



Key success factors for transforming classrooms into learning communities in digital learning ecosystem at secondary schools in Thailand

Kulthida Tuamsuk ^{1,2*}

 0000-0003-0852-8945

Lan Thi Nguyen ¹

 0000-0002-8848-2168

Issara Kanjug ²

 0000-0001-6820-442X

Grichawat Lowatcharin ²

 0000-0002-2623-1769

Teeradej Manakul ²

 0000-0003-4234-8470

Kornwipa Poonpon ²

 0000-0002-8349-2834

Weerachai Sarakorn ²

 0000-0003-2334-8213

Anucha Somabut ²

 0000-0001-7293-2016

Niwat Srisawasdi ²

 0000-0002-2042-2601

Saksuriya Traiyarach ²

 0000-0001-8053-9425

¹ Department of Information Science, Faculty of Humanities & Social Sciences, Khon Kaen University, Khon Kaen, THAILAND

² Smart Learning Innovation Research Center, Khon Kaen University, Khon Kaen, THAILAND

* Corresponding author: kultua@kku.ac.th

Citation: Tuamsuk, K., Nguyen, L. T., Kanjug, I., Lowatcharin, G., Manakul, T., Poonpon, K., Sarakorn, W., Somabut, A., Srisawasdi, N., & Traiyarach, S. (2023). Key success factors for transforming classrooms into learning communities in digital learning ecosystem at secondary schools in Thailand. *Contemporary Educational Technology*, 15(2), ep408. <https://doi.org/10.30935/cedtech/12920>

ARTICLE INFO

Received: 25 Sep 2022

Accepted: 20 Nov 2022

ABSTRACT

This study aimed to investigate the success factors for transforming classrooms into learning communities in digital learning ecosystem (DLE) of Thailand's secondary schools. Quantitative research was conducted by using a questionnaire as the research instrument to measure teachers' evaluation of factors. Purposive sampling was applied to obtain a sample group of secondary schools. The questionnaires were sent to teachers at secondary schools in 20 provinces in Northeast Thailand that were employing the smart learning project for their teaching and learning. Data analysis was performed using descriptive statistics, exploratory factor analysis, and confirmatory factor analysis. The results revealed that learning support technologies, teachers, and learners were the three most important factors influencing the development of DLE (\bar{x} =4.64, \bar{x} =4.61, and \bar{x} =4.49, respectively). The findings of this study have

implications for educators, administrators, and teachers to review and discover appropriate ways to invest the necessary conditions that can enhance the quality of DLEs and improve teaching and learning activities in the digital environment at secondary schools.

Keywords: success factors, learning community, digital learning ecosystem, secondary schools, Thailand

INTRODUCTION

Information and communication technology (ICT) have become increasingly popular, quickly creating digital transformation and affecting the educational structure and learning environment, leading to the timely adaptability of educational institutions. They can capitalize on and integrate digital technologies into the design and innovation of learning content, learning spaces, technologies, and pedagogical methods (Adedoyin & Soykan, 2020; Balyer & Oz, 2018). In addition, learners have more opportunities to be exposed to the online learning sphere, accessing learning materials through the Internet, sharing learning resources, and increasing collaboration (Rospigliosi, 2020). Therefore, it is desirable to design and create appropriate learning environments for teachers and learners. Consequently, digital transformation can support the design of smart learning solutions. Smart learning is considered a new learning paradigm and plays an important role in creating learning environments effectively, providing learners with a convenient communication environment, and both diverse and personalized learning content (Sung, 2015).

A digital learning ecosystem (DLE) is defined as an “adaptive socio-technical system consisting of mutually interacting digital species (tools, services, and content used in learning process) and communities of users (learners, facilitators, and experts) together with their social, economic and cultural environment” (Laanpere et al., 2014, p. 422). It plays an important role in designing and assessing learning situations in digital environments, as well as enhancing learning performance and navigation and accessible and interactive ability (Reyna, 2011). In addition, the governance of the DLE needs to be deployed to navigate strategies for educational initiatives, allocate appropriate resources, and manage risks that could occur in the ecosystem (Chang & Uden, 2008). Subsequently, core elements (i.e., structures, processes, communication, and relational mechanisms, and pedagogies and instructional designs) should be identified and explored to understand the nature and features of the learning ecosystem, and to overcome barriers and enable users to learn, share, and interact together. Additionally, Chang and Guetl (2007) confirmed that intrinsic and extrinsic factors, for instance, “evolution of knowledge, educational goals, learning tasks, cultural and sociological aspects, and expectations by society, private industry and business organizations, the government, public service and not-for-profit organizations” (p. 421-422) influence the ecosystem conditions. The change of conditions in an ecosystem could impact its behavior and components and requires individuals and stakeholders to adapt to contribute to the success of DLE (Chang & Guetl, 2007). Therefore, this ecosystem must be evaluated in the socio-technical context that stakeholders could find and identify opportunities and challenges therein (Jeladze et al., 2017).

Smart learning is a research project of the university in Thailand that was launched in 2016. The aim of the project is to develop students’ competency and support the schools’ teachers to be able to transform the classroom into a community learning environment. This is accomplished by implementing course teaching in a digital learning environment at secondary schools through innovative teaching and learning strategies developed by the university’s faculty from research results and academic activities. The project development commences by addressing teaching and learning in the three core subjects of Mathematics, Science, and English. The target group of this project was secondary school students (grades seven to nine) in medium-sized schools in the northeast of Thailand. The smart learning model has the following components (Tuamsuk, 2019):

1. *Learning outcomes (expected competencies)* are analyzed and synthesized based on (1) secondary school level of the basic education core curriculum B.E. 2551 OBEC, (2) PISA exams, (3) 21st century learning skills, and (4) international standards related to the subject matter, such as STEM (science) and CEFR (English), developed by the smart learning project.
2. *Learning content* are designed based on a curriculum that focuses on students’ understanding of the lesson and helps students gain knowledge from learning rather than memorization. In addition,

students can usefully link knowledge with situations and use technologies for learning in a digital environment.

