PPT - Completed document of full-wave rectifier - Lab. #4
11-12	4/4/4	CLO1 CLO2 CLO3	- Ability to compute the Buck-Boost Converter, Cuk and SEPIC Con. - Ability to analyze the Buck-Boost, Cuk, and SEPIC operations. - Ability to simulate the Buck-Boost/Cuk/SEPIC Converter with a case study. - Ability to build Buck-Boost.	Lecture 6: Operation and Device Sizing for DC-DC Non-isolated Converter Part 2	- Lecture on a Buck-Boost Converter, Cuk Converter, and SEPIC Converter - Demonstrate how to use Matlab/Simulink for a case study Buck-Boost/Cuk/SEPIC converter - Provide 12-15 problems (case study) - Assign students as a group responsible for the oral presentation for 1 case study - Recall the format of the report and the deadline to submit the report. - Demonstrate how to perform Lab. #5: Flyback Converter for 25 W	- Review how to use software (Matlab/Simulink, Spice) in the rectifier system. - Working as a group of two students on the provided topic for the selected names. - Teach or instruct others in the class on the group findings (***only for assigned students***) - Submit a synthesis report of the case study. - Review Lab. #5 before class	- Progressive report and presentation according to lecture: ***Rubrics*** (devices, construct PE, Modeling PE, prototype, Report) 5 slides & 3 minutes presentation. - Lab & assignment: hardware and report - Class Test #2 (Quiz2)	- PPT - Completed document of full-wave rectifier - Lab. #5 - Quiz #2
13-14	4/4/4	CLO1 CLO2 CLO3	- Ability to compute the Flyback Converter, Forward Converter - Ability to analyze the Flyback/Forward converter operations. - Ability to simulate the Flyback/Forward Converter. - Ability to build Flyback.	Lecture 7: DC-Power Supply Part 1	- Lecture on a Flyback and Forward Converter - Demonstrate how to use Matlab/Simulink for building a case study Flyback/Forward converter as well as the plot of the waveform - Provide 12-15 problems (case study) - Assign students as a group responsible for the oral presentation for 1 case study - Recall the format of the report and the deadline to submit the report. - Monitor on Lab. #5: 25W Flyback Converter	- Review how to use software (Matlab/Simulink, Spice) in the rectifier system. - Working as a group of two students on the provided topic for the selected names. - Teach or instruct others in the class on the group findings (***only for assigned students***) - Submit a synthesis report of the case study. - Continuous working on Lav. #5	- Progressive report and presentation according to lecture: ***Rubrics*** (devices, construct PE, Modeling PE, prototype, Report) 5 slides & 3 minutes presentation. - Lab & assignment: hardware and report	- PPT - Completed document of full-wave rectifier - Lab. #5
15-16	4/4/4	CLO1 CLO2 CLO3	- Ability to compute the Push-Pull Converter, Half-Bridge, and Full-Bridge Converter - Ability to analyze the push-pull, half/full bridge converter operations. - Ability to simulate the push-pull/half-bridge/full-bridge Converter with a case study.	Lecture 8: DC-Power Supply Part 2	- Lecture on a Push-Pull/Half-bridge/Full-bridge Converter - Lecture on device selection for a case study problem. - Demonstrate how to use Matlab/Simulink for building a case study Flyback/Forward converter as well as the plot of the waveform - Provide 12-15 problems (case study) - Assign students as a group responsible for the oral presentation for 1 case study - Recall the format of the report and the deadline to submit the report.	- Review how to use software (Matlab/Simulink, Spice) in the rectifier system. - Working as a group of two students on the provided topic for the selected names. - Teach or instruct others in the class on the group findings (***only for assigned students***) - Submit a synthesis report of the case study. - Submit Lab. Report - Oral presentation on Lab	- Progressive report and presentation according to lecture: ***Rubrics*** (devices, construct PE, Modeling PE, prototype, Report) 5 slides: intro → device → model → conclusion, 3 minutes presentation. - Lab & assignment: hardware and report	-
17	2	CLO1					Final exam	Final doc.

Table 8: **Detail assessment breakdown for the course "Power Electronics" in the EA Program**

No.	Categories	Assessment tools	% of score	Matching CLOs	SLT (h)
1	Continuous Assessment	Progressive report & presentation according to lectures	25	CLO3	30
2		Lab & assignment of modeling/ hardware and report	25	CLO2	30
3		Class Test #1 (Quiz)	5	CLO1	60
4		Class Test #2 (Quiz)	5		
5	Summative Assessment	Mid-Term exam	20		
6		Final Exam	20		
		Total	**100%**		**120**

The final aspect of implementing the course syllabus is the construction of the Rubrics and Marking schemes for assessing and evaluating each CLO. To illustrate this arrangement, let's consider that the CLO2 for the course Power Electronics will be assessed and evaluated. The responsible lecturer develops the assessment question by taking into account the topics associated with the CLO2 and the Bloom learning level (Cognitive skill C6: Level of Creation) that defines the core learning objectives. Therefore, the questions for assessing the CLO2 in practical classes must evaluate whether the students are able to demonstrate the ability to create the power electronics board by applying their acquired domain-specific knowledge and skills. Then to assess and measure the extent to which the students learned the subject matter in achieving CLO2, the Rubric associated with the CLO is used. Figure 7 presents the standard definition of the Rubric to evaluate students' outcomes for CLO2 in this course. As shown in this Figure, the rubric for CLO2 has five evaluation categories that are targeted to measure and grade five distinct qualities associated with creative skills. Each category is scored within the range of 0-5 marks which leads to a maximum attainable mark of 25.
As presented in Figure 8, if a student can obtain at least 60% marks out of 25 then that student will pass the CLO2. This threshold is usually fixed by the course faculties who are the domain experts.
Using this kind of rubric offers an academic standard, quality, transparency, and traceability in judgment that assists the teachers in defending how and why a student is evaluated in relation to their performance. Finally, the transcript of the rubric evaluation, i.e., the student answer scripts for CLO2 is categorically stored in the official Google Drive folder for any further reference and correspondence.

