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Trends and Development of Artificial Intelligence in Game-based Learning from 2011 to 2022: A Promising Environment for Learning Digital Citizenship Behaviors in Thailand

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Abstract: This study has reviewed the relevant journal articles about the trends and developments of Artificial Intelligence (AI) in game-based learning in the recent decade (from 2011 to 2022). This study investigated many research issues, such as countries, learning content, learners, and AI algorithms/strategies. Furthermore, this study reveals that AI in game-based learning has been an attractive topic in the development of computers and technology in education, and learning logs have been an essential part of supporting desired learning behaviors. However, only a few studies have conducted AI in game-based learning to promote essential skills in the 21st century. In other words, essential skills have a potential domain with the rapid development of AI. Through the analysis of the trends and developments in the various dimensions of AI in game-based learning, further research directions and challenges in AI- enabled game-based learning regarding promoting desired digital citizenship behaviors, mainly among young Thai students, are discussed in this paper.

Keywords: Quality education, essential skills, lifelong learning, digital literacy, learning behaviors

1. Background and Motivation

With the emergence of new technologies and social media platforms, the increase in internet accessibility has changed the way of humans exchange information and participate in online social activities. The Internet has become an essential part of our everyday life. Especially for the younger generation, those born in the digital age perceive the Internet as a powerful tool for learning and empowerment (Fioravanti et al., 2012; Hong et al., 2003; Valaitis, 2005). Accessing the Internet is becoming an increasingly common substitute for face-to-face interaction, communication, work-from- home, and online-learning activities. The concern for adolescents' well-being and digital safety education, thus, has been raised among scholars (Almourad et al., 2021; Edwards et al., 2018; Richardson et al., 2021; Tapingkae et al., 2020). As citizens of the world, youths of the 21st century are expected to understand their roles as digital citizens, be respectful of others and themselves, and be responsible to the online

community. Hence, digital citizenship has been considered one of the necessary competencies by various world-renowned educational and economic policy development organizations (ISTE, 2007; OECD, 2018; UNESCO, 2015). It covers a set of competencies that determines not only human internet behaviors but also a factor determining an individual's learning, indicating how critically and ethically a person processes the information (Hollandsworth et al., 2011).

Various definitions of digital citizenship have been continuously discussed and evolved throughout the past decades. Generally, "digital citizenship" refers to safe and responsible technology usage behaviors. The basic perspective of digital citizenship emphasizes the norms of the individual's

behaviors comprised of responsibility, rights, safety, and security in technology use (Ribble et al., 2004). However, as time passed, the concept was extended to the concepts of global citizenship from the perspective of using digital technologies to support social development and humanity (Choi, 2016; Emejulu & McGregor, 2019; Martens & Hobbs, 2015). Additionally, the scope of digital citizenship was mentioned using the term "media or information literacy." Martens & Hobbs (2015) defined media literacy as "a competence and positive engagement with digital technologies regarding creating, working, sharing, socializing, investigating, playing, communicating, and learning. Participating actively and responsibly in the aspects of values, attitudes, skills, and knowledge in online communities at the political, economic, social, cultural, and intercultural levels. Being involved in a double lifelong learning process and continuously defending human dignity."

According to the definitions mentioned earlier, however, the scholars coherently agreed that these two concepts should be harmonized in the field of teaching digital citizenship since literacy, namely a capability to read, write, and communicate to engage as a part of the online community if not all but it stills the fundamental competences and skills leading to a higher level of ethical digital practice (Buchholz et al., 2020; Pangrazio & Sefton-Green, 2021; Saputra & al Siddiq, 2020). Therefore, we review journal articles that lay on digital citizenship and digital literacy in this article. With various teaching and learning strategies during the past decade, technology-enhanced learning or using information communication technology (ICT) has challenged educational reforms in promoting desired digital citizenship behaviors in emerging countries such as Thailand. In the context of Thailand, digital citizenship or digital literacy has been defined as a safe, ethical, lawful, and effective use of ICT. Individuals can appropriately access, evaluate, and create data, information, or content media (Ministry of Digital Economy and Society, 2020). However, the teaching and learning strategies for providing knowledge and proper skills/behaviors to digital citizenships have not been well studied. That is to say, this paper aims to promise an educational position for promoting digital citizenship behaviors in the context of Thailand.