3. *Teaching methods (pedagogy)* focus on improving teachers' knowledge and understanding of teaching subjects, and teachers can choose appropriate teaching methods and organize learning activities. Further, teachers can use learning support technologies to create a learning atmosphere in a digital environment.

The deployment and application of the smart learning project at secondary schools in Northeast Thailand is considered a DLE; thus, the aim of this study is to investigate the success factors for transforming classrooms into learning communities in this ecosystem.

LITERATURE REVIEW

Internal Factors

Some intrinsic elements affect the sustainable development of DLEs, such as governance/management, policy, technologies, teacher competence, learner factors, infrastructure, and learning content. Further explanations on some of these elements ensue.

Governance/management

The governance of a learning ecosystem is essential for an organization because of certain irrelevant internal factors. Undoubtedly, providers, barriers, processes, and learning aspects need to be considered. The ways to select and use data from learners, to connect the system with resources, and to negotiate with stakeholders to meet the required competition must be clarified in learning ecosystem governance (Giattino & Stafford, 2019). However, how do we create a governance structure to maximize elements and maintain flexibility to enhance the interaction among communities, users, and tools? Giattino and Stafford (2019) noted that six steps can be designed and carried out toward achieving a successful learning ecosystem:

- (1) identifying stakeholders and choosing framers,
- (2) selecting issues,
- (3) building a charter,
- (4) coordinating the charter,
- (5) building responsiveness into administration, and
- (6) addressing grievances.

Accordingly, Chang and Uden (2008) revealed that the structure of an ecosystem pertains to the position and duties of individuals, organizational structure, committee, administrators, and senior leaders. Management processes should include resources, networks, infrastructure, "strategic planning, licensing and regulations, service level agreements, service and technical management, information security and risk management" (p. 343), and collaboration and participation of stakeholders. The last factor in the governance of ecosystems is revealed through standards of instructional design, learning styles, strategies of pedagogy, and cognitive learning. In addition, people take responsibility for establishing policy needs to be determined, as functions and decisions would impact components, needs, processes, and results in the ecosystem (Giattino & Stafford, 2019).

Learning technologies and content, and infrastructure

To expand upon prior research presented here regarding factors leading to the efficacy of digital learning, previous studies have indicated several challenges: those related to learning tools, new pedagogical methods, and the sustainable development of ecosystems (Põldoja, 2016); the institution's management, infrastructure, learning resources, and tools (Väljataga et al., 2020); learning facilitation and change management, limited budget, the large number of students in a classroom, and traditional teaching methods (Quaicoe et al., 2016), all of which are considered to influence the pressures and chances of exploring DLE services and the development of ICT competencies of schools.

It is important to identify the needs and selection processes and determine criteria so that educational institutions can have the best solutions to meet their requirements and standards. Moreover, an ecosystem must ensure precise, inheritance and automated technology solutions, and have the ability to integrate training features with other systems to be cost-effective and not bound by proprietary systems. According to Uden et al. (2007), “the design of e-learning should be based on sound principles from instructional and learning theories” (p. 116). The content in the ecosystem must be combined, reused, distributed, interoperable with different vendors, and integrated with technologies and learning management. Applications and infrastructure must be continually improved to enable the management and optimization of e-learning ecosystems (Uden et al., 2007). Ensuring the security and privacy of e-learning is necessary to increase the usage of e-learning ecosystems in educational institutions. In addition, policies, procedures, and technologies are necessary to ensure system security (Eswari, 2011).

Teacher and learner factors

It is interesting to note that teachers’ digital competence (Väljataga et al., 2020), information access ability, knowledge consolidation, and technology use (Virgili, 2013 as cited in Ospina & Galvis, 2017) are necessary conditions for transforming and developing the learning ecosystem. Giannakos et al. (2016) emphasized that a learning ecosystem helps develop an active learning method and a profound understanding of the learning material and evolves teaching methods to promote learners’ motivation and needs. Therefore, an understanding of the learning styles helps teachers choose appropriate teaching approaches to enhance teaching effectiveness, improve learning processes and achievement, and design appropriate curriculum and syllabi for students (Vaseghi et al., 2012).

Furthermore, the factors relating to learners, such as learning duties (Chang & Gütl, 2008), self-learning and learning from others, and building relationships with people in the ecosystem (Virgili, 2013 as cited in Ospina & Galvis, 2017) also need to be considered for the development of a DLE.

External Factors

Chang and Gütl (2008) confirmed that the influences of external factors in a learning ecosystem must be identified as the conditions for undergoing the boundaries. These external factors include elements such as knowledge progression, national education objectives, cultural and social factors, and desires of the society, organizations, and the government. It is therefore worthwhile to explore their impact by analyzing them in the context of how these human, material, social, and cultural factors interrelate to meet educational aspirations (Sarnok et al., 2020). Additionally, Põldoja (2016) pointed out that educational policies, funding and its stability (Allen et al., 2020), competency framework, and the requirements of the national curriculum (Quaicoe et al., 2016) also affect the effectiveness of DLE.

METHODS

The survey method helps collect and analyze data from respondents who represent the entire population (Pickard, 2007). Thus, in this study, a quantitative methodology was used to explore the success factors for transforming classrooms into learning communities in DLE.

Sampling and Research Instrument

The participants of this study were teachers at secondary schools in 20 provinces in Northeast Thailand, which directly used the KKU smart learning project for their teaching and learning activities in three subjects (mathematics, science, and English).

Teachers were randomly selected at three levels, from grades seven to nine. The sample of the population was selected based on the sampling formula of Yamane (1973) with errors set at 0.5.