Figure 7: The Rubric definition for categories evaluation of CLO2

CLO 2 Evaluation Rubric		
Evaluation Categories	**Evaluation Definition**	**Mark Allocation**
Selection of Devices	Read PE specification and device selection	0 - 5
Construct PE	Build PE with Active & Passive for suitable application	0 - 5
Modeling PE	Build device model in Matlab/PSIM	0 - 5
Coding in Software	Improve code in M.file for executing PE in Simulink/PSIM	0 - 5
Completion of project: Prototypes + reports	Design suitable Hardware in the Lab and test from the provided specific application	0 - 5

Figure 8: The automatic evaluation for CLO2

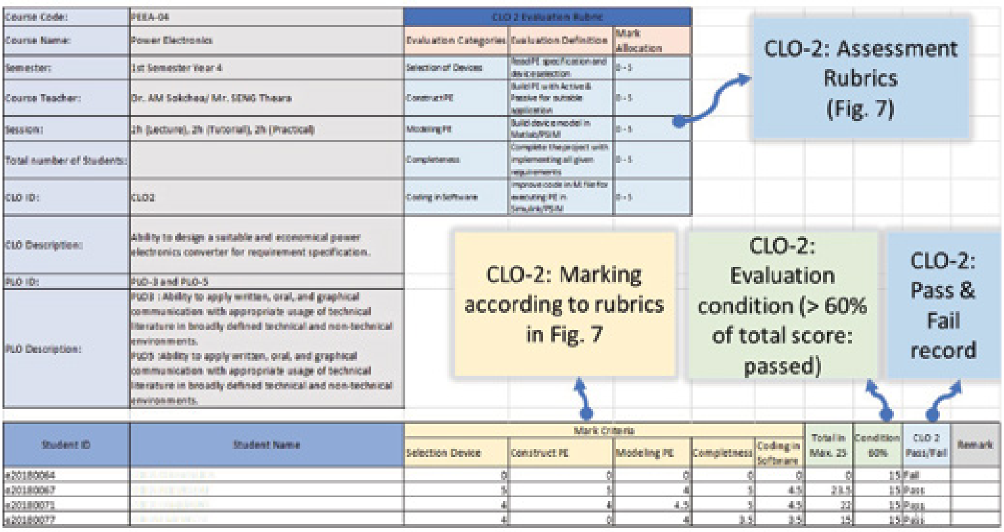
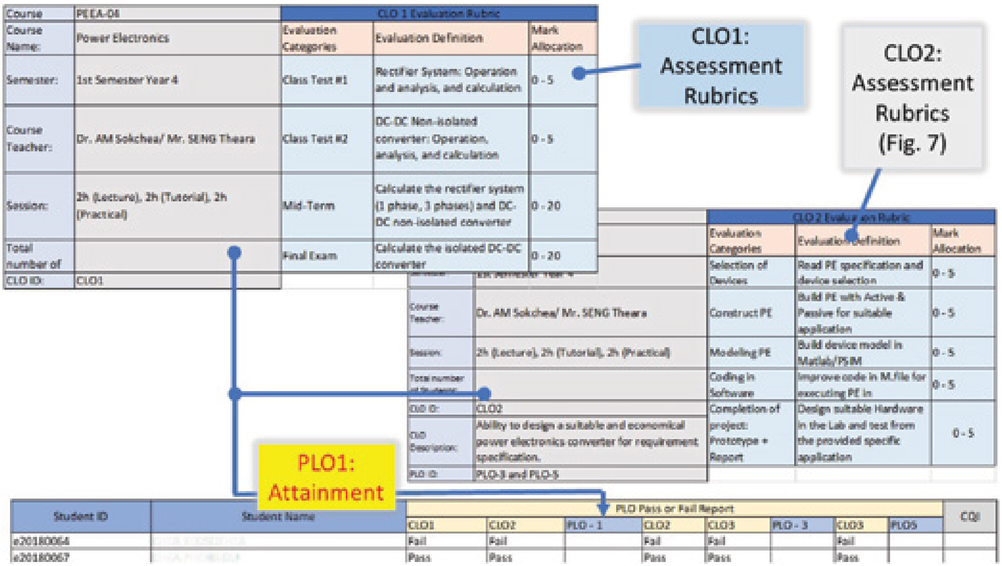


Figure 9 shows an overall evaluation sheet for PLO1 as an example of the selected course. The CLO1 and CLO2 evaluations are presented on the top side and middle side, respectively. The final tab automatically measures the attainment of the PLO1 depending on the result of the mapped CLO1 and CLO2 evaluations. According to this Figure, PLO3 and PLO5 attainments are highlighted as well.

Figure 9: The automatic evaluation for PLO1



4. Significant Results of PBL Implementation in the EA Engineering Program

4.1 Project-Based Learning (PBL): Project Module, Outlines, Assessment and Evaluation Plan

According to Figure 4 and Table 7, 5 main courses (Student Project Part 1 – 4 and final year internship) are designed for PBL implementation and are crucial aspects to support the attainments of three PEO statements in the EA program. The main idea of PBL is to make way for students to have creative thinking skills, innovation skills, and entrepreneurship mindset. Therefore, a proper design of the PBL project module outlines and an assessment plan should be developed to help track the right implementation for each student. Table 9 demonstrates the PBL project module outlines, prerequisites, assessment and evaluation plan, and scoring.

Table 9: PBL project module outlines, and assessment plan

Module Title	Auto Electro Invention, Innovation, Partnership
Course	Student Project Part SPP: 1 – 4 (1.5 Year), and Final Year Internship (0.5 Year)
SDG Goal	#4 (Quality Education), #9 (Industry Innovation), #11 (Sustainable cities)
Duration	SPP1EA: 4+ hours (face-to-face), 8 weeks; SPP2EA: 4+ hours (face-to-face), 8 weeks SPP3EA: 4+ hours (face-to-face), 8 weeks; SPP4EA: 4+ hours (face-to-face), 8 weeks FYIEA: weekly meeting, 8 weeks
Learning Resources	1. Reliable reference books/articles that help to define the problems. 2. Operation manual on using software for modeling 3. Media resource; Safety guideline → Prototype + testing
Prior Knowledge	1. Engineering Innovation and Ethics 2. Research Methodology, Communication and Interpersonal Relations 3. Electronics Design and Manufacturing
Key terms	Research project, end product, electronics designer, automation system designer
Learning Outcomes	At the end of this module, students should be able to: 1. Design a suitable economical electronics and automation system for specific requirements (C6, P7) 2. Conduct elements of ethics and professionalism in entrepreneurship, creativity, and innovation (A5)
Course Contents and Learning Activities	1. Divide yourself into 10 groups → Assigned team leader and member's role (max. 5) 2. Define the problem from given reliable references/reports on electronics and automation systems for specific requirements 3. Project #1 --- #N: Identify resources for further reading, main HR 4. Current technology and 1 Poster Presentation on finding and collecting more inputs → Possibilities for further improvement on the current product → Final report of a defined topic 5. System verification: modeling → 1 poster presentation 6. Prototype + testing at Lab → Presentation on department reunion event 7. Seek investors/join the competition → Sustainability (expand production)
Summary	Research capability and hands-on experience in prototype and business