2. Context and Literature

2.1 Definitions and Frameworks of Digital Citizenship/Digital Literacy

Scholars have defined and proposed a framework for digital citizenship in the past decade. According to Ribble (2015), digital citizenship was specifically identified into nine areas of behavior. *Digital access* refers to as full electronic participation in society. *Digital commerce*: electronic buying and selling of goods. *Digital communication*: electronic exchange of information. *Digital literacy:* teaching and learning about technology and its use. *Digital etiquette:* electronic standards of conduct or procedure. *Digital law:* electronic responsibility for actions and deeds. *Digital rights:* those freedoms extended to everyone in a digital world. *Digital safety:* physical and psychological well-being in a digital world. *Digital security or self-protection:* electronic precautions to guarantee safety. The International Society for Technology in Education (ISTE, 2018) mentioned that a good digital citizen should be able to *"advocate equal digital rights and digital access for all, try to understand all points of view, communicate and empathize with other people through digital channels and treat them with empathy, use critical thinking for all online resources and do not share unreliable sources such as fake news or advertisements, use technology to support and develop social goals, give importance to*

physical, emotional and mental health while using digital tools, use digital tools to collaborate with other people, understand the permanence of the digital world and manages his/her digital identity by taking the necessary measures."

Additionally, Choi (2016) divided digital citizenship into a multidimensional concept consisting of four dimensions: (1) *digital ethics* defined as responsible, ethical, and safe online behaviors; (2) *media and information literacy* defined as accessibilities, psychological capabilities, and skills to use digital technologies to communicate; (3) *participation/engagement* defines as personally using digital technologies as a tool or platform to participate and engage politically, socio-economically, or culturally online; and (4) *critical resistance* defines as a higher level of online engagement and participation by using digital technologies to achieve social justice and challenge the status quo. Therefore, media and information literacy were considered important resources to fulfill the component of digital citizenship. On the other hand, Jones and Mitchell (2016) argued that digital citizenship should be differentiated from digital literacy since digital literacy refers to a specific set of computer and internet-based skills. Meanwhile, digital citizenship focuses on practicing respectful behaviors toward others and promoting civic engagement activities online. The Internet can provide important opportunities for youth to exercise positive social skills and engage with their community in ways that may positively impact offline civic engagement.

2.2 AI in Education and Digital Game-based Learning

With the advancement of modern-day digital technologies, Artificial Intelligence (AI), defined as computational machines capable of performing actions that require human intelligence (Chen et al., 2020; Hwang et al., 2020b), has been exponentially recognized as a new possibility to overcome challenges in many different fields (Aguilar et al., 2021; Chintalapati & Pandey, 2022; Enholm et al., 2021; Nguyen et al., 2021). In education, AI paradigms were used for profiling, predicting, assessing, and evaluating students' performances or academic decisions, either working as intelligent tutoring systems or providing support those are adaptive to students' learning needs (Tang et al., 2021). Furthermore, the article also emphasized that the key role of AI in education is to facilitate individual differences and personalized learning. For instance, Hwang et al. (2020a) implemented an adaptive learning system based on an expert system approach to analyze individual learners' affective and cognitive status in a fifth-grade mathematics course. It was reported that the students who learned with the developed approach significantly improved their learning achievements more than those who learned with a cognitive-based adaptive learning system and a conventional learning system, reducing their mathematic anxieties. Moreover, the system also helped students with lower learning performance complete their learning tasks by supplying materials suitable to overcome learning difficulties. Due to this potential, AI-oriented educators can be encouraged to apply AI technologies in enhancing the existing learning approach to fulfill the learning gaps of different learners in the collective environment where individual learning is hard to be precisely personalized.