The questionnaire was a research tool developed and designed based on the results of the literature review, which was then validated by three lecturers of computer education and science education. Following this, it was designed to clarify eight success factors for transforming classrooms into learning communities in DLE (i.e., policy, management, infrastructure, learning support technologies, learning content, teachers, learners, and external factors). Close-ended questions were designed to allow respondents to choose their

answers based on a five-point Likert scale (5=strongly agree to 1=strongly disagree). Open-ended questions were also integrated to obtain views and perceptions of participants relating to other success factors supporting learning and teaching activities in DLE.

Data Collection and Analysis

A pilot study was conducted with 40 teachers to assess the reliability of the variables. The results indicated that all the variables had Cronbach's alpha values greater than 0.9. Thus, the questionnaire was highly reliable.

The final version of the questionnaire was delivered to the schools' teachers under the University smart learning project in 20 provinces of the northeast of Thailand via Google Form from June to August 2021. The researchers received 350 valid responses from the teachers distributed in all 20 provinces, which accounted for a 96.4% response rate. The collected questionnaires were selected and chosen in order to remove inappropriate samples. Data analysis was conducted in two steps:

- (1) Step 1: Exploratory factor analysis in SPSS was performed to measure factor structure. Consequently, five items were deleted because the factor loading value (β) was less than 0.5 (Hair et al., 2009).
- (2) Step 2: A confirmatory factor analysis of AMOS was performed to test the fit indices of the model.

According to the standards defined by Hair et al. (2009) of indicators used to assess the model fit, the fit indices for success factors for transforming classrooms into learning communities in DLE are acceptable (Chi-square/df=2.328, RMSEA=0.062, CFI=0.951, GFI=0.820, and TLI=0.946). In addition, all factor loading values of the items were consistent with the necessary conditions, with values greater than 0.5.

FINDINGS AND DISCUSSIONS

The demographic information showed that the sample consisted of 58.4% female teachers and 41.4% male teachers. Of the total sample, 52.0% had a master's degree and 31.7% had been teaching for more than 20 years. In addition, 42.0% of the teachers were teaching science subjects using KKU smart learning. Of these, 51.1% were grade nine teachers at secondary schools.

The statistical results in **Table 1** indicate that technology used in learning has the highest score with a mean value of 4.64, followed by teacher and learner factors (\bar{x} =4.61 and \bar{x} =4.49, respectively).

Table 1. Summary of Cronbach's alpha, mean, and standard deviation of the factors

Success factors	Number of items	Cronbach's alpha	Mean	Standard deviation
Learning support technology	7	0.963	4.64	.532
Teacher	6	0.956	4.61	.529
Learner	4	0.941	4.49	.619
Management	5	0.941	4.39	.627
Policy	2	0.884	4.36	.660
Learning content	5	0.971	4.32	.763
External factors	4	0.944	4.24	.733
Infrastructure	5	0.974	4.16	1.006

Some prominent findings based on the results of data analysis are shown in **Table 2**.

Table 2. Means, standard deviations (SDs), and standardized factor loading (SFL) of items

Success factors	Items	Mean	SD	SFL (>0.5)
1. Policy	Schools should have policies for teaching and learning in DLE	4.40	.672	.869
	Schools should formulate strategies (strategic plan or annual action plan) to promote teaching and learning in DLE	4.33	.721	.914
2. Management	Schools should have a systematic process for supervising and monitoring the results of teaching and learning in DLE	4.41	.670	.888
	Schools should define the roles and duties of the various departments that are clearly involved in teaching and learning in DLE	4.40	.689	.893
	Schools should have rules & channels for exchanging knowledge to support meeting, receive comments, & solve teaching & learning problems in DLE	4.40	.702	.863
	Schools should adopt guidelines for teaching and learning in the DLE and set clear guidelines (i.e. content management, teaching methods, learning activities, using digital technology to promote learning)	4.39	.716	.835
	Schools should provide criteria or indicators for assessing the quality of teaching and learning in DLE	4.36	.707	.891

Table 2 (Continued). Means, standard deviations (SDs), and standardized factor loading (SFL) of items