Module Title	Auto Electro Invention, Innovation, Partnership
Assignment	1. Abstract of the project (1 page) + team leader and members' role 2. Produce a short poster (1 page) on finding references 3. Produce a short poster (1 page) on the system verification (simulation) 4. List down the required equipment for building the prototype in economical ways 5. Prepare a short presentation to alumni/company 6. Produce a quality technical report (include all necessary elements: max. 8 pages) 7. Marketing of product: short video, magazine, …
*Assessment**	1. Team structure + Summary report from given technical reports/ references (10%) 2. 1 Poster presentation on the system verification (simulation) (15%) 3. Demonstration on Working prototype + test results (30%) 4. 10 minutes presentation to the private sector or pitching in competition (15%) 5. Final report (20%) and Marketing of product (10%)
Reflection	1. Student's feedback after the completion of the semester 2. Reflection by the instructors & students on the module based on students' feedback.
Production	Prototype

4.2 Significant results in PBL implementation

For PBL implementation of this engineering program, each student is required to complete or be involved in a project for about 2 years before their graduation. In the project-based case teaching system, students conduct their projects and seek investment from private investors for further business. Some students join industry projects to strengthen their Knowledge/ Skills/Attitude toward 21st-century skills and be ready for the workplace. Given the varying levels of innovative and entrepreneurship training programs for students, a technological innovation mechanism is established step by step, and innovation and entrepreneurial ability are cultivated in many ways. The content of innovation and entrepreneurship education should gradually form from the theoretical stage to the practical stage, from the subject curriculum to the activity content, and by learning the hidden curriculum content in the process of practice. Such content should actively rely on various innovation and entrepreneurship education platforms in colleges and encourage the coexistence of different objectives and types of entrepreneurial activities. Diversity is reflected in the content of entrepreneurship, organizational forms, and entrepreneurial environment to adapt to the social demand for diversified entrepreneurial talents. The practice teaching would be strengthened, and the practice topic can be decomposed from scientific research innovation and technology services. Experimental material and engineering projects would then be developed. Therefore, the chart in Figure 10 shows the number of projects that were implemented for the academic year 2022-2023 in the EA Engineering Program. There are 22 projects categorized into 12 projects implemented 100% at university, 8 projects joint with industries, and 2 projects in collaboration with a foreign university.

Figure 11 summarizes some main outcomes of PBL implementation that have been developed into one final product, one fully working prototype, three projects that won a prize from a Techno Innovation Challenge Cambodia 2023, and one final product joint with industry. Figure 11a shows the final product of project P1: the KHQR vending machine is in full operation and being commercialized in the local market. The final working prototype of the solar cleaning robot (project P2) is presented in Figure 11b. Figures 11c and 11d show the three projects that won the national challenge. Figure 11e describes the success of the joint project with the industry that can increase the revenue of 600 US Dollars per hour (150 USD/h/production line and 4 production lines) compared to their previous operation system.

Figure 10: C22 Projects implementation in the 2022-2023 academic year

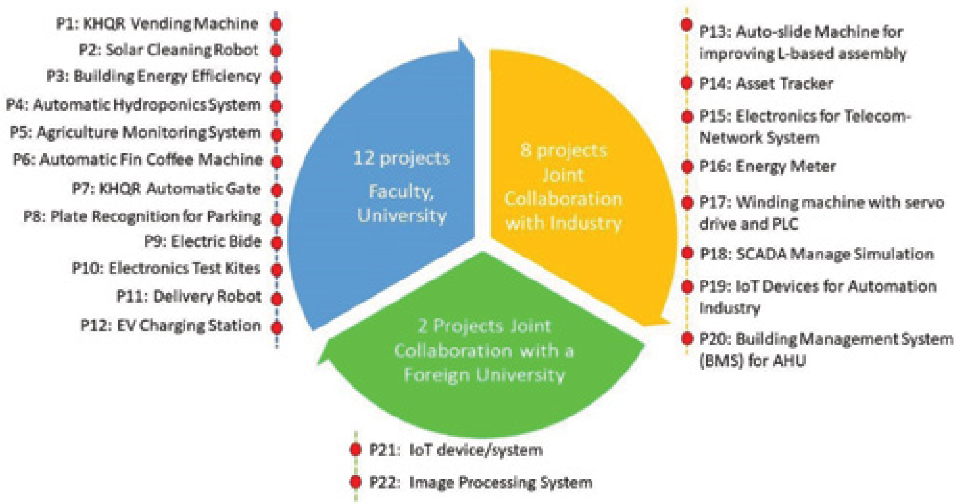


Figure 11: Significant Outcomes of PBL Implementation

5. Conclusion and perspectives

This article studies a comprehensive and concrete academic framework, that produce graduates with 21st-century skill, that comply with the benchmark mandates and guidelines of Outcome Based Education (OBE). We introduced the PBL approach by setting up several series of courses that help students to do projects within the university or industrial projects. As a result, we achieved a) 8 joint projects with industries, b) 2 projects with an abroad university, and c) 12 projects in the institution. Among those projects, the KHQR vending machine is in full operation and being commercialized. The project on the solar cleaning robot is positively progressing and hope to get investment soon from the private sector. Three projects won the innovation challenge and are planning to seek investment for further business. At the course level, to ensure the achievement of defined CLOs, we introduced an ALS learning method that helps students to be more active and learn by themselves. Moreover, we developed effective assessment rubrics to assess and evaluate student's learning outcomes.

For future work, we will study the development of a digital assessment platform for every course in the new program. Moreover, the research work on the development of CQI for maintaining and improving the quality of this engineering program will be conducted.

6. Acknowledgement

This article was an outcome of research on curriculum improvement for the engineering field toward 21st-century skills graduates. The work was funded by the Cambodia Higher Education Improvement Project (Credit No. 6221-KH), Cambodia.

