A RESEARCH SYNTHESIS ON DIGITAL GAME PROMOTING 21ST CENTURY SKILLS IN BASIC EDUCATION LEVEL

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Abstract - The purpose of this research was to investigate the effects of digital games on enhancing 21st-century learning skills among students in basic education through a meta-analysis of studies published between 2014 and 2025. The research instruments included a research quality assessment form and a research characteristics recording form. The results revealed that 22 studies were synthesized, of which 11 provided sufficient statistical data for meta-analysis. The findings indicated that digital games have significant potential in promoting 21st-century learning skills. Puzzle games demonstrated the highest effect size, followed by role-playing games (RPGs) and adventure games. In terms of learning skills, creative problem-solving exhibited the strongest effect size, while computer literacy and digital intelligence, communication, and critical thinking followed respectively. These results highlight that digital games can serve as effective educational tools for fostering essential learning skills necessary for learners in the 21st century

Keywords - Digital Games, 21st Century Skills, Meta-Analysis, K-12

I. INTRODUCTION

Education is considered an important mechanism for developing a country's workforce, so that learners become high-quality human resources and a key force in Thailand's future development. Teaching and learning in an appropriate environment, together with the use of learning materials that match academic content and learners' developmental levels, are important factors that support effective learning.

At present, learning media are diverse and continue to develop along with technological progress. These include computer-assisted instruction that improves teaching and learning efficiency, multimedia that can present content in an interesting and comprehensive way, and digital games, which have recently gained attention as highly potential learning tools. Digital games have therefore played an important role in teaching and learning, leading to the researcher's interest in studying how digital games can be used as instructional media with maximum effectiveness.

From the literature review, it was found that the use of digital games in education has benefits, especially in enhancing learners' enjoyment of learning content. Many experimental studies support the effectiveness of digital games in educational contexts. For example, the study by Afthinos used the game Top Eleven to promote career inspiration for football club managers. However, each study was conducted under specific conditions and contexts. For instance, Oliver conducted an experiment at the post-secondary level and applied digital games in the subject area of social studies, religion, and culture. Differences in context and scope make it difficult to clearly conclude which educational level and subject area are most suitable for the use of digital games.

Reviewing literature related to the use of digital games in teaching and learning is therefore essential in order to gain a deeper and clearer understanding of both the effectiveness and limitations of this type of learning tool. A meta-analysis study by Yu analyzed the effects of online gamification on learning outcomes by categorizing participants into three educational levels: basic education, higher education, and working adults. The study also compared STEM and non-STEM subjects. The results showed that online gamification had an overall moderate effect on learning outcomes. However, differences were found across educational levels: a low effect for basic education, a moderate effect for higher education, and a high effect for working adults. In contrast, the comparison between STEM and non-STEM subjects showed similar moderate effects, with no significant difference. Nevertheless, this study had limitations, including a lack of analysis on types of digital games suitable for STEM subjects and insufficient focus on specific levels within basic education. These gaps indicate a need for further research.

Based on these reasons and limitations of previous studies, the researcher conducted a study entitled "A Synthesis of Digital Game Research for Promoting 21st Century Learning Skills among Basic Education Learners." This study used research synthesis and meta-analysis methods to systematically and comprehensively examine the effects of digital games on the development of 21st century learning skills. The purpose of this study was to help educators and related stakeholders clearly understand the outcomes of using digital games to promote different types of learning skills. In addition, this research expanded the scope of meta-analysis to include several important variables, such as types of 21st century learning skills that digital games can most effectively promote, as well as types of digital games suitable for promoting

each type of skill. This approach helps fill academic gaps that previous studies did not examine in detail. Therefore, this study is expected to provide useful empirical evidence for developing effective instructional strategies that use digital games to promote 21st century learning skills among learners in basic education.

The purpose of this research is to synthesize previous studies on the effects of using digital games to promote 21st century learning skills among learners at the basic education level. In addition, this study aims to examine the effect sizes of digital games in promoting 21st century learning skills, including each type of 21st century learning skill. Furthermore, the research seeks to analyze the effect sizes of different types of digital games that can promote 21st century learning skills in each specific skill area.