Success factors	Items	Mean	SD	SFL (>0.5)
3. Infrastructure	Internet system is stable, convenient, & can be accessed quickly in school area	4.22	1.025	.890
	Schools have technologies and applications that facilitate the storage, use, and management of information	4.17	1.041	.947
	A variety of other facilities (i.e., classroom, laboratories, library, learning center, etc.) facilitates the teaching and learning	4.16	1.038	.943
	Teaching support equipment are adequately equipped (i.e., smartboards, projectors, TVs, printers, scanners, speakers, and digital cameras)	4.15	1.089	.957
	Digital devices (i.e., smartphone, tablets, laptops, computers, etc.) are adequately installed in every classroom	4.12	1.088	.949
4. Learning support technology	Learning support technology should be designed to be easy to use and consistent with the teachers and students' capabilities	4.67	.566	.856
	Learning support technology should be secured in terms of information and can be accessed anytime and anywhere	4.67	.580	.849
	Classroom and meeting management tools (i.e., Google Classroom, Google Meet, Zoom, etc.) should be used to manage teaching in DLE	4.66	.583	.905
	Applications and learning support materials should be designed for each course's topic that teachers can use to teach, and learners can self-learn in DLE	4.65	.570	.899
	Communication tools (i.e., chats, email, discussions, social media, etc.) should be used to encourage interactive learning and discussion with others in teaching and learning in DLE	4.64	.602	.897
	Various digital learning platforms (i.e., videos, animations, photos, audio recordings, etc.) should be used to manage teaching in the DLE	4.61	.623	.916
	Collaboration tools (i.e., Wikis, Blogs, Cloud services, etc.) should be used to develop learning and collaborative relationships in teaching and learning in DLE	4.61	.594	.871
5. Learning content	Learning content is designed help stimulate learners' digital knowledge & skills	4.36	.799	.930
	The content comprehension assessment is properly designed and consistent with learning in DLE	4.34	.791	.925
	Presenting learning content in DLE in line with the teachers & learners' ability	4.32	.791	.926
	The quality of learning content in DLE is carefully filtered, selected and assessed before being used in teaching	4.31	.814	.952
	Learning contents in DLE have enough quantity for students to learn & access easily	4.28	.838	.913
6. Teacher	Teachers should be knowledgeable in a variety of teaching methods, and able to choose the appropriate teaching methods for different content to stimulate learners' learning in DLE	4.63	.581	.918
	Teachers should have digital literacy skills and be able to use digital tools to properly manage teaching in DLE	4.63	.560	.887
	Teachers should have knowledge of the teaching subject to link content to learners' experiences and to implement in DLE	4.62	.563	.905
	Teachers should have the opportunity to regularly participate in competency development activities which is necessary for teaching and learning in DLE	4.60	.601	.844
	Teachers should understand elements & features of a DLE (i.e., contents, teaching methods, learning activities, & using digital technology to support learning)	4.59	.582	.865
	Teachers should have knowledge of learners' desirable characteristics to generate expected learning outcomes in teaching & learning management in DLE	4.58	.595	.902
7. Learner	Learners have a positive attitude towards learning in a variety of ways in DLE	4.51	.650	.868
	Learners should be aware of the need to learn with and to cooperate with peers in a group or class	4.51	.663	.934
	Learners should be aware of the need and responsibility for self-learning	4.49	.684	.915
	Learners should have digital literacy skills and be able to use digital tools appropriately to learn in DLE	4.45	.687	.864
8. External factors	Social needs require schools must have the changes to improve their educational quality and efficiency	4.26	.796	.853
	Competency frameworks are clearly defined for learners and help develop learners' knowledge, skills and attitudes	4.25	.767	.905
	The effectiveness of national educational policies and objectives helps to better orientate and create school education strategies	4.24	.779	.924
	The national curriculum is modern, stable and aligned with the development of society and learners' abilities help to better design and develop the school curriculum	4.21	.825	.916

(1) Learning support technologies should be designed in accordance with the teachers' and students' capabilities, easy to use, secure in terms of information, and accessible every time and everywhere (\bar{x} =4.67).

- (2) Teachers' competence in the choice of appropriate teaching methods, digital literacy skills, and knowledge of the teaching subject influence the effectiveness of educational activities ($\bar{x}=4.63$ and $\bar{x}=4.62$).
- (3) Learners need to have positive learning attitudes, connection with other peers, self-learning responsibilities, and digital literacy skills ($\bar{x}=4.51$, $\bar{x}=4.49$, and $\bar{x}=4.45$, respectively).
- (4) The systematic process for supervising and monitoring the results of teaching and learning ($\bar{x}=4.41$ and $\beta=0.888$) and education policies ($\bar{x}=4.40$ and $\beta=0.869$) should be issued by schools.
- (5) Learning content must be designed to stimulate learners' digital knowledge and skills ($\bar{x}=4.36$ and $\beta=0.930$).
- (6) Social needs require changes in schools to improve educational quality and effectiveness ($\bar{x}=4.26$). In addition, the Internet system is stable and can be accessed quickly ($\bar{x}=4.22$), and strongly affects teaching and learning transformation.

Other items that influence the success of classroom transformation in a DLE are also mentioned by teachers in their responses to the open-ended questions:

- Readiness of teaching and learning in terms of learning equipment, digital devices, technologies, media, the Internet, learning materials, students' learning attitudes, and cooperation between stakeholders (i.e., administrators, family, supporters, teachers, learners, etc.).
- It is necessary for teachers to follow-up and share learning management practices and continually learn, adjust, and develop in different situations.
- Guiding and providing training for teachers to have a consistent understanding and lead teaching objectives for learners.
- Learners should be supported to improve discipline, interaction, the use of digital media and digital devices, information searching skills, interest in learning, and learning to adapt with the changes.
- Schools should have more budgets and funding to invest in laboratories, equipment, and digital devices.
- The government should provide opportunities for schools to manage fixed budgets. In addition, operational policies should be flexible according to different situations and must be actively and continuously promoted.

Learning Support Technology

Improving the quality of learning support technology is essential for deploying teaching and learning activities. Following this measure, schools should design and apply various appropriate platforms, tools, and applications for teachers and learners. However, the design of technologies must rely on the users' characteristics and ensure that information is secure, up-to-date, and accessible. Moreover, the guidelines of these technologies need to be published to support teachers and learners in their use. Previous research confirms that learning technologies used in the classroom help increase student engagement in learning activities (Bergdahl et al., 2018), develop digital literacy, learning motivation, and communication skills, enhance search for various resources, and improve completion of learning tasks (Budnyk et al., 2021). Hence, teachers need to integrate different technologies into lessons to boost students' participation, interaction, and navigation in learning, change pedagogical methods, and enhance learning effectiveness (Mashau & Nyawo, 2021).

Teacher Factor

In order to improve teachers' competence, schools should conduct and allow teachers to join advanced courses and training programs pertaining to expertise, information technologies, digital literacy, and pedagogical methods. In addition, teachers need to actively update and engage in self-study to acquire the necessary teaching knowledge and skills and determine students' characteristics to choose and adjust appropriate teaching methods. Previous research has shown that students' learning outcomes are affected by teachers' competence, such as pedagogical content knowledge, domains of instruction, beliefs and motivation, student assessment, classroom management (Kunter et al., 2013), and knowledge and skills in

using ICT (Bukaliya & Mubika, 2011). Furthermore, learning styles and characteristics affect learners' development; therefore, teachers can design teaching activities based on context and learning progress (Kumar & Bharti, 2020); prepare video-lectures and support students in learning (Drozdkova-Zaripova & Sabirova, 2020); and improve their knowledge and skills to develop positive attitudes in teaching (Pit-ten Cate et al., 2018). They also need to have communication and interaction skills, and knowledge of video production to conduct teaching activities effectively in digital environment (Grunis et al., 2021).