1 *"Techno Innovation Challenge Cambodia 2023", Sala, accessed November 2, 2023, https://www.sala.co/events/techno-innovation-challenge-cambodia-2023.*

2 *Lucas Memmert, Navid Tavanapour and Eva Bittner, "Learning by Doing: Educators' Perspective on an Illustrative Tool for AI-Generated Scaffolding for Students in Conceptualizing Design Science Research Studies", Journal of Information Systems Education, 34, no.3, (September 2023): 279-292.*

3 *Miriam Friedman Ben-David, "AMEE Guide No. 14: Outcome-based education: Part 3-Assessment in outcome-based education", Medical Teacher 21, no.1 (1999, published online July 2009): 23-25.*

4 *William G. Spady, "Organizing for results: The basis of authentic restructuring and reform", In Educ. Leadership 46, no.7, (1988): 4-8.*

5 *Randy Zitterkopf, "A fundamentalist's defense of OBE". In Educ. Leadership 51, no.6, (1994): 76-78.*

6 *Mahbubul Syeed et al. (2022). "Outcome-Based Education (OBE): Defining the process and practice for Engineering Education", In Institute of Electrical and Electronics Engineers Access 10, 119170-119192, https://doi.org/10.1109/ACCESS.2022.3219477.*

7 *Jean A. Pratt et al., "Preparing Information Systems Graduates for a Complex Society: Aligning IS Curricula with Liberal Education Learning Outcomes," Journal of Information Systems Education 25, no.1, (2014): 35-44.*

8 *Abdullah M. Almuhaideb and Saqib Saeed, "Fostering Sustainable Quality Assurance Practices in Outcome-Based Education: Lessons Learned from ABET Accreditation Process of Computing Programs", Sustainability 12, no. 20 (2020): 8380. https://doi.org/10.3390/su12208380.*

9 *David R. Krathwohl et al., "A revision of Bloom's taxonomy: an overview", In Theory into Pract. 41, no.4 (2002, published online June 2010): 212 - 218.*

10 *Faridah Musa et al., "Project-based learning (PBL): Inculcating soft skills in the 21st-century workplace", In Procedia Soc. Behav. Sci., no. 59, (October 2012): 565–573.*

11 *Institute of Technology of Cambodia. "10-year strategies of ITC 2021 – 2030", Policy Document, 2021, https://itc.edu.kh/newsevent/news/itc-strategy-2021-2030/.*

12 *David Bozward et al., "How can entrepreneurial interventions in a university context impact the entrepreneurial intention of their students?" Entrep. Educ. 6, (June 2023): 1–23.*

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Phok Chrin was born in Kampot, Cambodia in 1981. He received his B.S. degree in Electrical and Energy Engineering from the Institute of Technology of Cambodia (ITC), Cambodia in 2005, His Master of Control Engineering from King Mongkut's Institute of Technology Ladkrabang (KMITL), Thailand in 2007 and his Ph. D. degrees in Electrical Engineering from Federal University of Toulouse Midi-Pyrénées, "Laboratoire Plasma et Conversion d'Energie (LAPLACE)" Toulouse, France in 2016. In 2007, he joined Institute of Technology of Cambodia as lecturer and then he went for PhD study after 5 years working. In November 2016, Dr. Phok joined ITC again as a lecturer-researcher. Since October 2018, he was assigned to be Head of the Department of electrical and energy engineering at ITC.

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Koksal CHOU

Chou Koksal was born in 1995 in the Siemreap province of Cambodia. He earned his Bachelor of Engineering degree in Electrical and Energy Engineering from the Institute of Technology of Cambodia (ITC) in 2017. Following this, he pursued a Master's degree in Management Technology at Sirindhorn International Institute of Technology, Thammasat University, Thailand, which he successfully completed in 2019. In 2021, Chou Koksal embarked on a career in academia by joining the Institute of Technology of Cambodia as a Lecturer. He was promoted to the position of Deputy Head of the Department of Electrical and Energy Engineering at ITC in October 2022. Chou Koksal's research interests include Image Processing, Optimization, Digital Electronics, and Curriculum development.

Digital Technology as a Tool for Upper Secondary Education: What Do Our Teachers Need?

A Case Study in Kampot Province

Pharino CHUM, Muyny CHHOM and Noy MOUNH

STEM (Science, Technology, Engineering, and Mathematics) is an interdisciplinary approach to learning that emphasizes the application of knowledge and skills from these four areas.[1] STEM education is increasingly important in today's world, as it prepares students for the jobs of the future. This educational framework can help students develop critical thinking, problem-solving, and creativity skills. It can also help them learn how to apply their knowledge to real-world problems. STEM education is important for all students, regardless of their interests or abilities.

STEM education in Cambodia is still in its early stages of development. The government is committed to providing all students with the opportunity to learn STEM and pursue STEM careers and has therefore taken several initiatives to support STEM education in the country. These initiatives include:

- The Science and Technology Project in Upper Secondary Education (STEP-USE) is a USD 70 million project funded by the Asian Development Bank (ADB). The project aims to improve the quality of STEM education in upper secondary schools by providing new facilities, training teachers, and developing curriculum materials.[2]
- The New Generation Schools (NGS) are a network of public schools that offer a more rigorous STEM curriculum. The NGS also have state-of-the-art facilities and equipment, and they provide students with opportunities to participate in extracurricular STEM activities. The purpose of NGS is to 'create a new development track within the public education system that will lead to the creation of autonomous public schools, which receive high investment linked to new standards of accountability and governance as well as professional standards for 21st Century learning.[3] For supporting the objectives of NGS, the following activities are implemented: Including the establishment of the National and Subnational Oversight Boards for coordination of NGS, and Evaluation and accrediting Sub-committee; create the formulation of regulation; seeking financial suport through multiple channels; human resource by implementing the training; and prepare investment plans. By 2017, NGS had nine

school locations in four municipalities or provinces, including Phnom Penh, Kampong Cham, Kandal, and Kampong Speu, where it was formally operating. By 2022, the MoEYS intends to expand NGS to 100 schools and at least two provinces.[4]