II. METHDOLOGY

This research defines a clear scope of study by reviewing research related to digital games and 21st century learning skills published between 2014 and 2025. The researcher selected three databases at both national and international levels: the Thai Journals Online database (ThaiJo), Scopus, and ERIC. The keyword used in ThaiJo was digital games (in Thai is เกมดิจิทัล). For Scopus and ERIC, the keywords included “digital games” OR “online games” OR “educational games” OR “serious games” AND “problem solving skill” OR “communication skill” OR “social skill” OR “critical thinking skill” OR “digital literacy skill” OR “21st century skills” AND “K-12” OR “primary” OR “secondary” OR “high school” OR “students”.

The researcher established inclusion criteria as follows: (1) studies related to digital games and 21st century learning skills, (2) studies conducted at the basic education level, (3) studies within the specified subject areas, (4) studies published in Thai or English, (5) studies published between 2014 and 2025, (6) studies with full-text availability, and (7) studies that passed quality assessment. The exclusion criteria included: (1) studies without accessible full texts, (2) studies conducted with students with special educational needs, and (3) studies not related to education.

The research search and selection process consisted of five steps. First, studies were searched from three databases—ThaiJo, Scopus, and ERIC—using both Thai and English keywords. Second, studies were screened based on their titles. Third, abstracts were reviewed to assess relevance. Fourth, full-text studies were collected and further screened according to the inclusion criteria. Fifth, the quality of the selected studies was evaluated using a research quality assessment tool. The researcher employed the Joanna Briggs Institute (JBI) critical appraisal checklist for quasi-experimental studies.

This research synthesis employed two research instruments: a research quality assessment form and a research characteristic coding table. The research characteristic form and coding manual were developed based on Littell and Nonglak Wiratchai. Microsoft Excel was used as a data recording tool. The recorded variables included publication year, continent of publication, number of studies by type of digital game, number of studies by type of 21st century learning skill, number of studies by basic education level, and number of studies by subject area. In addition, the JBI quasi-experimental appraisal form was used to assess research quality.

For the meta-analysis, statistical data from the selected studies were analyzed. The analysis focused on (1) the effect sizes of digital games on overall 21st century learning skills and on each specific skill area, and (2) the effect sizes of different types of digital games on 21st century learning skills, classified by each skill area. Effect sizes were interpreted as follows: effect sizes less than 0.5 indicated a small but statistically significant effect, effect sizes between 0.5 and 0.8 indicated a moderate effect with practical significance, and effect sizes greater than 0.8 indicated a large effect with strong practical significance.

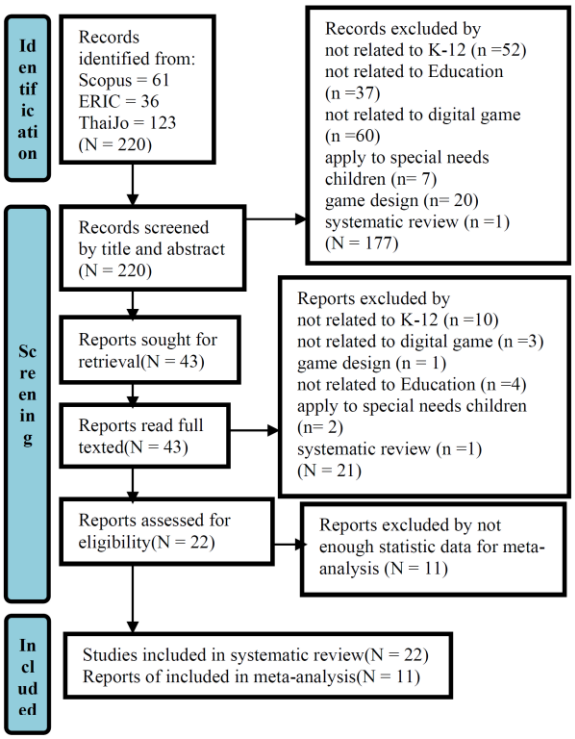
III. RESULTS AND DISCUSSION

3.1. A Synthesis of Research on the Effects of Digital Games on 21st Century Learning Skills among Basic Education Learners

The PRISMA diagram illustrates the step-by-step process used to select research studies included in this study. The researcher conducted a systematic search and data collection from three reliable and widely accepted electronic databases: Thai Journals Online (ThaiJo), which is an important source of Thai-language research articles; Scopus, an international database covering a wide range of academic disciplines; and ERIC, a specialized database focusing on education and learning development. The initial search identified a total of 220 studies that met the basic search criteria, including 123 studies from ThaiJo, 61 studies from Scopus, and 36 studies from ERIC.