Regarding the variety of methods for teaching digital citizenship, game-based learning has been recognized as one of the effective approaches to facilitating digital citizenship education (Calvo-Morata et al., 2018, 2020; Chee et al., 2013; De Troyer et al., 2016; Hill, 2015; Tapingkae et al., 2020). It has been mostly recognized as the designed integration of gameplay, subject content, and pedagogy with expected outcomes for learning (Plass et al., 2015). Due to that, game-based learning can highly engage the learners in a safe, joyful, and interactive context-based environment to acquire their knowledge through experience, trial, and challenge with feedback (DeKanter, 2005; Wu et al., 2012). Furthermore, games allow learners to apply their newly founded knowledge in different artificial scenarios to construct meaningful knowledge to overcome contextual challenges (Boyle et al., 2011). Previous research has shown the game's benefit on students' digital citizenship behaviors. For example, Tapingkae et al. (2020) developed a digital game with a formative assessment-based contextual gaming approach which successfully helps secondary students to promote respectful and tolerant online behaviors and civic engagement, as well as motivation to learn and learning perceptions. However, the challenge of designing a successful game for learning depends on the balance between the flow

of content, enjoyment, and learning strategies that is adequate to provide the learning benefits and suitable for the individual differences of the learners. Therefore, the technology-enhanced element in the game should be adaptive to personalize the learning experience to match individual learners' needs (Ravyse et al., 2017).

To cope with the above concerns in the design and development of game-based learning, the argumentation of AI applications or AI techniques to enrich adaptivity in game-based learning has been brought to scholars' attention. The game design components supported learning cover AI-based functionalities, such as personalization, game difficulty balancing, assessment, player analytics, competence modeling, social gamification, language technologies, and affective computing (Westera et al., 2020).

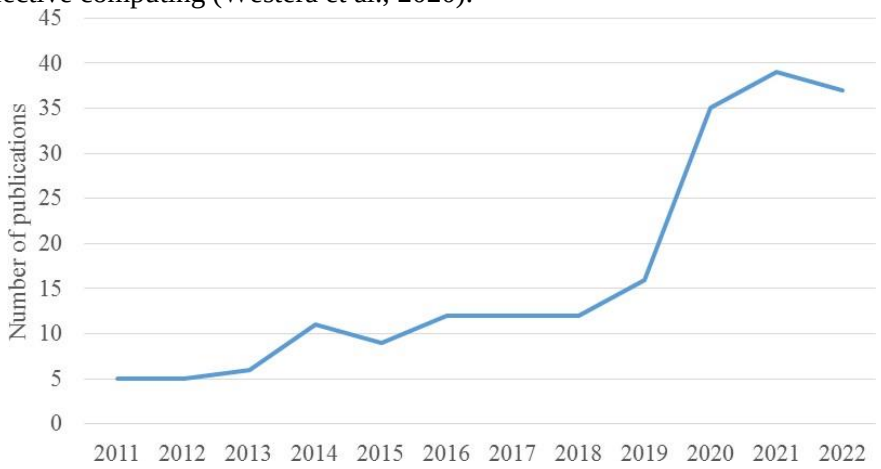

Figure 1. The number of Scopus Indexed Journals' publications on Artificial Intelligence in game- based learning from 2011 to 2022 (August).

Inspired by a growing number of articles related to artificial intelligence in game-based learning, as shown in Figure 1, a systematic review of literature must be conducted to indicate the trends and challenges in development, implementation, gaps, and contribution to future research. However, the recent review on artificial intelligence in games mainly focused on the AI methods in game development (Fan et al., 2020; Zhai et al., 2021) or other fields of the content subjects such as public health (Rafiq et al., 2021). Therefore, it is challenging to focus on using AI in game-based learning that would be promising to teach digital citizenship behaviors.

3. Methods

3.1 Data Collection and Processing

The systematic literature reviewed the research studies conducted from 2011 to 2021 based on the review process of the previous research (Hwang & Tsai, 2011; Xie et al., 2019). The SCOPUS database was selected as the data source due to its high journal quality standard that is reliable and accepted among scholars. The search was conducted by combining two sets of words addressing artificial intelligence in game-based learning, yielding the search query ("artificial intelligence" or "AI" AND "game-based learning" or "game"). To observe the trend and developments of the concerning topic, the publication period was set as a decade between 2011 and 2022. The publication type was set as "article" in the categories of "social science," only written in English. The search results showed 199 articles in total. In order to make sure the articles were relevant to artificial intelligence in game-based learning in education perspectives and excluded commercial perspectives, they were carefully read and selected with the inclusion criteria. Each article must be relevant to proposing AI methods/techniques/strategies to support gaming functions/interfaces and implementing concrete gaming activities. That is to say, 118 irrelevant articles were excluded from the list, and the remaining 22 articles formed the final dataset for analysis.