- The Cambodia Science and Technology Center (CSTC) is a new center that will provide STEM education resources and training to teachers and students across the country via loan from Asian Development Bank (ADB). The CSTC will also host STEM-related events and activities. In the report from the president to the board of directors, quality of science, technology, engineering, and mathematics teaching and learning strengthened was one of the main three outputs of CSTC. It is specifically focused on the design, establishment, and put into operation the CSTC that serves as a link between science and society after conducting a feasibility assessment of the project. Through a physical presence in Phnom Penh at the Institute for Technology of Cambodia (ITC) and a digital outreach program for access in schools and communities nationwide, the CSTC will promote STEM in a dynamic and creative way to the general public. Additionally, it will connect secondary schools and industry, as well as regional and international STEM communities, and serve as a hub for the STEM eco-system for teacher training institutes and higher education institutions for research and teaching purposes.[5]
- In the Education Strategic Plan 2019-2023 and Policy on Science, Technology, Engineering and Mathematics Education, the Ministry of Education, Youth and Sport (MoEYS) has set out priorities and strategies to improve the capacity of teachers and academic staffs in the field of STEM.[6] [7] The focus aims at developing knowledge about STEM education to teachers as well as promoting digital education through the integration of information and communication technology for teaching and learning at all levels of education.[8]

In addition to these government initiatives, there are several non-governmental organizations (NGOs) that are working to promote STEM education in Cambodia. These NGOs provide STEM education programs and activities to students in rural areas and to students from underrepre-sented groups. They also work to raise awareness of the importance of STEM education and to promote STEM careers. The combined efforts of the government and NGOs are making a significant difference in STEM education in Cambodia. However: “According to MoEYS statistics for the academic year 2018-2019, the percentage of Cambodian students choosing science track has significantly dropped to about only 49% while the percentage of students in the social science counterpart has jumped dramatically than ever before to 51%. This sheds a great concern for MoEYS in aiming to enhance science and mathematics education at upper secondary school”. [9] By promoting STEM major and career, this could help increasing students’ interest to enrol in STEM programs at university and choose to pursue STEM careers. As a result, Cambodia could be well-positioned to take advantage of the opportunities that the 21st-century economy has to offer.[10]

Despite these efforts, there are still several challenges to STEM education in Cambodia. These challenges include the lack of qualified STEM teachers, access to STEM resources, and low awareness of the importance of STEM education overall.[11] The above initiatives are helping to improve the state of STEM education in Cambodia. However, there is still more work to be done. The government, the private sector, NGOs, and educators need to continue to work together to promote STEM education in the country.

KESTI (Kampot Enrichment in Science, Technology & Innovation) project is one such initiative led by the Ministry of Industry, Science, Technology & Innovation (MISTI) in collaboration with the Embassy of India in Cambodia and is a part of the Government of India's Quick Impact Project (QIP) Scheme under the framework of the Mekong Ganga Cooperation. The Government of India cooperates with the Royal Government of Cambodia (RGC) on many grants assistance programs that contribute significantly to the socio-economic development of the people of Cambodia. The RGC has a vision of becoming an upper-middle-income country by 2030 and a high income country by 2050. To achieve this vision, it has transformed the three main economic pillars of garments, tourism, and construction into an industry-oriented economy (RGC, 2015).[12] This requires human resources in the fields of STEM to be more competitive in the region. MISTI's overall mandate is to serve and work for the development of STI in Cambodia. STI development in the country directly links to human capital development nationwide. As one of the four pillars of Cambodia's STI roadmap 2030, education is an essential sector to strengthen and invest more. By 2030, it hopes that 50% of undergraduate students will have earned degrees in STEM fields, and 40% of graduate are women.[13] To ensure that the nation's plan and vision 2030 are realized in the education sector, MISTI focuses on governance and coordination. This project is novel in that it was developed by MISTI beginning in 2020. Due to the project's practical design, its impact will be long-lasting and it gives stakeholders the chance to continue implementing it. In order to encourage students' interest in choosing STEM for their further education, this is intended to address the development of human resources in this sector. From May 2022 to June 2023, 25 STEM teachers from five public high schools in Kampot province participated in at least 10 trainings on „STEM Education Instruction/Pedagogy or How to Teach STEM Subjects" in order to share additional knowledge about the STEM Education framework on pedagogies and learning methods that provide in-depth analytical skills, problem-solving skills, and collaboration using the most recent technologies.[14]

This academic paper provides a case study and recommendation for implementing digital transformation in post-secondary education from urban and rural teachers' perspectives to equip them with adequate digital technology skills.

We conducted 10 training modules on digital technologies for teaching and learning STEM subjects (mathematics, physics, chemistry, and biology) to over 25 teachers from five selected high schools in Kampot province. We conducted surveys on their knowledge and their challenges in using digital technology to support teaching. We reviewed their baseline knowledge of digital technology for education and improvement after training. We shared the lessons learned during our project, challenges and recommendation for integrating digital technology in teaching and learning STEM subjects effectively.

This paper aims to capture the interest of young educators and educational policymakers in practical challenges in implementing digital technology in urban and rural high schools in Cambodia.

Research methodology

The online questionnaires were used as a tool to collect data from participants in our research. The participants were STEM teachers from all 5 target schools that participated in the KESTI project. The questionnaires were organized into two categories: closed form and open form. Researchers have developed a series of questionnaires focusing on two main areas: STEM education methods and tools for teaching and learning STEM subjects. Before delivering the questionnaires' link to participants via Telegram and Google Classroom, STEM trainers and project coordinators examined and tested them in Google Forms.

The selection of participants in this study involved the identification of suitable participants from a database of 25 STEM teachers in the five target schools of the KESTI project. The selected partcipants teach STEM subjects, including mathematics, physics, and chemistry, or biology. The project was conducted in Kampot province for a period of 9 months, from September 2022 to May 2023. The questionnaires were conducted through the Google Forms in Khmer language to accommodate the participants' language proficiency. The data was recorded in the report to ensure accuracy and allow the analysis of the participant's responses in order to align the research findings.

- **Desk review:** We critically evaluated and cross-referenced national sources to clarify their credibility, reliability, and relevance. Throughout the process, the source of references was carefully selected based on STEM teaching methods in national and international trends.
- **Online questionnaire:** This pilot testing helped identify the knowledge STEM education level of STEM teachers and high school students. Once finalized, the questionnaire was distributed to participants by Telegram App. Using this digital platform ensured a broad reach and was commonly used, and timely.