Learner Factor

It is important to enhance the learning attitude, self-learning, digital literacy skills, and the connection of learners in the digital environment. Therefore, schools should design appropriate courses to integrate technologies within this space and boost students' technological capabilities. Teachers must also choose teaching methods and organize learning activities to stimulate students' learning motivation and attitudes, to boost creative thinking and the interaction between learners and teachers. Assignments and homework should also be designed to improve self-learning abilities. The findings of previous studies indicate that learning activities should start from students' perceptions, and teachers should instruct students to establish an accurate self-concept for properly understanding the affairs in the environment. In turn, this would create experiences with active attitudes and accurate approaches so that individuals' perceptions can be constructively changed by learning activities (Shieh et al., 2013). The best way to provide learning to students is to determine learning styles through indicators such as capability, individuality, recognition, and intelligence (Zhao et al., 2021). According to Lilian (2021), lack of motivation affects learners' learning processes; therefore, it is necessary to have pedagogical support from teachers in online spaces (Yates et al., 2021) and to connect with other students and join in the learning community to avoid feeling isolated (Hunt, 2015; Oh et al., 2018).

Abedini (2020) noted that students have higher creative thinking in digital learning environment than ordinary courses. However, creativity depends on organizing learning process for learners in digital environment. Accordingly, the teacher-learner interaction, students' engagement, the credibility of teachers, encouragement and listening, fair and support of teachers in the classroom have critical role in learning process (Cooper & Mines, 2014; Goldman & Martin, 2016). The creativity could be developed when students allowed to access interest-based documents; had discussion, video-using, feedback, references provision, information synthesis, and knowledge application into daily life (Manurung et al., 2022; Prayoga, 2021). Thus, using different teaching methods, games, funny activities, digital tools and technologies is necessary to enhance learners' competence and creativity (Hashim, 2018; Manurung et al., 2022; Sobhani & Bagheri, 2014; van Rensburg et al., 2022).

In addition, digital literacy plays important roles in promoting students' learning motivation and autonomy (He & Wray, 2017), and in enhancing their learning performance and success (Alavi et al., 2016). However, the level of digital literacy of students is limited and depends on the availability of digital facilities and tools (Cote & Milliner, 2017; Dashtestani & Hojatpanah, 2020).

Management Factor

A management mechanism should be clearly established to supervise and control educational processes at secondary schools. The roles and responsibilities of individuals, units, and stakeholders must be defined in the documents. In addition, the rules, processes, guidelines, and channels concerning content management, teaching methods, learning activities, use of supportive digital technology, receiving information, and problem solving in teaching and learning need to be issued. Evaluation criteria or indicators must be clarified to provide detailed administrative procedures and facilitate the management of teaching and learning results in DLE.

Giattino and Stafford (2019) confirmed that there is no difference of ecosystem in the governance of organizations between the educational sector and other sectors because it is worth considering that the effectiveness of governance structure must encompass the simultaneous combination of personal needs, resources, and abilities, to "better support for, and service to, their organizational constituencies" (p. 322). However, these components must include the participation of a group of professionals to "discover the breadth of the organization's stakeholders and the key issues to be addressed" (p. 322), thereby choosing, creating, and managing its ecosystem.

Policy Factor

Based on the national policies on education, schools should build policies, plans, and strategies in line with their teaching and learning objectives, features, and conditions. These documents must be characterized as a “lodestar” to navigate and promote educational activities, manage and control pedagogical processes, as well as create criteria and evaluate the effectiveness of academic performance. Some prominent results of past research have shown that understanding the ecosystem helps policy makers identify the roles of stakeholders in designing and making decisions, and developing different components and utilities (Põldoja, 2016). Hence, administrators need to consider who takes responsibility in establishing functions and decisions and solving problems influencing the needs and processes of the ecosystem. In addition, potential scenarios should be identified to set up appropriate solutions in case of changes (Giattino & Stafford, 2019).

Learning Content

In order to improve the quality of learning content, schools need to create a group of teachers and administrators who are knowledgeable about teaching subjects, proficient in computer education and digital literacy to select various information resources, and able to design courses and programs in line with the teachers’ and learners’ abilities. Further, learning content must be designed to stimulate students’ digital knowledge and skills, self-learning, critical thinking, and learning motivation. They must then be evaluated and validated by experts before their official use.

Previous research mentioned some challenges for educational institutions in designing digital learning resources, such as the lack of the collaboration between stakeholders and the limitation of “reuse, revising and remixing” (Põldoja, 2016, p. 75). In addition, the availability, accessibility, reusability, quality, and relevance of learning resources have been found to affect e-learning effectiveness (Sridharan et al., 2010). The information provision of learning content helps learners enhance questioning strategies, trigger prior knowledge, and exchange relevant knowledge (Erkens & Bodemer, 2019).

Infrastructure Factors

In the digital learning environment, the Internet is the most important item to support learning and teaching. Thus, it is necessary for schools to invest in Internet infrastructure, technologies, and applications used for the storage, usage, and management of information. In addition to teaching support equipment and facilities, digital devices should be equipped and installed in classrooms. Other studies mentioned that digital devices, the Internet, and technology equipment are considered as the basic tools for smart classrooms (Yang et al., 2018), and that students achieved higher learning performance when learning in a smart classroom (Menon, 2015).

However, the limitation of technological infrastructure has impacted students’ learning achievement and learning experience (Quaicoe et al., 2016). Therefore, schools must be equipped with digital devices, software, and new technologies. Besides, teachers need to be trained in using teaching facilities in smart classrooms to boost teacher’s capacity and students’ perception and motivation (Raghunath et al., 2018; Sethy & Mohalik, 2019).

