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Implementation of Computational Thinking through Game-Based Learning: A Systematic Literature Review

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Abstract.
Computational thinking (CT) is one of the 21st century life skills that students must have. To equip students with computational thinking skills, an effective learning strategy is needed. One of the alternative learning strategies in the implementation of CT is game-based learning. This study uses a systematic literature review analysis method. Searching using the keywords “Computational Thinking” and “Game-Based Learning” using publish or perish software, obtained 950 literature published from 2018 to 2022. From the results of the analysis of CT components in the title and abstract, further research opportunities can be obtained by linking the keywords computational thinking and game-based learning. Analysis results from the literature review showed that game-based learning is an interesting and fun strategy to implement CT skills for students.

Keywords: computational thinking, game-based learning, systematic literature review

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1. INTRODUCTION

Computational thinking skills are one of the 21st century life skills that must and help students solve problems, through the stages of decomposition, pattern recognition, abstraction, and algorithms [1]. Computational thinking skills itself is a thought process in problem formulation and finding solutions that are represented in an effective form by information processing agents [2]. Hemmendinger actually calls computational thinking a useful thought for teaching students to understand how to use computational steps to solve problems [3]. In other words, computational thinking is very useful for students to solve problems and make decisions in everyday life.

Currently in Indonesia, computational thinking skills are one of the focus skills that are clearly stated in the curriculum at all levels of education. Computational thinking

is no longer centered on computer science, but also on other sciences [3]. For this reason, educators must understand strategies for instilling computational thinking skills in students. In this case, educators need to innovate in learning.

One of the innovations to implement computational thinking in learning is through educational games. Educational game applications aim to provoke students' interest in learning so that they can more easily understand the subject matter presented. Educational Game is a game that integrates and combines subject matter into the components of the game [4]. According to Cahyo, a game is said to be educational if the game can utilize and hone the ability of the left brain function as it should [5].

The implementation of educational games in the world of education stems from the very rapid development of video games, making them an alternative media in learning activities [6]. Educational games in the world of formal and informal education have the opportunity to improve the education system, to be better. Based on the popularity of the game, educators think that they have a good opportunity to use game design components and apply them to learning that is tailored to the curriculum. Here, educational games are used as learning media to provide meaningful experiences to students by integrating computational thinking in them. But then the question arises, how to implement computational thinking through games as a learning medium?. In addition to these questions, the question also arises what kind of game-based learning can be used in an effort to improve students' computational thinking skills?. To answer this question, a more in-depth study is needed regarding the application of game-based learning to improve computational thinking for students through research with literature reviews. Thus, this study aims to help researchers and educators gain a better understanding by systematically reviewing and synthesizing research on computational thinking and its relation to game based learning in the last five years.

2. RESEARCH METHOD

This research uses the systematic literature review method which is defined by Liberati et al. as a systematic review as a research method and process to identify and critically assess relevant research, as well as to collect and analyze data from the research [7]. The goal of a systematic review is to identify all empirical evidence that fits pre-determined inclusion criteria to answer research questions [7]. In this study using a systematic literature review method with five steps (presented in Figure 1). The first step is to define search keywords, where the search keywords used are computational thinking and game based learning. Second, collect initial search results by utilizing

publish or pherish applications related to these keywords with year limits starting from 2018 to 2022. After an initial search, articles with educational disciplines, open access, and in English were selected. To compile data statistics, the researcher read the entire text of the article, looked at its suitability with the inclusion criteria, and looked at the relevance of the manuscript to the research question.

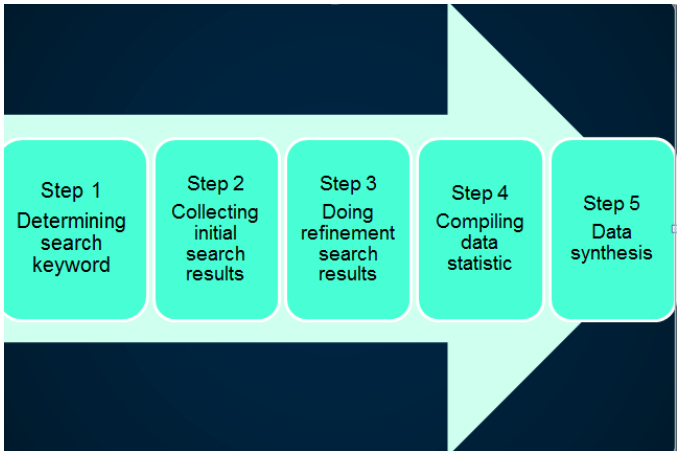

Figure 1: Five-step method of systematic literature review.

3. RESULTS AND DISCUSSION

An initial search with the keywords computational thinking and game-based learning through the publish and pheris application for the last 5 years (2018-2022) resulted in 950 articles searched from Google Scholar. Of the 950 literatures, only journal articles were used in the study. Furthermore, the journal articles are filtered by adjusting the quality of the article, the reputation of the journal and publisher, and the impact factor of the indexing journal. Based on these criteria, there are 22 journal articles that are relevant and meet the eligibility requirements according to the established criteria. The sources of data and documents identified in the initial search are presented in the Table 1.

