International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Social Mobile Learning with 21st Century Learning for Thailand Education 4.0

Sascha H. Funk[1], Ray Wang[2]

[1,2]Faculty of Journalism & Mass Communication, Thammasat University, Bangkok, Thailand

Abstract

The Thailand 4.0 initiative aims to transform the country into a digital economy, with education reform being a crucial component. Social mobile learning has the potential to support this transformation. However, engagement with social mobile learning varies among different groups. This paper examines the relationship between education reform, the Thailand 4.0 initiative, and social mobile learning. It explores the challenges of communication for sustainability, the importance of reflection in understanding complexity, the role of design thinking in teaching sustainability, and examples of teaching for sustainable development within the context of Thailand 4.0 and social mobile learning. The study's findings suggest that while social mobile learning can support education reform and the Thailand 4.0 initiative, effective engagement varies. Incorporating sustainable development teaching into Thailand 4.0's education system can help promote a culture of sustainability.

Keywords: Social Mobile Learning, Peer Learning, Education Technology, Higher Education

Introduction

Thailand has embarked on an ambitious initiative called Thailand 4.0 that seeks to transform the nation into an innovative, technology-driven knowledge economy. A pivotal component of this plan is reforming the education system to equip learners with essential 21st-century skills and align teaching and learning practices with the demands of the digital era (Office of the Education Council, 2017). This article provides a comprehensive analysis of how the thoughtful integration of social mobile learning - leveraging mobile technologies and social media - can support Thailand 4.0 by enhancing student engagement, collaboration, and skill development.

The Thailand 4.0 plan recognizes that thriving in today's digital, globalized world requires equipping youth with 21st-century skills like critical thinking, creativity, collaboration, and communication. Education 4.0 aims to cultivate these competencies while reducing disparities and improving access to high-quality learning opportunities. This signifies a paradigm shift from rote memorization and passive learning to participatory, student-centered pedagogies enhanced by technology. Social mobile learning's emphasis on engagement, personalized learning, and technology integration strongly complements these goals. This article delves into the potential benefits as well as persistent challenges that must be addressed to effectively leverage social mobile learning to achieve the vision of Thailand 4.0.

Perspectives on Learning for Sustainability

Education for sustainable development (ESD) is imperative for realizing the UN's Sustainable Development Goals and the vision of Thailand 4.0 (United Nations, 2015). Research indicates that

impactful ESD must extend beyond mere knowledge transmission to facilitate a deeper transformation in learners' skills, values, behaviors and mindsets (Savage et al., 2015). Scholars advocate that ESD should incorporate innovative, student-centered pedagogical approaches such as problem-based and project-based learning. Such methods can nurture key competencies needed to address complex sustainability challenges, including systems thinking, futures thinking, values thinking, strategic planning, and collaboration (Cörvers et al., 2016; Wiek & Kay, 2015). However, some scholars note that sustainability-related professional skills demanded in emerging work contexts are not always adequately developed in higher education programs (Brundiers & Wiek, 2013). Outstanding questions remain regarding which specific teaching and learning activities would be optimally suited to cultivating students' sustainability competencies. Research indicates that impactful education for sustainability should provide opportunities for learners to engage actively with real-world sustainability problems in applied settings, rather than merely acquiring conceptual knowledge through passive means like lectures (Brundiers & Wiek, 2013; Quelhas et al., 2019; Wyness & Dalton, 2018). Transformative pedagogies like project-based and problem-based learning that situate learning within meaningful contexts show particular promise for enabling the applied, experiential learning required for sustainability education (Cörvers et al., 2016).

ESD faces unique challenges due to the systemic, interconnected nature of sustainability issues. Teaching must move beyond siloed disciplinary perspectives to nurture integrated systems thinking. Learners must also develop solutions-oriented mindsets focused on collaborative problem-solving. Social mobile learning provides opportunities to engage diverse voices and grapple with real-world sustainability dilemmas. However, successfully incorporating ESD principles requires supportive policies, educator training, and updated curricula attuned to sustainability competencies.