The data analysis process in this research used both quantitative and qualitative methods. In the quantitative method, the raw data was screened and cleaned in Microsoft Excel, plot the graph by using Microsoft Power BI desktop.[15]

Statistical tests were then performed to identify communication patterns and significant differences among the data. Quality data obtained from participants' feedback was collected through keyword identification. We have defined recurring shapes and assigned codes to sections of these data, facilitating their preparation and interpretation.

Both datasets were then aggregated and summarized to provide an overview of the research results. Descriptive statistics such as percentages and frequencies were used for sector quantitative data, while topical analysis was used for qualitative data. Throughout the process, we relied on data visualization techniques to present our findings clearly and efficiently. We also used case studies from the data collected to highlight specific points or topics, adding depth and context to the study's findings. This approach ensures a comprehensive and clear understanding of teaching methods and tools for STEM education.

Result and discussion

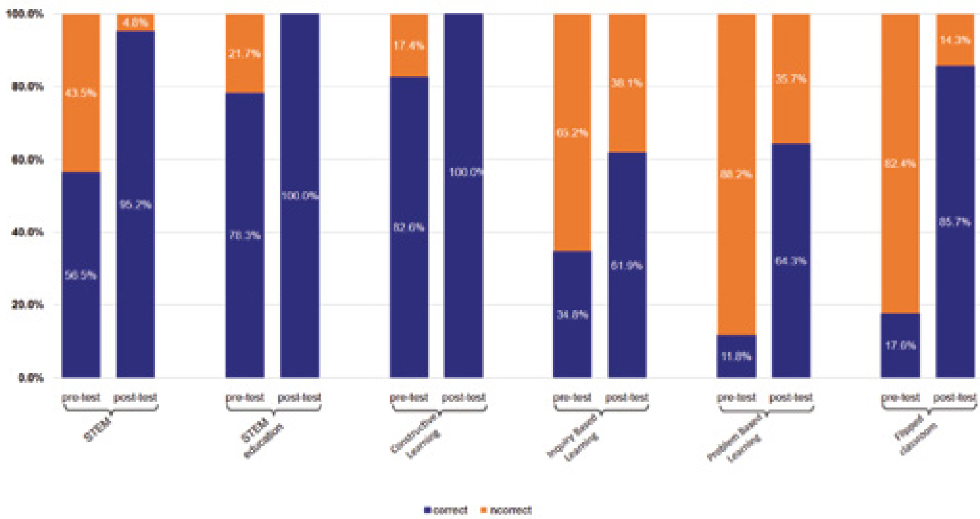
Among all STEM teachers, 38.1% of them have teaching experience over 10 years. Teaching load is between 13-18 hours per week. Among all teaching subjects, 47.6% report that they did not conduction any experiment in their teaching subject at all. Moreover, in the past five years, 57.1% of them have not had much capacity building or training to strengthen their professional skills. Among the remaining, 42.9% who have been participating in any trainings, most of those reported having at least 5 years of experience in STEM subjects. This experience could be valuable in imparting subject knowledge to students effectively. However, the challenge also came up when teachers had to handle various classes simultaneously, as mentioned in the respondents' feedback. All teachers report the challenges faced by science teachers in Kampot Province, citing the need for a balanced mix of 1) appropriate workload management, 2) dedicated time for experiment preparation, and 3) continuous professional development.

Based on the pre-survey and post-survey results from 10 modules that are shown in Figure 1. It is evident that the training had a significant impact on improving teachers' knowledge about STEM teaching methods. In the pre-test, 43.5% of teachers answered incorrectly regarding STEM definition and 21.7% of teachers answered incorrectly regarding STEM education, indicating a lack of understanding of the concept and principles. After the training, the number of incorrect answers on the STEM definition and education was reduced significantly to 4.8% and 0%, respectively. These results have shown that the training effectively enhanced teachers' understanding of the STEM concept and had a profound impact on teachers' comprehension of STEM education principles.

Related to teaching methods, Constructivism Learning, Inquiry-Based Learning, Problem-Based Learning, and Flipped Classroom methods were put into the questionnaire for pretest and posttest. Before the training, the result of the pre-test showed that 17.4%, 65.2%, 88.2%, and 82.4% were incorrect answers on the method of Constructivism Learning, Inquiry-Based Learning, Problem-Based Learning, and Flipped Classroom, respectively. This suggested a considerable lack of understanding and knowledge about the learning approach, student-centered approach, and innovative teaching method. After the training all teachers incorrectly answered 0%, 38.1%, 35.7%, and 14.3% on the method of Constructivism Learning, Inquiry-Based Learning, Problem-Based Learning, and Flipped Classroom respectively. The improvement is notable - the training effectively clarified the concept as well as enhanced teachers' knowledge of all methods.

After the training, the percentage of incorrect answers decreased in all areas, demonstrating the effectiveness of the training program (Figure 1). Overall, the results of the pretest and post-test assessments clearly indicated that the KESTI training had a positive and significant impact on teachers' understanding of various STEM teaching methods and technology. However, the findings also indicate that some areas, such as inquiry-based learning and problem-based learning, may require additional attention and support in future training sessions to ensure a deeper understanding among educators.

Figure 1: The result of pre-test and post-test on the STEM education and teaching methodologies



Further questions on teaching pedagogies, there were the top two problem-teaching strategies teachers frequently used which are imitating learning and the divide-and-conquer approaches for problem solving in the classroom. Solving similar problems was perceived as the most useful strategy suggesting that teachers recognize the importance of providing students with a step-by-step approach to problem-solving. This approach allowed students to build their confidence and competence gradually before tackling more complex problems. Furthermore, the use of unanimous or separated approval indicates that teachers value group discussions and individual validation, which can foster a collaborative learning environment and address individual learning needs effectively.

Additionally, the study identified the lack of materials and large class sizes as significant barriers to effective teaching. These findings also aligned with Figure 1, which mentions the result of a high percentage of teachers reporting no experiment preparation. Based on these results, it was clear that there is a need for education policies and partnerships to address these challenges and enhance the quality of teaching and learning. By implementing these strategies and prioritizing continuous professional development, education stakeholders can empower teachers with effective problem-solving strategies and overcome barriers to teaching, leading to improved learning outcomes and a more enriching educational experience for students.