External Factors

Schools should design and adjust educational plans and strategies, curricula, and courses that rely on social needs, national policies, and goals. Schools’ educational criteria and the design of programs must also rely on a common competency framework to develop learners’ knowledge, skills, and attitudes. Past studies have revealed that learner-centered educational strategies (i.e., active learning, collaborative learning, adaptive learning, and blended learning) impact the sustainable development of e-learning ecosystems. However, they must be appropriately supported by technology (Sridharan et al., 2010). In addition, learning achievement in the education ecosystem is also influenced by factors concerning socio-economic, political, and psychological contexts (Bandyopadhyay et al., 2021), teachers’ roles or work requirements, and the development of expertise (Blundell et al., 2016).

CONCLUSION

Evidently, several elements contribute to the successful transformation of a classroom into a learning community in a DLE. Based on the responses and opinions of teachers, the design and deployment of various learning technologies, the Internet connection, the readiness of learners and teachers, teachers' competence, and the quality of learning content are the most important items. Therefore, in order to improve the quality and effectiveness of teaching and learning at secondary schools, it is necessary for governments, schools, administrators, teachers, and stakeholders to design and conduct well-rounded solutions to boost learning motivation and attitudes of learners and maintain the sustainable development of learning ecosystems in the digital space.

- (1) Policy makers and educators should consider and issue policies and strategic plans to invest and develop technology infrastructure for educational institutions; build up competency framework for teachers and learners in the digital learning context, as well as have policies and programs to support schools enhancing the educational performance.
- (2) Administrators should focus on developing learning management system; allocating budget to design and evolve digital learning contents, technology platforms, tools, applications and digital devices to support teaching and learning; organizing programs to enhance teachers' competency and improve teaching effectiveness.
- (3) It is important for teachers to understand their learners (i.e., knowledge, skills, learning attitudes, and digital literacy) to establish appropriate teaching programs and activities to foster learning interest, motivation, and engagement; enhance the interaction, communication of students; use appropriate technologies and create a comfortable learning environment to boost students' higher order thinking skills.

Author notes: This research is a part of post-doctoral training, supported by the Division of Research and Graduate Studies, Khon Kaen University, Thailand.

Author contributions: **KT:** supervision, manuscript editing, & corresponding; **LTN:** manuscript preparation; **KT & LTN:** design, conceptual framework, tools, analysis, validation, & conclusions; **LTN & TM:** data collection & data analysis; & **IK, GL, KP, WS, AS, NS, & ST:** resources, content experts, & results validation. All authors approve final version of the article.

Funding: This research is supported by the Program Unit for Human Resources & Institutional Development (PMU-B), Office of National Higher Education Science Research and Innovation Policy Council, Thailand with project number: B05F640229.

Acknowledgement: Authors would like to thank the Smart Learning Innovation Research Center (SLIRC), Khon Kaen University, Thailand for supporting the study.

Ethics declaration: Authors declared that the study has been reviewed by Khon Kaen University Ethics Committee in Human Research based on the Declaration of Helsinki and the ICH Good Clinical Practice Guidelines, and approved on August 18, 2021.

Declaration of interest: Authors declare no competing interest.

Data availability: Data generated or analyzed during this study are available from the authors on request.

REFERENCES

- Abedini, Y. (2020). Students' creativity in virtual vs. classroom courses on the basis of their personality traits: A prediction study. *Electronic Journal of E-Learning*, 18(6), 525-536. <https://doi.org/10.34190/JEL.18.6.005>
- Adedoyin, O. B., & Soykan, E. (2020). COVID-19 pandemic and online learning: The challenges and opportunities. *Interactive Learning Environments*. <https://doi.org/10.1080/10494820.2020.1813180>
- Alavi, S. M., Borzabadi, D., & Dashtestani, R. (2016). Computer literacy in learning academic English: Iranian EAP students' and instructors' attitudes and perspectives. *Teaching English with Technology*, 16(4), 56-77.
- Allen, P. J., Lewis-Warner, K., & Noam, G. G. (2020). Partnerships to transform STEM learning: A case study of a STEM learning ecosystem. *Afterschool Matters*, 31, 30-41.
- Balyer, A., & Oz, O. (2018). Academicians' views on digital transformation in education. *International Online Journal of Education and Teaching*, 5(4), 809-830.
- Bandyopadhyay, S., Bardhan, A., Dey, P., & Bhattacharyya, S. (2021). *Bridging the education divide using social technologies*. Springer. <https://doi.org/10.1007/978-981-33-6738-8>