Educational Principles in Sustainability

In examining pedagogical strategies for sustainability education, important parallels can be drawn with medical education, which shares similarities as a complex, multifaceted domain. Exploring the intersection between medical education and sustainability education reveals vital shared instructional approaches and strategies. It also illuminates key contextual distinctions in their respective applications. Sterling's seminal work puts forth a systemic learning framework that connects educational principles with sustainability imperatives across disciplinary boundaries (Sterling, 2004). Additionally, Tilbury, Ryan, and Tyler emphasize education's critical role in shaping sustainable futures. Their scholarship proposes strategies to align educational principles and practices with sustainability, which represents an evolving, interdisciplinary arena (Tilbury et al., 2017). This highlights that pedagogical innovation for sustainability should be firmly grounded in learner-centered educational values and perspectives.

Both medical education and sustainability education grapple with conveying complex systemic knowledge, training specialized practical skills, and shaping professional ethics and values. Problem-based and project-based learning can provide meaningful contexts for developing sustainability competencies just as case-based approaches do in medical training. However, sustainability education must also foster big-picture thinking that transcends narrow disciplines. Learners should become adept at integrating diverse perspectives to solve multidimensional sustainability challenges.

Problem-based and Project-based Learning (PPBL)

Problem-based learning (PBL) and project-based learning (PBL) have been increasingly utilized in sustainability education contexts. These student-centered instructional approaches situate learning within

authentic, real-world problems and contexts. They promote competencies like critical thinking, problem-solving, innovation, and communication by engaging learners in applied projects and inquiry-driven activities (Brundiers & Wiek, 2013; Córvers et al., 2016). Research demonstrates PBL and PPBL can effectively enable the development of sustainability competencies. However, the success of collaborative teamwork depends on careful facilitation and instructional design (Brundiers & Wiek, 2013; Michaelsen & Sweet, 2008; Watkins et al., 2018; Wyness & Dalton, 2018). While differences exist, PBL and PPBL share valuable commonalities underpinning their relevance for sustainability education, including: anchoring learning in real-world contexts, facilitating learner-centered strategies, enabling small group work and peer collaboration, and providing authentic professional settings for applied learning (Brundiers & Wiek, 2013; Córvers et al., 2016). Their significant overlap has led many sustainability education initiatives to adopt an integrated PPBL approach.

PPBL provides opportunities for constructivist learning and grappling with ill-defined sustainability problems mirroring real-world complexities. It fosters collaboration, co-creation of knowledge, and development of self-directed learning skills. However, problems like student disengagement, social loafing, and conflict must be anticipated and mitigated through thoughtful team design, clear expectations-setting, and facilitator guidance. Blended PPBL that strategically incorporates virtual components could support engagement and collaborative learning.

Social Mobile Learning: Definition and Key Attributes

Social mobile learning integrates mobile technologies and social media platforms to enable engaging, interactive, collaborative educational experiences tailored for digital learners (Cochrane, 2014). This emerging paradigm leverages mobile devices' affordances and social media's networking capacities to facilitate student-centered learning aligned with 21st-century competency demands. Key attributes of social mobile learning include: accessibility, personalization, collaboration, and context-awareness (Ally, 2009; Kukulska-Hulme & Viberg, 2018). Mobility enables ubiquitous access to learning materials, permitting participation across settings. Personalization involves adapting learning to align with individuals' needs and profiles. Social media provides collaboration and knowledge sharing opportunities. Context-awareness involves leveraging data like locations and learner profiles to provide tailored learning experiences. Overall, these attributes present opportunities for learner autonomy, social construction of knowledge, and development of digital literacy skills.

Mobile technologies and social media tools open up new possibilities for participatory, digitally-connected learning. Students can access educational resources, interact with peers, share ideas, and showcase learning outcomes through a variety of platforms, apps, and devices. However, supporting students in navigating these emerging spaces thoughtfully and responsibly poses new competency demands for educators. Teacher training, ongoing communities of practice, and development of social-emotional learning are essential to maximize social mobile learning's potential.

While social media platforms rapidly evolve, insights from foundational scholarship retain relevance for elucidating technology's changing role in education. For instance, Junco's (2012) research exploring links between Facebook usage and academic performance offers useful perspectives on how social media participation can impact learning, despite drastic technological shifts since its publication (Junco, 2012). Similarly, Junco and Clem's work revealed how digital tools like social media influence academic outcomes, further highlighting its educational potential (Junco & Clem, 2015). Revisiting seminal social media research through a contemporary lens can thus enrich understanding of effective integration.