3.2 Coding Scheme

The four main categories of coding schemes are used to investigate and analyze the trends and developments of artificial intelligence in game-based learning.

(1) Codes for authors: The basic information of articles is queried to understand which countries have more frequently contributed research and published articles about artificial intelligence in game-based learning.

(2) Codes for learners: The codes aim to categorize the participants according to their education levels, including elementary school students, primary school students, secondary school students, higher education students, and other and non-specified.

(3) Codes for the learning content: The codes include various disciplines, such as science/engineering/computer science, natural science, social science or social studies, skills, literacy, and other and non-specified.

(4) Codes for the AI methods/mechanism/strategies: As Hwang and Tu (2021) suggested, the codes for AI methods/mechanism/strategies are user-oriented and relevant to support gaming functions/interfaces and implement concrete gaming activities. For example, *evolutionary algorithms* (i.e., genetic algorithm, ant colony, tabu search), *fuzzy set theory*, *deep learning/neural networks* (i.e., voice-to-text translation), *case-based reasoning* (i.e., making decisions based on similar case studies from experts in the field), *data mining/personal recommendation* (i.e., classification, grouping, association rules), *traditional machine learning approach* (i.e., creating decision tree based on case studies from experts in the field to lead or support classification or decision making), *statistical learning* (i.e., linear regression, polynomial regression for prediction or reasoning), *natural language processing* (i.e., chatbots with freestyle conversational user interface), and *knowledge elicitation methods via interviewing domain experts* (i.e., repertory grid, EMCUD for developing expert interviewing domain experts systems).

4. Research Results

4.1 Countries

The countries of the authors who contributed to the published articles on artificial intelligence in game- based learning were counted in this study. From the results, it can be found that many researchers from different countries worldwide attempt to apply artificial intelligence in game-based learning. Figure 2 shows the distribution of the countries. It was found that the top five countries are the United States (5), the United Kingdom (4), Taiwan (3), Netherlands (2), Portugal (2), and Sweden (2).

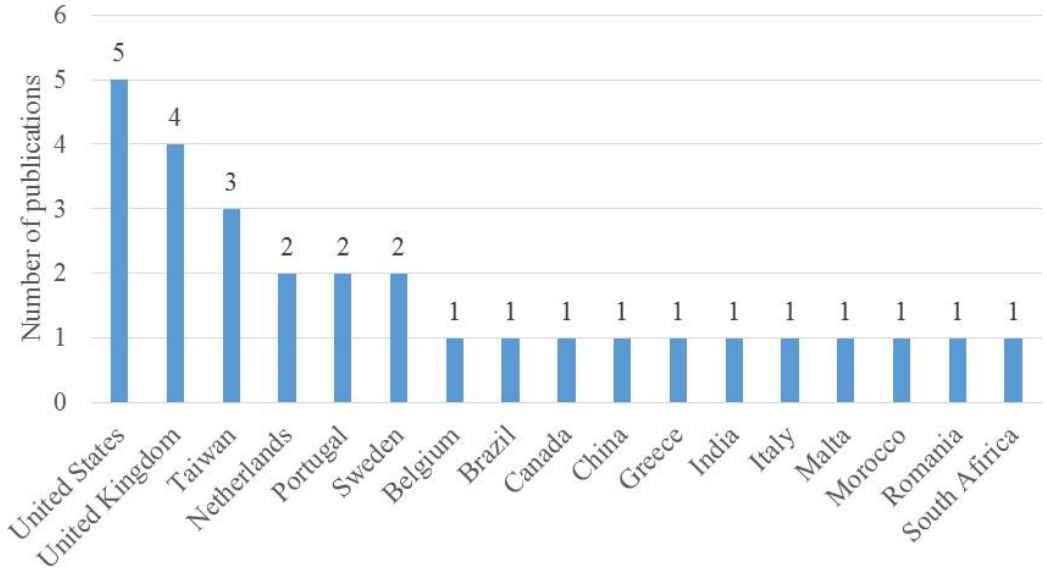

Figure 2. The distribution of countries contributed to artificial intelligence in game-based learning during 2011-2022 (August).