The 220 studies identified in the initial search were then screened using clearly defined and systematic selection criteria. In the first screening stage, the researcher carefully reviewed the titles and abstracts of all studies to assess their relevance to the research objectives. As a result, 177 studies were excluded for various reasons: 52 studies were not related to basic education, 37 studies were not directly related to education, 60 studies were not related to digital

games, 7 studies focused on learners with special educational needs, 20 studies focused only on digital game design without linking to learning outcomes, and 1 study was a research synthesis. After this stage, 43 studies remained for further review.



Following the title and abstract screening, the remaining 43 studies were reviewed in full-text form. At this stage, 21 studies were excluded for the following reasons: 10 studies did not focus on basic education, 3 studies were not directly related to digital games, 4 studies were not related to education, 2 studies focused on learners with special educational needs, 1 study focused only on digital game design without addressing learning skill development, and 1 study was a research synthesis. As a result, 22 studies passed the preliminary selection process.

From the entire screening and selection process, a total of 22 studies were assessed for quality using the research quality criteria defined by the researcher. The results indicated that all selected studies were of sufficient quality and appropriate for inclusion in the research synthesis. In addition, among these studies, 11 studies were found to have adequate suitability and sufficient data for meta-analysis. These studies enabled the researcher to quantitatively examine the relationship between the use of digital games and the development of 21st century learning skills in a systematic and effective manner.

The researcher synthesized a total of 22 studies that examined the use of digital games to promote 21st century learning skills. The synthesis was conducted based on key research characteristics, as described below.

1.1 Publication Characteristics

The 22 selected studies focused on the use of digital games to promote 21st century learning skills. The analysis showed that the highest number of publications occurred in 2023 and 2024, with five studies published in each year, accounting for 22.73 percent per year. This was followed by the year 2020, with four studies (18.18 percent), and the year 2019, with two studies (9.09 percent). The years 2015, 2018, and 2025 had the lowest number of publications, with one study each (4.55 percent). In addition, no studies related to digital games and 21st century learning skills were published in the years 2014, 2016, 2017, and 2022.

In terms of publication regions, most studies were conducted in Asia, with 16 studies (72.73 percent). Europe ranked second with five studies (22.73 percent), followed by America with one study (4.55 percent).

1.2 Subject Areas

The 22 studies were classified by subject areas. The results indicated that science subjects received the greatest research attention, with 10 studies (43.48 percent). This was followed by foreign languages, with four studies (17.39 percent), mathematics with three studies (13.04 percent), and social studies, religion, and culture with two studies (8.70 percent). Career and technology education and health and physical education each had one study (4.35 percent). In addition, two studies did not specify a subject area: the studies by and Altanis. One study by KorchuleeSangkaew was conducted in computational science. As a result, the total number of studies by subject area increased to 23. However, the studies by Gaeta and Altanis did not provide sufficient statistical data for meta-analysis and therefore did not affect the grouping for meta-analytic analysis.

1.3 Educational Levels

When classified by educational level, the results showed that primary education was the most frequently studied level, appearing in 12 studies (50 percent). This was followed by upper secondary education with nine studies (37.50 percent), and lower secondary education with three studies (12.50 percent).

In addition, two studies (8.33 percent) involved multiple educational levels: the study by Gaeta, which included lower and upper secondary students, and the study by Cicchino, which included primary and lower secondary students. This resulted in a total of 24 studies when classified by educational level. However, both studies lacked sufficient statistical data for meta-analysis and therefore did not affect the grouping of studies for the meta-analysis.