Past social media research provides baseline insights into the benefits and pitfalls of participatory online spaces for learning. However, the dramatic pace of technological change necessitates continuously re-evaluating social media's impact. Longitudinal data could reveal shifting patterns in how students engage with and are shaped by social platforms. More research is needed focusing specifically on social media for sustainability education, an increasingly important intersection.

Benefits and Challenges of Social Mobile Learning

Thoughtfully designed social mobile learning interventions offer benefits aligned with 21st-century education priorities, including increased student engagement, motivation, critical thinking, collaboration, and academic performance (Crompton, 2013; Greenhow & Lewin, 2015; Kearney & Maher, 2012; Manca & Ranieri, 2016). However, implementing social mobile learning also presents challenges that should be strategically addressed, such as risks to privacy and security, digital distractions, unequal access to technology, resistance to new practices, and difficulty assessing online resource quality (Carpenter et al., 2016; Hew & Cheung, 2014; Manca & Ranieri, 2016; Purvis et al., 2020; Selwyn, 2011). Overcoming these requires comprehensive policies, educator training, technical support, and continuous evaluation.

Balancing social mobile learning's potential benefits with its inherent challenges remains an ongoing process. Studies reveal some positive learning impacts, but outcomes appear highly context-dependent. More longitudinal data is needed on evolving patterns in how students interact with social mobile platforms. Educators play a crucial role in maximizing benefits and mitigating risks through thoughtful integration. Prioritizing student well-being and equitable access should ground policymaking and implementation decisions.

Social Mobile Learning Implementation

Examining successful social mobile learning integration provides valuable insights into best practices across contexts. Bosch et al.'s study revealed enhanced engagement, critical thinking, and problem-solving by incorporating social media and mobile devices into project-based learning (Bosch et al., 2014). Kukulska-Hulme et al. demonstrated how mobile devices and social platforms improved motivation, autonomy, and proficiency in language learning (Kukulska-Hulme & Traxler, 2015). Carpenter et al. highlighted how online professional networking expanded teachers' development opportunities (Carpenter et al., 2016). Key strategies include aligning activities with learning goals, facilitating open communication, providing scaffolding, encouraging reflection, and continuous evaluation (Cochrane, 2014; Cochrane & Bateman, 2010; Crompton, 2013; Kukulska-Hulme & Viberg, 2018).

Careful examination of real-world social mobile learning implementations offers useful implications for policy and practice. Key takeaways include the importance of aligning activities with desired competencies, scaffolding learner autonomy, fostering idea exchange, providing ongoing educator support, and regularly assessing effectiveness. Investigating applications specifically within sustainability education could provide targeted insights to guide integration. More research is needed to develop comprehensive frameworks and evidence-based principles for social mobile learning implementation.

Thailand Education 4.0

Thailand Education 4.0 is a government initiative to bring innovation and technology into education to equip youth with 21st-century skills and align the education system with economic development priorities (Office of the Education Council, 2017). Core goals include improving educational quality, developing

human capital, fostering lifelong learning habits, and reducing disparities (Office of the Education Council, 2017). Rationale stems from recognizing Thailand's need to transition towards knowledge-based industries, necessitating students who can thrive in the digital economy (Siritongthaworn et al., 2016). Education 4.0 represents a shift from teacher-centered learning towards more student-centered pedagogies focused on skills like critical thinking, problem-solving, creativity, and communication (Boonlua & Kongchan, 2019; Freeman et al., 2014; Puncreobutr, 2016). However, Thailand still faces challenges like infrastructure limitations, uneven technology access, lack of teacher training, and resistance to pedagogical change (Chaiyajit & Nokham, 2020; Sangsawang, 2019).

While Education 4.0 sets forth an ambitious vision, systemic barriers persist. Top-down policy approaches must be accompanied by grassroots-level commitment to pedagogical transformation. Teachers are central catalysts within schools and require ongoing support to shift practices. Students also need scaffolding to transition successfully to new learning paradigms. A holistic approach addressing infrastructure, training, and stakeholder buy-in is essential for impactful change.