4.2 Learners

As shown in Figure 3, about 27% (6 out of 22) of the research studies relevant to artificial intelligence in game-based learning often selected primary school students as the participants. Higher education students are the second group of learners chosen as the participants in the research studies. Meanwhile, it was found that the frequency of elementary and secondary school students recruited as participants in the research studies is less than the above two groups of learners. It is worth pointing out that increasing the number of research studies relevant to artificial intelligence in game-based learning is challenging. It could be another perspective for a more understanding of how artificial intelligence in game-based learning could help elementary and secondary school students' learning.

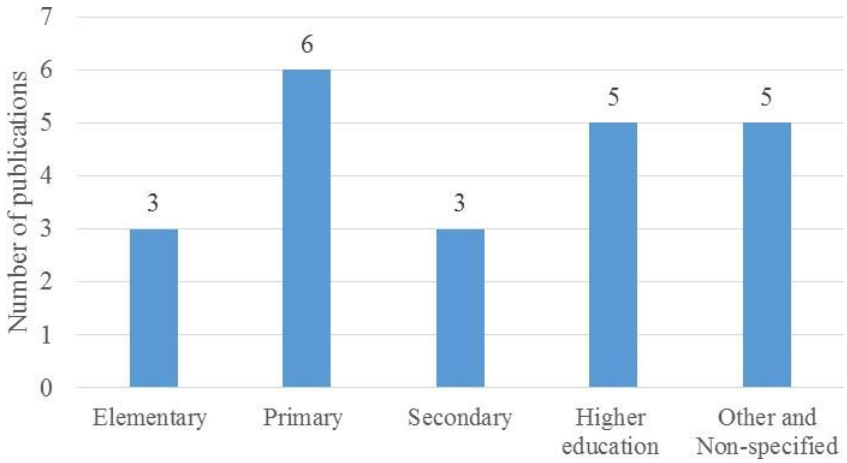

Figure 3. The distribution of learners contributed to artificial intelligence in game-based learning during 2011-2022 (August).

4.3 Leaning Contents

As shown in Figure 4, the most popular learning content is science/math/engineering/computer science, accounting for 32% of total research studies, similar to Xie et al.'s (2019) study on technology-enhanced adaptive/personalized learning. Another category of learning content, "other and non-specified," involved 8 studies unrelated to a specific subject. It involves students' perceptions and feelings of AI applications in the games and investigation of efficient AI techniques. However, in game-based learning studies, science/math/engineering/computer science and skills were frequently chosen as the learning content in artificial intelligence. It was found that other categories, such as social science/social studies and literacy, were seldom selected in the artificial intelligence in game-based learning studies. Future study is worth showing the potential of using artificial intelligence in game-based learning to promote learners' performance in social science/social study courses and literacy as essential skills in the 21st century.