3.1. Trend of Computational Thinking and Game-Based Learning Studies

Based on the initial search results with the keywords “computational thinking” and “game-based learning” starting from 2018 to 2022, it is seen that there is a decrease in research trends (presented in Figure 2). In 2018, 339 articles were found with these two keywords. This number decreased the following year to 329 articles. In 2020, only

TABLE 1: Detail results obtained by the search protocol.

Data Source	Documents Identified
Scopus	375
Springer Link	101
ACM Digital Library	61
IEEE Xplore	59
ERIC	19
Wiley Online Library	9
Web of Science	2
Others	324

225 articles were found. A drastic decline occurred in 2021, where articles searched for the keywords “computational thinking” and “game-based learning” only found 50 articles. The decline in studies marked by decreased article publications is possible because researchers are more likely to study elements of computational thinking, such as decomposition, abstraction, pattern recognition, and algorithms. In addition, Tang et. al. in their research found that computational thinking integrated learning is most often done in STEM education [8].

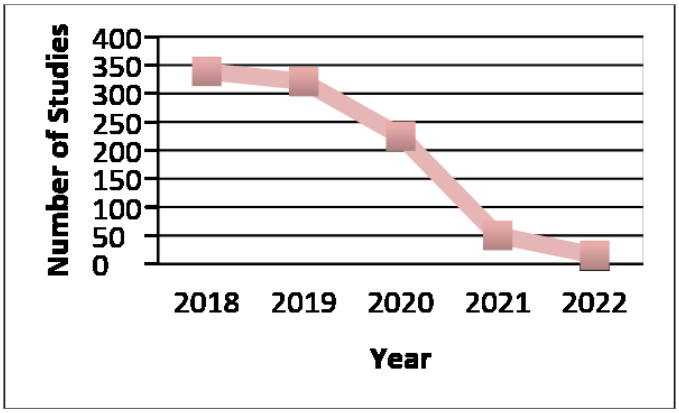

Figure 2: Distribution of CT publications (2018-2022).

3.2. Plugged and Unplugged Activity for CT Implementation

The results of data analysis indicate that computational thinking can be implemented through plugged and unplugged. Divya et.al found in their research that the unplugged activity approach and computer programming approach can help students stay active in the learning process [9]. Meanwhile, Chongo who utilizes learning by integrating computational thinking through uplugged and plugged-in programs shows that CT is effective in increasing understanding of electrochemical topics [10]. From these two

studies, it is clear that CT can be implemented in any condition, whether connected to a computer or not. Tsarava et.al. say that the process of implementing computational thinking is carried out using computer programming such as Stratch and Phyton [11].

3.3. Computational Thinking through Game-Based Learning

Games were initially only used for entertainment, but recently games have been widely used in learning. Chen studied the effects of digital games on students broadly. The results show that game-based learning has a positive effect on motivation and learning achievement [12]. This is in line with the research results of Chang et.al which showed that digital game-based learning gave students a higher enthusiasm for learning than non-game computer-based learning [13]. The results of research related to game-based learning of course become the basis for other research to improve students' computational thinking skills. Turchi et al. designed the TAPASPlay game to encourage computational thinking skills [14]. Programming is judged to have the potential to help students develop skills such as abstraction and problem decomposition. TAPASPlay is a turn-based game aimed at end users with little or no experience in programming, who are trained in CT skills to be able to participate in system design and activities. TAPASPlay was developed from the TANGible Programmable Augmented Surface (TAPAS). TAPASPlay is a serious turn-taking game in gameplay learning to cultivate CT skills by keeping students entertained. The result of this exploratory study is that fun plays an important role in engaging a wide audience in developing CT skills. Such reflections are sufficient to articulate CT skills for problem solving. Meanwhile, Emram and Zaibon found that there are 6 main elements of CT and 21 sub-elements of game-based learning that can be integrated [15]. The six main elements consist of rules, goals, feedback, interactions, challenges, and narrative. The sub-elements consist of ground rules, operating rules, goals, gamification goals, marks, rewards, badges, player style, characters, consequences, limitations, game levels, fun, competition, control, space, engagement, and curiosity. adapted to the main elements. The main elements and sub-elements of the GBL are called components of the GBL. Each GBL component is integrated with 7 CT concepts, namely decomposition, algorithm, abstraction, logical reasoning, assessment, evaluation, pattern recognition, and automation.

The implementation of computational thinking through game based learning is not only done through computer-connected activities. As explained above, CT can also be implemented through unplugged activities. Septiyanti et al. has conducted research to

encourage computational thinking through unplugged and robotic collaborative game-based learning [16]. The unplugged game in this research is called the Meta-Mind Table Game, while the plugged game is called the Meta-Mind Robotic Game. The results showed that there was a significant increase in the CT test after playing the Mind Table Game and Meta-Mind Robotic Game. This study reveals that the inclusion of unplugged and plugged-in game-based learning is beneficial for students in improving computational thinking skills.

4. CONCLUSION

Based on the results of a systematic literature review, it was found that computational thinking can be implemented through game-based learning, both unplugged and plugged. Some research results state that game-based learning can increase learning motivation which has an impact on improving students' CT skills. However, further research is needed related to the type of game that is most suitable for integrating CT elements into game components.

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