Integrating Social Mobile Learning into Education 4.0

Social mobile learning strongly aligns with Education 4.0's emphasis on student-centered learning and 21st century skill development (Boonlua & Kongchan, 2019). Mobile and social media technologies present opportunities for collaborative, authentic learning experiences that develop competencies like communication, cultural awareness, digital literacy, and critical thinking (Cochrane & Antonczak, 2013). However, effectively leveraging social mobile learning requires strategic efforts to tackle persistent barriers, like unequal access to technology across geographic and socioeconomic divides (Chaiyajit & Nokham, 2020).

Social media integration supports Education 4.0 goals by facilitating collaborative learning, enabling authentic learner-driven explorations of real-world issues, and building digital participation skills (Boonlua & Kongchan, 2019; Srichanyachon, 2014). As social technologies rapidly evolve, insights from foundational social media scholarship retain relevance for guiding integration. For example, research on Facebook's academic impacts sheds light on strategies to optimize social media's educational value (Junco, 2012).

Social mobile learning shows alignment with Education 4.0 priorities related to collaboration, digital literacy, cultural exchange, and real-world problem-solving. However, equitable access remains a substantial barrier. Blended approaches combining virtual and in-person learning could mitigate access disparities. Teacher training and updated curricula are needed to effectively leverage social mobile learning's affordances.

Education for sustainable development (ESD) represents another key priority within Thailand 4.0, as it strives to develop the knowledge, skills, and mindsets needed to drive sustainability initiatives. Incorporating ESD into Education 4.0 via social mobile learning approaches can increase student motivation and engagement. However, effectively realizing ESD's potential requires tackling challenges like language barriers that restrict access to sustainability information, gaps in sustainability awareness, and shifting educator mindsets and practices (Jiraphongsa et al., 2020; Reunamo & Pipere, 2011; Wongwiwatthananukit et al., 2019). Pedagogical approaches like project-based learning, community-based learning, and design thinking offer pathways for developing sustainability competencies through social mobile learning (Suwannakarn & Wongwiwatthananukit, n.d., p. 24–31).

ESD represents a key opportunity area for social mobile learning, enabling far-reaching exchanges and

participatory learning about complex sustainability issues. However, ingrained norms and knowledge gaps pose implementation challenges. Creative pedagogical strategies, updated curricula, and ongoing educator support can help realize social mobile learning's potential to advance ESD.

Mobile Learning in Thailand

Mobile learning has attracted growing attention in Thailand as a means of achieving Education 4.0 goals related to 21st century skills and student-centered pedagogy (Boonlua & Kongchan, 2019). Government initiatives have promoted adoption, including "One Tablet per Child" and university programs integrating online courses and mobile platforms (Donn & Almekhlafi, 2016; Suwannatthachote & Hetrakul, 2015). However, research reveals mixed outcomes, with some studies finding benefits like increased engagement and achievement, while others note challenges like infrastructure limitations, uneven device/internet access, and insufficient teacher training (Saekow & Samson, 2011; Sangsawang, 2019; Suwannatthachote & Hetrakul, 2015; Wiriyachitra, 2012). Achieving mobile learning's full potential requires concerted efforts to overcome these barriers and ensure equitable access (Chaiyajit & Nokham, 2020; Suwannatthachote & Hetrakul, 2015). Overall, mobile learning shows strong alignment with Education 4.0 goals, contingent on implementation strategies.

While government initiatives have expanded mobile technology access, systemic barriers to effective integration remain. Awareness-raising, educator support, updated curricula, and ongoing evaluation are needed to match the rapid pace of technological change. Blended approaches combining virtual and in-person learning could address uneven access issues. With strategic efforts, mobile learning can provide ubiquitous participatory learning aligned with Education 4.0 goals.