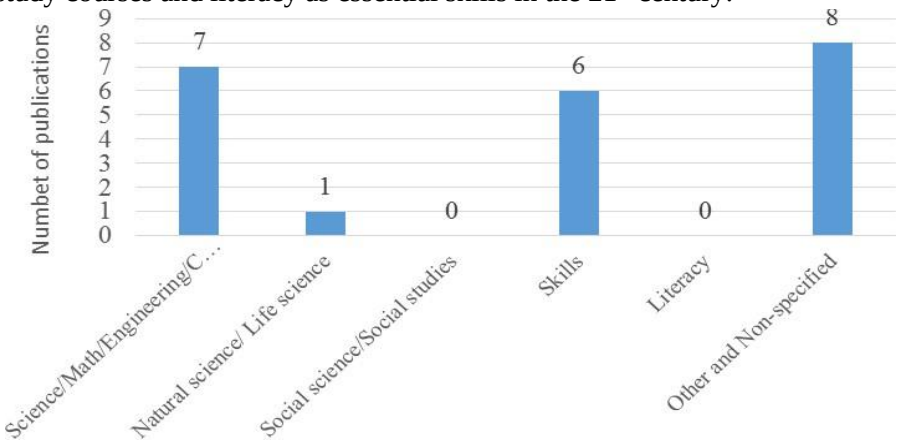

Figure 4. The distribution of learning contents contributed to artificial intelligence in game-based learning during 2011-2022 (August).

4.4 AI methods/mechanisms/strategies

Figure 5 illustrates the distribution of methods/mechanisms/strategies contributed to artificial intelligence in game-based learning. As revealed in Figure 5, the most AI methods/mechanisms/strategies employed to develop game-based learning are deep learning/neural networks, accounting for 36% of total research studies. The second methods/mechanisms/strategies of AI is data mining/personalized recommendation with a frequency of 31%. That is to say, most researchers often apply existing applications in the App Store or Google Play to teach learning content for learners. Some researchers prefer to take students' characteristics/ emotions/ behaviors to adapt gaming activities for individuals. The least frequent AI methods/mechanisms/strategies were genetic algorithms and the traditional machine learning approach as the decision-tree technique. These results might be conveyed that the traditional machine learning approach as the decision-tree technique can stimulate or situate gaming activities in which learning content.

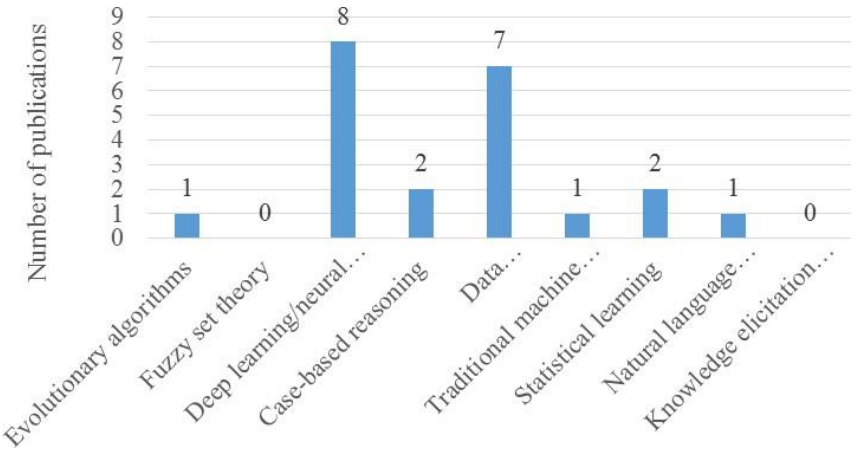

Figure 5. The distribution of methods/mechanisms/strategies contributed to artificial intelligence in game-based learning during 2011-2022 (August).

5. A Promising AI in Game-based Learning for Digital Citizenship Behaviors in the Thailand Context

This paper shows the results of a meta-review about artificial intelligence in game-based learning studies published in academic journals from 2011 to 2022 (August). It was found that the number of research studies in this area greatly increased over the years in many countries. It implies that educators or researchers worldwide are increasingly interested in developing game-based learning using AI methods/mechanisms/strategies or AI applications. In the meantime, Thailand was not found in this investigation, showing the opportunity and challenge for improving Thai students' learning performance using artificial intelligence in game-based learning. In addition, from the frequency of publications, it was found that learning content related to social science/social studies "literacy" was seldom conducted for artificial intelligence in game-based learning. Therefore, it is worth investigating the effectiveness of artificial intelligence in game-based learning on learners' performance in these subjects, especially in essential literacy related to "digital citizenship/digital literacy" in the 21st century. On the other hand, it can be found that several AI methods/mechanisms/strategies, such as fuzzy theory, knowledge elicitation methods via interviewing domain experts, genetic algorithms, and traditional machine learning approach as the decision-tree technique, were rarely adopted in game-based learning. Therefore, it is worth investigating the potential and possibility of applying or integrating them into game-based learning. In particular, the traditional machine learning approach as the decision-tree technique could benefit the learners in deciding their possible behaviors' consequences.