1.4 Types of Digital Games

The 22 studies were also classified by types of digital games. The analysis revealed that role-playing games (RPGs) were the most common, appearing in eight studies (34.78 percent). This was followed by adventure games with five studies (21.74 percent), problem-solving games with one study (4.35 percent), and other types of games totaling six studies (26.09 percent). These other types included quiz games, board games, card games, click-based games, and LEGO games.

The study by PanittaSinbua was a special case, as it used more than one type of digital game by combining RPG and adventure game elements. To accurately reflect quantitative data, the researcher classified this study into two game types based on the original study description. As a result, the total number of studies included for game-type analysis increased to 23. Since this study provided sufficient statistical data, it was included in the meta-analysis for both RPG and adventure game categories, allowing for a more comprehensive analysis.

1.5 21st Century Learning Skills

The 22 studies were further classified by specific 21st century learning skills. The analysis showed that creative problem-solving skills were the most frequently promoted, appearing in nine studies (39.13 percent). This was followed by communication skills in four studies (17.39 percent), critical thinking skills in three studies (13.04 percent), and computer or digital literacy skills in two studies (8.70 percent). Career and life skills appeared in only one study (4.35 percent).

However, four studies—by Prakitnonthakan, SontiyaYodsanga and Niwat Srisawat, SunantaSudjai and NiwatSrisawat (2021), and Mookkaew—did not clearly specify which 21st century learning skills were promoted and lacked sufficient statistical data for meta-analysis. Therefore, these studies were excluded to ensure the accuracy, reliability, and completeness of the overall findings.

In addition, the study by Korchulee Sangkaew examined two types of 21st century learning skills: creative problem-solving and critical thinking. The researcher synthesized this study into two separate skill categories. However, due to insufficient statistical data, this study could not be included in the meta-analysis.

3.2. Effect Sizes of Digital Games in Promoting 21st Century Learning Skills and Each Type of 21st Century Learning Skill

The results of the meta-analysis showed that digital games had a high effect on the development of 21st-century learning skills. A total of 12 studies were included in the analysis, with most studies focusing on creative problem-solving skills (6 studies), followed by communication skills (3 studies), critical thinking skills (1 study), and computer skills and digital literacy (1 study). When classified by game type, RPG games (5 studies) were the most frequently used, followed by adventure games (4 studies), puzzle games (1 study), and other types of games (2 studies). The findings indicated that puzzle digital games produced the highest effect size (ES = 11.72; 95% CI = 9.49–13.96), followed by RPG digital games (ES = 4.93; 95% CI = 3.53–6.32) and adventure digital games (ES = 2.69; 95% CI = 2.12–3.26). When classified by skill type, the use of digital games showed the strongest effect on creative problem-solving skills (ES = 11.72), followed by computer skills and digital literacy (ES = 1.53) and communication skills (ES = 1.03).

IV. CONCLUSIONS

The results of the research synthesis indicate that digital games demonstrate a high effect in promoting and developing 21st-century learning skills. When classified by game type, puzzle-based digital games showed the highest effect size (ES = 11.72), followed by role-playing games (RPGs) (ES = 4.93) and adventure games (ES = 2.69), respectively. In terms of 21st-century learning skills, digital games were found to be most effective in enhancing creative problem-solving skills (ES = 11.72), followed by computer and digital literacy skills (ES = 1.53) and communication skills (ES = 1.03). Overall, the meta-analysis confirms that digital games have significant potential to support the development of 21st-century learning skills at the basic education level. Among the various game types, puzzle-based games were the most effective, followed by RPGs and adventure games.

The researcher identified clear differences among digital game types in terms of competition characteristics, gameplay styles, and game design structures, which were significantly related to the outcomes of promoting 21st-century learning skills. Rizki employed digital games characterized by short, concise gameplay with limited playtime. The game design emphasized brief narratives and mission-based tasks that learners had to complete to progress through levels. Game activities were directly aligned with learning objectives, which facilitated short-term motivation, captured learners' attention, and supported sustained focus. As a result, this study reported the highest effect size in the meta-analysis, reflecting the strong potential of such compact and goal-oriented digital games to effectively promote 21st-century learning skills.