Teacher Professional Development

Teacher training and ongoing professional development are essential to effectively leverage social mobile learning, given the complex, shifting technology landscape (Crompton, 2013; Puentedura, 2010). Strategies like workshops, mentoring programs, online networks, and self-directed learning can facilitate continuous pedagogical and technological skill-building (Avalos, 2011; Carpenter et al., 2016; Desimone, 2009; Ertmer & Ottenbreit-Leftwich, 2010; Guskey, 2003). Best practices include aligning training with institutional goals, providing sustained support and feedback, emphasizing sound pedagogical uses of technology, nurturing adaptability and growth mindsets among educators, and cultivating cultures of learning and innovation (Dweck, 2008; Ertmer et al., 2012; Guskey, 2003; Puentedura, 2010). Overcoming barriers like resistance and resource constraints is critical for successful implementation (Crompton et al., 2017; Purvis et al., 2020).

Teacher training is integral yet often underemphasized in technology integration initiatives. Social mobile learning's rapid evolution requires continuous teacher education through diverse formal and informal mechanisms. Sustained communities enabling idea exchange, collaboration, and support are especially valuable. A culture embracing change, innovation, and lifelong learning is needed to thrive in these shifting educational landscapes.

Conceptual Framework

This study aimed to investigate social mobile learning's potential to enhance sustainability education. The conceptual framework aligned with literature emphasizing real-world, collaborative learning approaches like PPBL for ESD (Brundiers & Wiek, 2013; Córvers et al., 2016). Undergraduate students completed a

video sustainability solution pitch activity using the social media platform Soqqle, creating initial pitches, providing peer feedback for improvement, developing final pitches, and reflecting. Analysis evaluated video/critique quality, participation, and instructor observations to assess impacts on sustainability understanding, engagement, and skill-building. This framework enabled examining whether the social mobile learning activity could provide an authentic context for developing sustainability solutions competencies and nurture engagement through peer collaboration.

Methodology

This qualitative study involved undergraduate students participating in a sustainability solution video pitch activity using the social media platform Soqqle. Students created initial pitch videos, offered peer critiques, developed final pitches, and completed video reflections. Data analysis encompassed evaluating video/critique quality, participation rates, and instructor observations. A qualitative approach enabled an in-depth exploration of the complex intersection of sustainability education and social mobile learning. Methodological limitations are noted, such as the inability to incorporate a control group for comparison, though this could enrich insights in future studies.

Results

Analysis revealed variable outcomes from the social mobile learning intervention. Regarding video pitch improvements, 4 student groups demonstrated meaningful progress after peer feedback, while 2 lagged, potentially reflecting motivational issues. Peer critique quality was mixed, with some comments lacking depth or substantive feedback. Final reflection completion rates were low at 31%, surfacing possible engagement challenges. However, instructors perceived knowledge gains for some students attributable to experimentation and feedback facilitated by the social mobile approach. Instructors noted lingering difficulties motivating disengaged students. Additional scaffolding and individual assignments could optimize participation. Assessment methods provided useful insights into engagement levels. Overall, the activity showed promise contingent on student motivation and attitudes.

Discussion

Key insights emerged on social mobile learning for ESD. Benefits include enhanced experimentation, feedback, and access for engaged students versus static learning. However, intrinsic motivation issues persist, underscoring the need for differentiated instruction tailored to diverse needs. Barriers like privacy risks, divides, and evolving educator roles require strategic mitigation. While PPBL showed promise, modifications are needed to optimize participation and learning. Innovative assessments should align with social mobile learning's unique properties and provide meaningful feedback. Overall, further research should investigate social mobile learning's potential while considering student diversity and evidence-based instructional design adaptations.

Conclusion

This small-scale study provides useful starting insights but has limitations in scope and generalizability. Findings reveal social mobile learning's potential to meaningfully engage some students in sustainability education through experimentation, feedback, and co-creation. However, efficacy appears heavily contingent on student motivation and attitudes. Further research should explore strategies to increase participation among diverse learners with varied needs and motivations. Additional examination into how

social mobile learning activities enrich sustainability understanding and competencies is merited. Educators' changing roles in facilitating these emerging learning environments warrants exploration. By building on these initial findings, education stakeholders can work towards optimizing social mobile learning's advantages for sustainability education and sustainable development.

Discussion

The integration of social mobile learning into education holds much promise, but also poses numerous challenges that must be strategically addressed. Thoughtful policies, educator support, and instructional design are needed to create inclusive, ethical, and effective implementations.