From the above concerns, promising learning environment for AI in game-based learning to promote desired behaviors of digital Thai citizenship in the future study are listed as follows:

(1) In Thailand, the office of the national digital economy and society commission, the Ministry of Digital Economy and Society of Thailand, has established a digital literacy handbook for Thai citizens (Ministry of Digital Economy and Society, 2020). That is to say, digital citizenship/digital literacy has been defined as a set of competencies associated with the responsible use of ICT. Its framework consisted of *(a) access* includes definition, search/find, access, and retrieve of the information; *evaluation* includes understanding, assessment, evaluation, and organization of the information; *(b) creation* includes creation, communication, participation, and monitoring of the information; and *(c) use of tools and technology* refers to the competencies to execute various equipment, process, techniques, or innovations for accessing, evaluating and creating data, information, or content media appropriately. This establishment aims to enhance the citizens' knowledge, understanding, awareness, and skills on the creative use of digital technology as a tool for sustainable human development. Topics include: *digital rights* covers learning the rights and responsibilities as a digital citizen, *digital access* relates to learning the foundation of data, information, internet system, and how to use digital tools to acquire information efficiently, *digital communication* refers to learning the principles of online communication and privacy, *digital safety* is learning to protect oneself and avoid the risks from digital threats, *media and information literacy* according learning to critically analyze, interpret, differentiate, and evaluate the value of the information and its sources, *digital etiquette* involves learning the ethics and manners in using online technology and social platforms empathetically, *digital health* concerns with learning the physical and psychological impacts of the Internet and digital technology on individual's well-being, *digital commerce* associate with learning the essential elements of online marketing and making safe transactions, and *digital law* refers to learning the rules related to intellectual copyrights and digital economy in order to identify crime and penalty or the actions. The primary and secondary school Thai students have been taught and practiced to access learning management systems or online learning platforms, to use social media for group discussions or as digital tools, and use email for submitting the assignment or receiving relevant learning material.

That is to say, Thailand's basic education core curriculum mentioned by the Office of the Basic Education Commission of Thailand aims to promote good behaviors and daily life habits when the students participate with Internet access, social media platforms, and digital tools. As suggested by the Common Sense Media curriculum (2016) and Tapingkae et al. (2020), the

research-based curriculum relevant to digital citizenship or digital literacy would prepare students to behave safely in cyberbullying, digital drama, digital relationships, digital relationships, and online communication. Therefore, the potential topics for conducting the digital citizenship behaviors or digital literacies for Thai youth students are following:

- Cyberbullying or be upstanding: the students should be able to reflect on what it means to be brave enough to stand up and help others both online and offline, understand the feelings of cyberbullying people (Cyberbullying) or intimidation by using digital technology, and find solutions to help cyber-bullying people;
- Safe online talk: it involves descriptions of the positive aspects of texting and chatting online, identification of inappropriate and risky friendships or making friends, flirting, and conversation situations, and understanding of the rules for safe online messaging and a sense of power to deal with awkward situations when communicating online;
- Reality of digital drama: it refers to reflecting feelings about stories that happen in the digital world, comparing the messages that convey the stories that happened in the digital world and the real lives of teenagers, thinking critically about Gender stereotypes and general conclusions;
- Cyberbullying (crossing the line and making correct decisions): includes analyzing online bullying behavior that leads to crossing the line, learning about the bullying behaviors in the online world (e.g., flaming, deceiving, and harassment), and applying the perspective of people who have been bullied in the online world as a solution when faced with cyberbullying incidents.

(2) Applying the traditional machine learning approach as the decision-tree technique to create a storyline to trigger the students' good decisions.

(3) Applying instructional design as context-based learning to design gaming activities to situate the students' behavior aforementioned-item (1) digital citizenship behaviors or digital literacies.

(4) Analyzing learners' behaviors and interactive patterns in gaming activities with the decision-tree technique to understand changing and adapting undesired behaviors to desired behaviors.

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