Table 1: Ranking accessibility of using content creation and management for the classroom

(six ranking levels: 0 means the subject is not familiar with introducing software/application, while 5 means efficiently using software/application. Interactive presentation application: Microsoft PowerPoint, libre office. Video recording: Mobile recording app, Zoom, OBS studio. Video Editing: VN for Mobile, Openshot. Content Management: Youtube, Google Classroom.)

	Interactive presentation		Video Recording		Video Editing		Video Hosting		Content Management	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Rank 0	76.5%	7.1%	29.4%	0%	64.7%	0%	58.8%	0%	76.5%	0%
Rank 1	23.5%	7.1%	47.1%	14.3%	23.5%	7.1%	29.4%	7.1%	17.6%	14.3%
Rank 2	0%	57.1%	11.8%	21.4%	5.9%	42.9%	11.8%	42.9%	5.9%	42.9%
Rank 3	0%	28.6%	11.8%	50%	5.9%	35.7%	0%	50%	0%	35.7%
Rank 4	0%	0%	0%	14.3%	0%	14.3%	0%	0%	0%	7%
Rank 5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

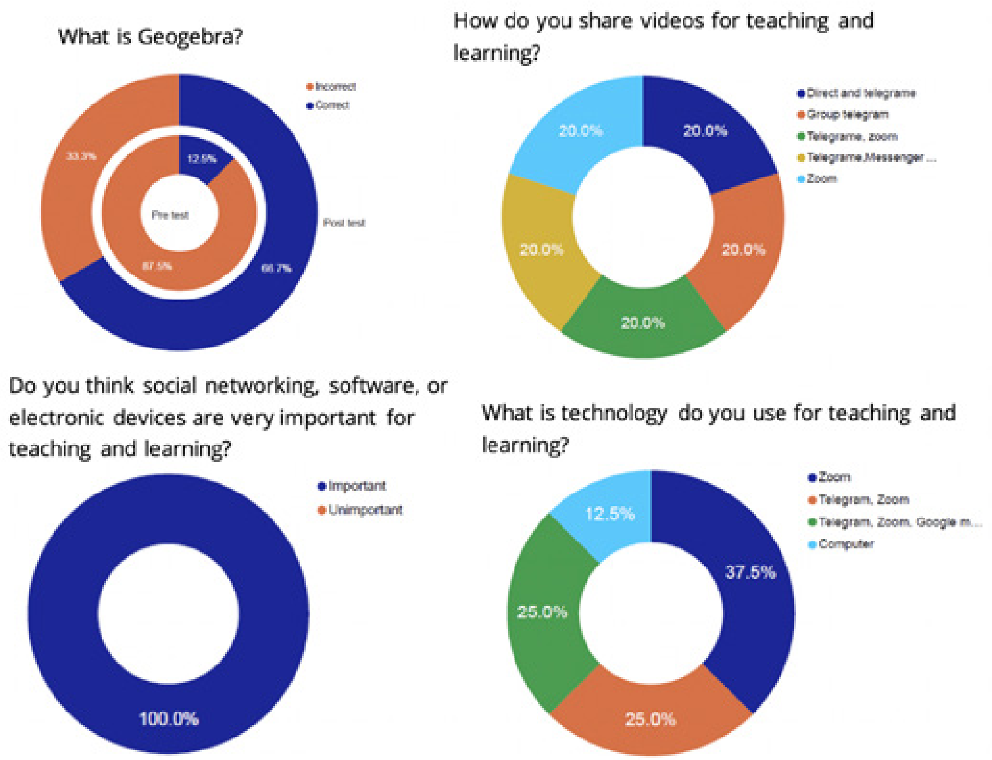
The results from Table 1 highlighted a concerning lack of knowledge and utilization of technology tools for creative teaching and learning among science teachers. The percentages of teachers who had never known or known but never used various technology tools, such as video recorders, video editing software, video hosting, content management, and interactive presentation programs, were notably high. This lack of familiarity with technology tools was consistent with the first findings, with many teachers reporting a lack of materials, no time to prepare experiments, and limited training opportunities to enhance their skills and knowledge.

These connected findings point to the urgent need for focused professional development initiatives that concentrate on incorporating technology into instructional strategies. The difficulties of material shortages and inadequate preparation for classroom experiments can be addressed by education stakeholders by giving science instructors training and support in using digital tools efficiently. This should enable them to create engaging and interactive learning experiences. Emphasizing the use of technology in the classroom can ultimately result in better teaching techniques and student learning results by bridging the knowledge gap between teachers and its practical use in the classroom.

After training, STEM teachers had shown improvement in their understanding of video recorders, video editing software, video hosting, content management, and interactive presentation programs, reaching a level described as „some" and „medium." This progress demonstrated the effectiveness of the training in enhancing teachers' knowledge of these technology tools. However, the finding also suggested that further training and support were needed to help teachers confidently apply these tools in the classroom effectively. Education stakeholders should continue offering continuing, focused training sessions that emphasize hands-on experience and real-world classroom integration in order to close this knowledge gap between theoretical understanding and practical application. Additionally, promoting a culture of continual improvement in teaching practices can be accomplished by creating a welcoming environment where teachers have access to resources and technical help. By doing this, science educators can use technology to develop more interactive and engaging lessons that will ultimately improve student learning outcomes and educational quality.

Figure 2 illustrated technologies as tools were considered very important in teaching and learning, with 100% agreement among teachers. Zoom, Telegram, Group Telegram, Messenger, Google Meet, and computers were frequently used in the teaching and learning process as well as technology applications for sharing videos. Further evidence of the beneficial effects of professional development on technology integration in the classroom came from the fact that instructors' proficiency with Geogebra significantly improved following training, with the percentage of right answers rising from 12.5% to 66.7%. These results imply that educators had accepted technology as a useful tool for instruction and had gotten better at utilizing it for educational objectives. However, in order to fully utilize the advantages of technology in education, it is crucial for education stakeholders to maintain and provide continuing support and training to ensure that instructors are proficient with and confident using these technologies.[16] A culture of innovation and the sharing of best practices among educators can also promote the use of technology in the teaching and learning process, resulting in more interactive and engaging learning opportunities for students and ultimately improving overall learning outcomes.