Policies should mitigate risks related to privacy, security, and digital divides, while fostering digital citizenship skills (Hew & Cheung, 2014; Ribble, 2015). Teacher training should develop both technological and pedagogical competencies needed to facilitate social mobile learning (Koehler & Mishra, 2009; Puentedura, 2010). Ongoing professional development and communities of practice are essential to provide sustained support in this dynamic landscape (Carpenter et al., 2016; Desimone, 2009). Instructional design should align activities with learning objectives, provide scaffolding, encourage reflection, and continuously evaluate efficacy (Cochrane, 2014; Kukulska-Hulme & Viberg, 2018). Importantly, motivational barriers must be addressed through personalized, relevant learning experiences tailored to diverse needs (Deci & Ryan, 2000; Pintrich, 2003).

As social mobile learning evolves, focus must remain on equitable access, ethical technology uses, and evidence-based practices centered on learners' development. With thoughtful implementation, social mobile learning can empower students to thrive in an interconnected world.

References

1. Ally, M. (2009). *Mobile learning: transforming the delivery of education and training*.
2. Athabasca University Press.
3. Avalos, B. (2011). Teacher professional development in Teaching and Teacher Education over ten years. *Teaching and Teacher Education*, *27*(1), 10–20. https://doi.org/10.1016/j.tate.2010.08.007.
4. Boonlua, S., & Kongchan, C. (2019). Thailand 4.0 and the future of higher education: a review. In S. Boonlua, & C. Kongchan (Eds.), *Thailand 4.0 and higher education institutions* (pp. 1–19). Springer.
5. Bosch, T. E., Tait, A., & Venter, K. (2014). Integrating online learning in a South African university: A case study. *South African Journal of Higher Education*, *28*(5), 1561–1577.
6. Brundiers, K., & Wiek, A. (2013). Do We Teach What We Preach? An International Comparison of Problem- and Project-Based Learning Courses in Sustainability. *Sustainability*, *5*(4)
7. Chaiyajit, N., & Nokham, R. (2020). Digital inequality. *In Education* 4.0: Challenges and coping strategies of learners in a rural community in Thailand. *Education and Information Technologies*, 25(6), 5,291–5,309.
8. Cochrane, T., & Bateman, R. (2010). Smartphones give you wings: pedagogical affordances of mobile Web 2.0. *Australasian Journal of Educational Technology*, *26*(1), 1–14. https://doi.org/10.14742/ajet.1098.
9. Cochrane, T. D. (2014). Critical success factors for transforming pedagogy with mobile Web 2.0. *British Journal of Educational Technology*, *45*(1), 65–82. https://doi.org/10.1111/j.1467-8535.2012.01384.x.
10. Cochrane, T., & Antonczak, L. (2013). Designing creative learning environments. Retrieved from

https://www.researchgate.net/publication/280134546_Designing_Creative_Learning_Environments
11. Cörvers, R., Wiek, A., de Kraker, J., Lang, D. J., & Martens, P. (2016). Problem-based and project-based learning for sustainable development. *Sustainability science: an introduction*, 349–358.
12. Crompton, H. (2013). A historical overview of mobile learning: toward learner-centered education. In Z. L. Berge, & L. Y. Muilenburg (Eds.), *Handbook of mobile learning* (pp. 3–14). Routledge.
13. Crompton, H., Burke, D., & Gregory, K. H. (2017). The use of mobile learning in PK-12 education: A systematic review. *Computers & Education, 110*, 51-63. https://www.sciencedirect.com/science/article/abs/pii/S0360131517300660
14. Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: human needs and the self-determination of behavior. *Psychological Inquiry*, *11*(4), 227–268. https://doi.org/10.1207/S15327965PLI1104_01.
15. Desimone, L. M. (2009). Improving impact studies of teachers' professional development: toward better conceptualizations and measures. *Educational Researcher*, *38*(3), 181–199. https://doi.org/10.3102/0013189X08331140.
16. Donn, G., & Almekhlafi, A. G. (2016). One tablet per child in Thailand. *Educational Technology Research and Development*, *64*(2), 359–373.
17. Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: how knowledge, confidence, beliefs, and culture intersect. *Journal of Research on Technology in Education*, *42*(3), 255–284. https://doi.org/10.1080/15391523.2010.10782551.
18. Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. Retrieved from https://www.researchgate.net/publication/257171177_Teacher_beliefs_and_technology_integration_practices_A_critical_relationship
19. Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, *111*(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111.
20. Greenhow, C., & Lewin, C. (2015). Social media and education: reconceptualizing the boundaries of formal and informal learning. Learning, Media and Technology, *41*(1), 6–30. https://doi.org/10.1080/17439884.2015.1064954.
21. Guskey, T. R. (2003). What makes professional development effective? *Phi Delta Kappan*, *84*, 748-750. http://dx.doi.org/10.1177/003172170308401007
22. Hew, K. F., & Cheung, W. S. (2014). Students' and instructors' use of massive open online courses (MOOCs): Motivations and challenges. *Educational Research Review*, *12*, 45-58. http://dx.doi.org/10.1016/j.edurev.2014.05.001
23. Jiraphongsa, C., Srisawat, N., & Srisawat, K. (2020). Awareness and understanding of sustainable development among Thai university students. *Sustainability*, *12*(2), 522. Junco, R. (2012). Too much face and not enough books: the relationship between multiple indices of Facebook use and academic performance. *Computers in Human Behavior*, *28*(1), 187–198. https://doi.org/10.1016/j.chb.2011.08.026.
24. Junco, R., & Clem, C. (2015). Predicting course outcomes with digital textbook usage data. *Internet and Higher Education*, *27*, 54–63. https://doi.org/10.1016/j.iheduc.2015.06.001.