Similarly, Nohutilized digital games consisting of multiple levels designed with a systematic progression of difficulty. The gameplay began with simpler levels and gradually increased in complexity,

allowing learners to continuously practice and develop their skills in a step-by-step manner. In addition, the game incorporated a reward system that players could utilize in subsequent levels, which enhanced positive motivation and encouraged ongoing engagement in the learning process. This design approach reflects a deliberate intention to support scaffolded learning and corresponds with a high effect size, ranking second after short and concise game formats.

In contrast, the study by Jirayu Nimnuan employed digital games divided into multiple stages based on learning objectives, such as land evaporation, water evaporation, condensation, rainfall, and water accumulation. However, each stage was designed as an independent unit, lacking continuity in both content and difficulty progression. The stages were not structurally linked in a sequential manner, which may have limited learners' sense of continuity and gradually increasing challenge. This design characteristic may have negatively affected learners' motivation and long-term engagement, which is consistent with the lower effect size observed when compared with studies employing sequential and interconnected game designs.

In summary, differences in the characteristics and structural design of digital games are clearly associated with variations in effect sizes for promoting 21st-century learning skills. Short, concise games that emphasize rapid motivation tend to yield the highest effects, while multi-level games with progressive difficulty and reward systems remain highly effective at a slightly lower level. Conversely, games that divide content into disconnected stages without structural continuity tend to produce lower effects. These findings highlight the importance of designing digital games with coherent structures and process-oriented learning support.

Furthermore, the meta-analysis revealed that digital games can promote creative problem-solving skills, computer and digital literacy, communication skills, and critical thinking skills. The researcher further discussed the elements of digital games associated with these four skills. The findings indicate that the most frequently occurring and most important elements were narrative (storyline) and rules, both of which appeared consistently across all digital games analyzed. This suggests that a clear storyline and well-defined rules serve as fundamental factors in establishing learning frameworks and defining gameplay goals that learners can easily understand and follow. In addition, competition was identified as another highly important element, as it effectively stimulates learner motivation and sustained engagement.

Elements playing a moderate role included avatars and feedback. Avatars allow learners to create representations of themselves within the game environment, fostering a sense of ownership and deeper engagement. Feedback functions as a mechanism for reflecting learners' actions, enabling them to adjust strategies and continuously improve learning outcomes. Although these elements appeared less frequently than the core elements, they still play an important role in enhancing motivation and enjoyment in learning.

Overall, both primary structural elements—such as narrative, rules, and competition—and secondary elements—such as avatars and feedback—interact to create learning environments that support the comprehensive and sustainable development of 21st-century learning skills.

The digital game elements identified in this study align with the framework for promoting 21st-century learning skills proposed by PimphanDechakup and Phayao Yindeesuk which emphasizes creating positive learning environments in both physical and psychological dimensions. This approach includes the use of digital games incorporating key elements such as narrative, competition, and rules to maintain learners' alertness and engagement throughout the learning process. Such educational digital game designs not only stimulate learners' interest and motivation but also effectively promote creative thinking, problem-solving, and communication skills, which are essential competencies in the 21st century.In addition, the researcher reviewed the study by Rizki, which focused on developing critical thinking skills and learning motivation in physics among upper secondary school students through the use of digital games and virtual reality technologies. The sample consisted of 54 students. The results showed that the developed instructional tools and learning media demonstrated high validity and reliability, were suitable for practical implementation, and significantly enhanced students' critical thinking skills and learning motivation. Furthermore, students reported a high level of satisfaction with the learning approach. This study underscores the importance of creating engaging and interactive digital learning innovations to effectively promote 21st-century skills and academic achievement.

ACKNOWLEDGMENTS

I would like to express my sincere gratitude to my family for their continuous support, motivation, and encouragement throughout the completion of this paper. I am also deeply thankful to my professor for the guidance and encouragement to publish this work at the international level. It is my hope that the knowledge presented in this study will provide useful

guidelines for designing digital games that promote 21st-century skills.

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