- Bergdahl, N., Fors, U., Hernwall, P., & Knutsson, O. (2018). The use of learning technologies and student engagement in learning activities. *Nordic Journal of Digital Literacy*, 13(2), 113-130. <https://doi.org/10.18261/issn.1891-943x-2018-02-04>
- Blundell, C. N., Lee, K. T., & Nykvist, S. (2016). Digital learning in schools: Conceptualizing the challenges and influences on teacher practice. *Journal of Information Technology Education: Research*, 15, 535-560. <https://doi.org/10.28945/3578>
- Budnyk, O., Zozuliak-Sluchy, R., Nedilskyi, S., Chervinska, I., Malaniuk, T., Prevysokova, N., & Ketsyk-Zinchenko, U. (2021). Modern digital distance learning technologies: Challenges of future teacher training. *Revista Inclusiones [Inclusions Magazine]*, 8(1), 41-53.
- Bukaliya, R., & Mubika, A. K. (2011). Teacher competence in ICT: Implications for computer education in Zimbabwean secondary schools. *International Journal of Social Sciences & Education*, 1(4), 414-425.
- Chang, V., & Guetl, C. (2007). E-learning ecosystem (ELES)-a holistic approach for the development of more effective learning environment for small-and-medium sized enterprises (SMES). In *Proceedings of the Inaugural IEEE-IES Digital EcoSystems and Technologies Conference* (pp. 420-425). IEEE Publications. <https://doi.org/10.1109/DEST.2007.372010>
- Chang, V., & Gütl, C. (2008). Ecosystem concept and models to support e-learning 2.0. In *Proceedings of the Interactive Collaboration Learning* (pp. 1-9).
- Chang, V., & Uden, L. (2008). Governance for e-learning ecosystem. In *Proceedings of the International Conference on Digital Ecosystems and Technologies* (pp. 340-345). <https://doi.org/10.1109/DEST.2008.4635164>
- Cooper, K. S., & Miness, A. (2014). The co-creation of caring student-teacher relationships: Does teacher understanding matter? *The High School Journal*, 97(4), 264-290. <https://doi.org/10.1353/hsj.2014.0005>
- Cote, T. J., & Miller, B. (2017). Preparing Japanese students' digital literacy for study abroad: Is more training needed? *The JALT CALL Journal*, 13(3), 187-197. <https://doi.org/10.29140/jaltcall.v13n3.218>
- Dashtestani, R., & Hojatpanah, S. (2020). Digital literacy of EFL students in a junior high school in Iran: Voices of teachers, students and ministry directors. *Computer Assisted Language Learning*, 35(4), 635-665. <https://doi.org/10.1080/09588221.2020.1744664>
- Drozdikova-Zaripova, A. R., & Sabirova, E. G. (2020). Usage of digital educational resources in teaching students with application of "flipped classroom" technology. *Contemporary Educational Technology*, 12(2), ep278. <https://doi.org/10.30935/cedtech/8582>
- Erkens, M., & Bodemer, D. (2019). Improving collaborative learning: Guiding knowledge exchange through the provision of information about learning partners and learning contents. *Computers and Education*, 128, 452-472. <https://doi.org/10.1016/j.compedu.2018.10.009>
- Eswari, P. L. (2011). A process framework for securing an e-learning ecosystem. In F. B. Shaikh, & S. Haider (Eds.), *Proceedings of the IEEE International Conference for Internet Technology and Secured Transactions* (pp. 403-407).
- Giannakos, M. N., Krogstie, J., & Aalberg, T. (2016). Video-based learning ecosystem to support active learning: Application to an introductory computer science course. *Smart Learning Environments*, 3(1), 1-13. <https://doi.org/10.1186/s40561-016-0036-0>
- Giattino, T., & Stafford, M. (2019). Governance for learning ecosystem. In J. J. Walcutt, & S. Schatz (Eds.), *Modernizing learning: Building the future learning ecosystem*. Government Publishing Office.
- Goldman, Z. W., & Martin, M. M. (2016). Millennial students in the college classroom: Adjusting to academic entitlement. *Communication Education*, 65(3), 365-367. <https://doi.org/10.1080/03634523.2016.1177841>
- Grunis, M. L., Golovanova, I. I., Kirilova, G. I., Levina, E. Y., & Sizova, Z. M. (2021). Transformation of pedagogical communicative competence during creation digital online courses. *Contemporary Educational Technology*, 13(1), ep289. <https://doi.org/10.30935/cedtech/9313>
- Hair, J., Black, W., Babin, B., & Anderson, R. (2009). *Multivariate data analysis*. Prentice Hall.
- Hashim, H. (2018). Application of technology in the digital era education. *International Journal of Research in Counseling and Education*, 1(2), 1-5. <https://doi.org/10.24036/002za0002>
- Hunt, A.-M. (2015). Blended online learning in initial teacher education: A professional inquiry into pre-service teachers' inquiry projects. *Journal of Open, Flexible and Distance Learning*, 19(2), 48-60.
- Jeladze, E., Pata, K., & Quaiocoe, J. S. (2017). Factors determining digital learning ecosystem smartness in schools. *Interaction Design and Architecture(s) Journal*, 35, 32-55. <https://doi.org/10.55612/s-5002-035-002>