Figure 2: The description of common tools and programs for using in the classroom



Conclusion and recommendation

In conclusion, the thorough examination of the findings offers insightful information about the situation of high school science educators in Kampot Province, Cambodia. The information revealed the difficulties teachers face, the benefits of KESTI training for STEM teaching strategies and technological literacy, the urgent need for targeted professional development in technology integration, and the significance of addressing material shortages and large class sizes. Education stakeholders can collaborate to overcome obstacles, improve teaching methods, and give science teachers in Kampot Province, Cambodia, the support and resources they need to provide students with a high-quality educational experience by putting the suggested strategies of continuous professional development, collaborative learning, resource allocation, technology integration training, and promoting innovative teaching practices into practice.

To address the identified challenges and further improve STEM education in Kampot Province, Cambodia, the following suggestions are recommended:

- **Continuous professional develop-ment:** To provide instructors with the skills and knowledge they need, create continuing, targeted professional development programs that concentrate on STEM teaching techniques, technology integration, and problem-solving techniques.[17]

- **Collaborative learning and support:** Promote regular sharing of effective teaching strategies and best practices among instructors to foster teamwork. Create a welcoming environment where educators may ask questions and exchange experiences, thereby improving the effectiveness of instruction.[18]
- **Resource allocation:** Promote regular sharing of effective teaching strategies and best practices among instructors to foster teamwork. Create a welcoming environment where educators may ask questions and exchange experiences, thereby improving the effectiveness of instruction.
- **Technology integration training:** Provide instructors with specialized training to help them become more comfortable using technology tools in the classroom. To increase teachers' comfort level and technical competence, offer continual support.[19]
- **Cultivating innovative teaching practices:** Promote a culture of innovation in teaching by encouraging teachers to experiment with new teaching methods and technology tools. Recognize and celebrate innovative practices that lead to improved learning outcomes.

By implementing these suggestions, education stakeholders can work collaboratively to overcome challenges, enhance teaching practices, and provide science teachers with the necessary support and resources to deliver a high-quality learning experience for students in Cambodia.

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1 *Rodger W. Bybee, "What Is STEM Education?", Science 329, no. 5995 (August 2010): 996, https://doi.org/10.1126/science.1194998.*

2 *Robert Davis and Soleil C. Mom, "ADB to Strengthen Upper Secondary STEM Education Reforms in Cambodia | Asian Development Bank", The Asian Development Bank (ADB), last modified November 2, 2022, https://www.adb.org/news/adb-strengthen-upper-secondary-stem-education-reforms-cambodia.*

3 *Kurt Bredenberg, "New Generation School National Survey", (September 2016): 35, doi: 10.13140/RG.2.2.18375.91048*

4 *Chankoulika Bo, "New Generation Schools in Cambodia: Innovative School Governance for Sustainable Quality of 21st Century Learning and Instruction", Advances in Social Science, Education and Humanities Research, vol 526, (January 2021): doi:10.2991/assehr.k.210212.105*

5 *Asian Develpoment Bank, "Kingdom of Cambodia: Science and Technology Project in Upper Secondary Education", (October 2022): 5, https://www.adb.org/sites/default/files/project-documents/55134/55134-001-rrp-en.pdf.*

6 *Ministry of Education, Youth and Sport, "Education Strategic Plan 2019-2023 - Library Records OD Mekong Datahub," 2019.*

7 *Ministry of Education, Youth and Sport, "Policy on Science, Technology, Engineering and Mathematics Education - Laws OD Mekong Datahub," 2016, https://data.opendevelopmentcambodia.net/en/laws_record/policy-on-science-technology-engineering-and-mathematics-education.*

8 *Ministry of Education, Youth and Sport, "Policy on Science, Technology, Engineering and Mathematics Education - Laws OD Mekong Datahub", 2016.*

9 *Kao Sovansophal, and Shimizu Kinya, "Factors Affecting Cambodian Upper Secondary School Students' Choice of Science Track", International Journal of Sociology of Education 9, no. 3 (October 2020): 262–92, https://doi.org/10.17583/rise.2020.4823.*

10 *Sopheap Kaing, "How Can STEM Education Help Stimulate Economic Growth in Cambodia", (July 2016): 2, https://www.researchgate.net/publication/308725757_How_Can_STEM_Education_Help_Stimulate_Economic_Growth_in_Cambodia.*

11 *Chanphalla Ban, "The Current State of Cambodia's STEM Education: A Case Study of the Preah Sisowath New Generation School." (2020): 5, https://www.futureforum.asia/_files/ugd/dffd34_20532a2f6dbf41c09b30498c77f167d7.pdf.*

12 *Royal Government of Cambodia, "Cambodia industrial development policy 2015-2025", March 2015, 3.*

13 *Ministry of Industry, Science, Technology & Innovation, "CAMBODIA ' S SCIENCE , TECHNOLOGY & INNOVATION ROADMAP 2030", 2021, 10.*

14 *Tuy Engly, "Enrichment in Science, Technology, and Innovation, Kampot Province, Cambodia (KESTI) of Industry, Science, Technology, and Innovation (MISTI)", FYN, last modified April 1, 2022, https://findyournews.media/2022/04/01/enrichment-in-science-technology-and-innovation-kampot-province/.*

15 *Louis T. Becker and Elyssa M. Gould, "Microsoft Power BI: Extending Excel to Manipulate, Analyze, and Visualize Diverse Data", Serials Review vol 45, no. 3 (July 2019): 184–88, https://Doi.Org/10.1080/00987913.2019.1644891.*

16 *Seingheng Hul, "Cambodia: Innovation-Driven EduTech Roadmap 2030", Institure of Electrical and Electronics Engineers (December 2022): 315 – 321, https://doi.org/10.1109/SKIMA57145.2022.10029617.*

17 *Snezana Jovanova-Mitkovska, "The Need of Continuous Professional Teacher Development", Procedia - Social and Behavioral Sciences, (December 2010): 21 – 26, https://doi.org/10.1016/j.sbspro.2010.03.441.*

18 *Marjan Laal and Seyed Mohammad Ghodsi, "Benefits of Collaborative Learning", Procedia - Social and Behavioral Sciences, (December 2012): 486 – 490, https://doi.org/10.1016/j.sbspro.2011.12.091.*

19 *Mustafa Koç, "Implications of Learning Theories for Effective Technology Integration and Pre-Service Teacher Training: A Critical Literature Review", Journal of Turkish Science Education (January 2005): 2–18, https://www.tused.org/index.php/tused/article/view/51.*

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