25. Koehler, M. J., Mishra, P., & Cain, W. (2013). What is Technological Pedagogical Content Knowledge (TPACK)? *Journal of Education*, 193(3), 13–19. https://doi.org/10.1177/002205741319300303
26. Kearney, M., & Maher, D. (2012). Mobile learning in maths teacher education: Driving pre-service teachers' professional development. *Australian Educational Computing, 27*(3), 78-86. Retrieved from https://www.academia.edu/2498734/Kearney_M_and_Maher_D_2012_Mobile_learning_in_maths_teacher_education_Driving_pre_service_teachers_professional_development_Australian_Educational_Computing_27_3_78_86
27. Kukulska-Hulme, A., & Viberg, O. (2018). Mobile collaborative language learning: State of the art. *British Journal of Educational Technology, 49*, 207-218. https://doi.org/10.1111/bjet.12580
28. Kukulska-Hulme, A., & Traxler, J. (Eds.). (2015). *Mobile learning: the next generation*. Taylor & Francis Group.
29. Manca, S., & Ranieri, M. (2016). Facebook and the others. Potentials and obstacles of social media for teaching in higher education. *Computers and Education*, *95*, 216–230. https://doi.org/10.1016/j.compedu.2016.01.012.
30. Michaelsen, L. K., & Sweet, M. (2008). The essential elements of team-based learning. *New Directions for Teaching and Learning*, 2008(116), 7–27. https://doi.org/10.1002/tl.330.
31. Office of the Education Council. (2017). *Thailand Education* 4.0 Policy.
32. Pintrich, P. R. (2003). A motivational science perspective on the role of student motivation in learning and teaching contexts. *Journal of Educational Psychology*, *95*(4), 667–686. https://doi.org/10.1037/0022-0663.95.4.667.
33. Puentedura, R. (2010). SAMR and TPCK: Intro to advanced practice. Retrieved from http://hippasus.com/resources/sweden2010/SAMR_TPCK_IntroToAdvancedPractice.pdf
34. Puncreobutr, V. (2016). Education 4.0: New challenge of learning. *St. Theresa Journal of Humanities and Social Sciences, 2*(2).
35. Purvis, A. J., Rodger, H. M., & Beckingham, S. (2020). Experiences and perspectives of social media in learning and teaching in higher education. *International Journal of Educational Research Open*, *1*, 100,018.
36. Quelhas, O. L. G., Lima, G. B. A., Ludolf, N. V. E., Meiriño, M. J., Abreu, C., Anholon, R., Vieira Neto, J., & Rodrigues, L. S. G. (2019). Engineering education and the development of competencies for sustainability. *International Journal of Sustainability in Higher Education*, *20*(4), 614–629. https://doi.org/10.1108/IJSHE-07-2018-0125.
37. Ribble, M. (2015). *Digital citizenship in schools: Nine elements all students should know* (3rd ed.). Washington, DC: International Society for Technology in Education.
38. Reunamo, J., & Pipere, A. (2011). Doing research on education for sustainable development. *International Journal of Sustainability in Higher Education*, 12(2), 110–124. https://doi.org/10.1108/14676371111118183.
39. Saekow, A., & Samson, B. (2011). *E-learning readiness of Thailand's universities compared to the USA's cases*. International Journal of e-Education, e-Business, e-Management, and e-Learning, 1(2), 126–131.
40. Sangsawang, T. (2019). Implementation of mobile learning in higher education: opportunities and challenges. *International Journal of Emerging Technologies in Learning*, *14*(9), 4–18.