- Kumar, A., & Bharti, V. (2020). Contribution of learner characteristics in the development of adaptive learner model. In S. Choudhury, R. Gowri, B. S. Paul, & D. T. Do (Eds.), *Intelligent communication, control and devices* (pp. 637-646). Springer. https://doi.org/10.1007/978-981-13-8618-3_66
- Kunter, M., Klusmann, U., Baumert, J., Richter, D., Voss, T., & Hachfeld, A. (2013). Professional competence of teachers: Effects on instructional quality and student development. *Journal of Educational Psychology, 105*(3), 805-820. <https://doi.org/10.1037/a0032583>
- Laanpere, M., Pata, K., Normak, P., & Põldoja, H. (2014). Pedagogy-driven design of digital learning ecosystems. *Computer Science and Information Systems, 11*(1), 419-442. <https://doi.org/10.2298/CSIS121204015L>
- Lilian, A. (2021). Self-regulated learning strategies for smart learning: A case of a Malaysian university. *Asian Journal of Research in Education and Social Sciences, 3*(1), 72-83.
- Manurung, E. M., Purwadi, Y. S., & Sugiharto, I. B. (2022). Digital learning process: Challenges for specific creativity. *The Electronic Journal of e-Learning, 20*(2), 112-119. <https://doi.org/10.34190/ejel.20.2.2107>
- Mashau, P., & Nyawo, J. C. (2021). The use of an online learning platform: A step towards e-learning. *South African Journal of Higher Education, 35*(2), 123-143. <https://doi.org/10.20853/35-2-3985>
- Menon, A. (2015). Effectiveness of smart classroom teaching on the achievement in chemistry of secondary school students. *American International Journal of Research in Humanities, Arts and Social Sciences, 9*(2), 115-120.
- Oh, C. S., Bailenson, J. N., & Welch, G. F. (2018). A systematic review of social presence: Definition, antecedents, and implications. *Frontiers in Robotics and AI, 5*, 114. <https://doi.org/10.3389/frobt.2018.00114>
- Ospina, Y., & Galvis, J. (2017). A novel design of an e-learning digital ecosystem. *Tekhnê [Technology], 14*(1), 55-60.
- Pickard, A. J. (2007). *Research methods in information*. Facet Publishing.
- Pit-ten Cate, I. M., Markova, M., Krischler, M., & Krolak-Schwerdt, S. (2018). Promoting inclusive education: The role of teachers' competence and attitudes. *Insights into Learning Disabilities, 15*(1), 49-63.
- Põldoja, H. (2016). *The structure and components for the open education ecosystem-constructive design research of online learning tools* [Doctoral dissertation, Aalto University].
- Prayoga, A. S. (2021). Utilization internet technology as a media in the digital learning process. In *Proceeding of International Conference on Islamic Education* (pp. 17-23).
- Quaicoe, J. S., Pata, K., & Jeladze, E. (2016). Digital learning ecosystem services and educational change in Ghana's basic schools. In L. G. Chova, A. L. Martínez, & I. C. Torres (Eds.), *Proceedings of EDULEARN16* (pp. 4887-4895). IATED Academy. <https://doi.org/10.21125/edulearn.2016.2165>
- Raghunath, R., Anker, C., & Nortcliffe, A. (2018). Are academics ready for smart learning? *British Journal of Educational Technology, 49*(1), 182-197. <https://doi.org/10.1111/bjet.12532>
- Reyna, J. (2011). Digital teaching and learning ecosystem (DTLE): A theoretical approach for online learning environments. In G. Williams, P. Statham, N. Brown, & B. Cleland (Eds.), *Changing demands, changing directions* (pp. 1083-1088). University of Tasmania.
- Rospigliosi, P. A. (2020). Digital transformation of education: Can an online university function fully? *Interactive Learning Environments, 28*(8), 945-947. <https://doi.org/10.1080/10494820.2020.1843240>
- Sarnok, K., Wannapiroon, P., & Nilsook, P. (2020). DTL-eco system by digital storytelling to develop knowledge and digital intelligence for teacher profession students. *International Journal of Information and Education Technology, 10*(12), 865-872. <https://doi.org/10.18178/ijiet.2020.10.12.1472>
- Sethy, R., & Mohalik, R. (2019). Smart classroom for teaching learning at secondary level in West Bengal: An exploratory study. *American Journal of Social Sciences and Humanities, 4*(1), 129-137. <https://doi.org/10.20448/801.41.129.137>
- Shieh, C. J., Liao, Y., & Hu, R. (2013). Web-based instruction, learning effectiveness and learning behavior: The impact of relatedness. *EURASIA Journal of Mathematics, Science and Technology Education, 9*(4), 405-410. <https://doi.org/10.12973/eurasia.2013.949a>
- Sobhani, M., & Bagheri, M. S. (2014). Attitudes toward the effectiveness of communicative and educational language games and fun activities in teaching and learning English. *Theory and Practice in Language Studies, 4*(5), 1066. <https://doi.org/10.4304/tpis.4.5.1066-1073>
- Sridharan, B., Deng, H., & Corbitt, B. (2010). Critical success factors in e-learning ecosystems: A qualitative study. *Journal of Systems and Information Technology, 12*(4), 263-288. <https://doi.org/10.1108/13287261011095798>

- Sung, M. (2015). A study of adults' perception and needs for smart learning. *Procedia-Social and Behavioral Sciences*, 191, 115-120. <https://doi.org/10.1016/j.sbspro.2015.04.480>
- Tuamsuk, K. (2019). *Executive summary: Smart learning project operations* [Unpublished document]. The Minister of Education, Thailand.
- Uden, L., Wangsa, I. T., & Damiani, E. (2007). The future of e-learning: E-learning ecosystem. In F. K. Hussain (Ed.), *Proceedings of the Inaugural IEEE-IES Digital EcoSystems and Technologies Conference* (pp. 113-117). Curtin University of Technology. <https://doi.org/10.1109/DEST.2007.371955>
- Väljataga, T., Poom-Valickis, K., Rumma, K., & Aus, K. (2020). Transforming higher education learning ecosystem: Teachers' perspective. *Interaction Design and Architecture(s) Journal*, 46, 47-69. <https://doi.org/10.55612/s-5002-046-003>
- van Rensburg, C. J., Coetzee, S. A., & Schmulian, A. (2022). Developing digital creativity through authentic assessment. *Assessment & Evaluation in Higher Education*, 47(6), 857-877. <https://doi.org/10.1080/02602938.2021.1968791>
- Vaseghi, R., Ramezani, A. E., & Gholami, R. (2012). Language learning style preferences: A theoretical and empirical study. *Advances in Asian Social Science*, 2(2), 441-451.
- Yamane, T. (1973). *Statistics: An introductory analysis*. Harper & Row.
- Yang, J., Pan, H., Zhou, W., & Huang, R. (2018). Evaluation of smart classroom from the perspective of infusing technology into pedagogy. *Smart Learning Environments*, 5(1), 1-11. <https://doi.org/10.1186/s40561-018-0070-1>
- Yates, A., Starkey, L., Egerton, B., & Flueggen, F. (2021). High school students' experience of online learning during COVID-19: The influence of technology and pedagogy. *Technology, Pedagogy and Education*, 30(1), 59-73. <https://doi.org/10.1080/1475939X.2020.1854337>
- Zhao, X., Wang, J., Wang, M., Li, X., Gao, X., & Huang, C. (2021). A new model for assessing the impact of environmental psychology, e-learning, learning style and school design on the behavior of elementary students. *Kybernetes [Governors]*, 50(2), 512-527. <https://doi.org/10.1108/K-09-2019-0579>