41. Savage, E., Tapics, T., Evarts, J., Wilson, J., & Tirone, S. (2015). Experiential learning for sustainability leadership in higher education. *International Journal of Sustainability in Higher Education*, *16*(5), 692–705.
42. Selwyn, N. (2011). *Education and technology: Key issues and debates.* Continuum International Publishing Group.
43. Sharples, M., Taylor, J., & Vavoula, G. (2005). A theory of learning for the mobile age. Retrieved from https://telearn.hal.science/hal-00190276/file/Sharples_et_al_Theory_of_Mobile_Learning_preprint.pdf
44. Siritongthaworn, S., Krairit, D., Dimmitt, N. J., & Paul, H. (2016). The study of e-learning technology implementation: A preliminary investigation of universities in Thailand. Retrieved from https://www.researchgate.net/publication/225222989_The_study_of_e-learning_technology_implementation_A_preliminary_investigation_of_universities_in_Thailand
45. Srichanyachon, N. (2014). EFL learners' perceptions of using LMS. Retrieved from https://eric.ed.gov/?id=EJ1043183
46. Sterling, S. (2004). Higher education, sustainability, and the role of systemic learning. In P. B. Corcoran, & A. E. J. Wals (Eds.), *Higher education and the challenge of sustainability: problematics, promise, and practice* (pp. 49–70). Kluwer Academic Publishers.
47. Suwannakarn, K., & Wongwiwatthananukit, K. (n.d.). Project-based learning for sustainable development education in Thailand 4.0. *Journal of Sustainable Education*, *8*(2), 24–31.
48. Suwannatthachote, P., & Hetrakul, K. (2015). Mobile learning in Thailand: trends and challenges in higher education. *Procedia-Social and Behavioral Sciences*, *197*, 197–201.
49. Tilbury, D., Ryan, A., & Tyler, S. (Eds.). (2017). *Education and sustainability: responding to the global challenge*. Routledge.
50. United Nations. (2015). *Transforming our world: the 2030 agenda for sustainable development*. https://sustainabledevelopment.un.org/post2015/transformingourworld/publication.
51. (New York: United Nations, Department of Economic and Social Affairs, Issue.)
52. Watkins, K., Forge, N., Lewinson, T., Garner, B., Carter, L. D., & Greenwald, L. (2018). Undergraduate social work students' perceptions of a team-based learning approach to exploring adult development. *Journal of Teaching in Social Work*, *38*(2), 214–234. https://doi.org/10.1080/08841233.2018.1439428.
53. Wiek, A., & Kay, B. (2015). Learning while transforming: solution-oriented learning for urban sustainability in Phoenix, Arizona. In K. Lotz-Sisitka, J. W. M. Greig, & L. Chisholm (Eds.), *Learning and education for sustainability: A global overview* (pp. 262–280). Springer.
54. Wiriyachitra, A. (2012). English language teaching and learning in Thailand in this decade. *Thai. TESOL Focus*, 15(1), 4–9.
55. Wongwiwatthananukit, W., Wongwiwatthananukit, K., & Chantarasak, K. (2019). The digital divide in Thailand: access to and use of the internet. *Journal of the Eastern Asia Society for Transportation Studies*, *10*, 1047–1058.
56. Wyness, L., & Dalton, F. (2018). The value of problem-based learning in learning for sustainability: undergraduate accounting student perspectives. *Journal of Accounting Education*, *45*, 1–19.