Manuscript Submitted	4 Nov 2019
Accepted	18 Nov 2019
Published	26 Dec 2019

Games Based Learning for Computer Science Education: A Systematic Literature Review

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Abstract

Educational games are assumed to be an effective and efficient instructional strategy for computing education. The trend using educational games in elementary levels also applied to higher education level. Recently, researchers have shown an increased interest in using games in computer science. In this paper, we are presenting a systematic review and analysis of 6410 papers regarding games in computer science that was published within 2015 and above. After applying our inclusion criteria and inspection of these studies, we have ended up with 26 papers was selected. Based on a systematic process, we reported and discussed our findings with possible future research directions. The results of this study indicate that the studies are accumulated around 4 categories: Games that learners or students play, games that learners or students develop as projects, curriculum proposals, and developing or coming up with new approaches, tools, frameworks or suggestions

Keywords*: Systematic review, Games, Games Based Learning, Computer Science, Education*

1. Introduction

Computer science is the study of the phenomena surrounding computers (Newell & Simon, 1975). Computer science is becoming ever increasingly important to our society. Computer science may play the role of primary world-view when forming knowledge in 21st century society(Polak, 2016) . Computer science content has, however, not traditionally been considered a natural part of curricula for primary and secondary education. Games can be considered as a tool to train novice software practitioners and may address such problems that might cause by a lack of practical information (McGonigal, 2011).

Over the last several decades, new technologies have allowed digital media to create a multibillion- dollar entertainment industry commonly known as computer video and digital games. Sales in the U.S. digital games market had grown from $43.3 billion in revenue in 2018, up to 18 percent from 2017(The ESA, n.d.). Furthermore, retail sales of video games in U.S. reached a record US$7.4 billion in 2004. In 2004, Malaysia's online gaming market was worth US$7 million in subscription

revenue in 2019 up to 2 percent in 2018 (Statista, n.d.). This statistics doesn't yet include other type of games (non-online) that are pirated.

Educational games (or serious games) are specifically designed to teach people about a certain subject, expand concepts, reinforce development, or assist them in drilling or learning a skill or seeking a change of attitude as they play (Dempsey, Lucassen, & Rasmussen, 1996) Educational games can induce a wide range of emotions, and so recognizing specific emotions may be valuable for an intelligent system that aims to adapt to varying student needs so as to improve learning. (Amershi, Conati, & Maclaren, 2016) There are assumed to be an effective and efficient instructional strategy for computing education. However, it is essential to systematically evaluate such games in order to obtain sound evidence of their impact (Petri & von Wangenheim, 2017). Thus, in order to achieve more effective learning at higher levels we need instructional strategies focused on the students, which allow them to learn by doing it.

Games are natural tools for climate change education and engagement They can engross players and placed them in climate-centered scenarios. In this way, games provide designed experiences where players can learn through doing and being rather than absorbing information and traditional lecture formats. Digital game based learning has been applied in a wide array of educational domains, such as science (Shin et al., 2017), as well in mathematics (Castellar, All, De Marez, & Van Looy, 2015), and economics (Hwang, Sung, Hung, Huang, & Tsai, 2012), as a means to motivate and assist learners in achieving the intended objectives (Squire, 2006) Furthermore, games deliver experiences that tap into a range of human emotions from fear and aggression to joy and wonder. [5] Finding new, more effective solutions often involves a trial and error process and games can make it easier and less intimidating to identify new strategies (Bachofen et al., 2012) The future of the video game industry, concluded today, offering millions of gamers around the globe a look into the future of the $135 billion industry. (Entertainment Software Association, 2019). Current trends also show the popularity of a total of 42 percent of global revenues in the gaming industry currently come from smartphone and tablet games. In comparison, second-placed console games generate 31 percent.("Infographic," n.d.). Another study found that games positively motivating in their learning process. (Borna & Rad, 2018; Butler & Ahmed, 2016; Chen & Law, 2016; Tobar-Muñoz, Baldiris, & Fabregat, 2016)

This paper is structured as follows: Section 2 gives the methodology of the review with the research questions, inclusion criteria, data sources and search strategy. Then the results are described with primary findings in Section 3. In Section 4, the results are discussed and lastly at Section 5, the study is concluded and future d research are briefly provided.

2. Method

To carry out this review, we followed the recommendations by Kitchenham (Kitchenham, 2004), Keele (Keele, 2007) and Petersen (Petersen, Feldt, Mujtaba, & Mattsson, n.d.). In this section, the planning of the review is explained and the details of the review method are explained below. The details include the research questions, inclusion criteria, data sources and search strategy.

2.1 Research questions

The purpose of this study is to conduct a systematic literature review of research on the use of games in computer science education. We translate our research objectives into specific research questions as follows:

(RQ1) With what kinds of purposes are games used in computer science education?
(RQ2) What kinds of games are used in computer science education? Are they digital or non-digital?

2.2 Search process

The search was carried out for the studies since 2015. The search terms used that matched with the logical word and the selected keywords for the search were. The steps of search processes are:

1) Firstly, the systematic review process was started with the search for the studies by using the previously defined keywords : “computer science education” AND "educational game*".
2) Secondly the edited keyword:
“computer science education” AND "educational game*" OR "edutainment game*" OR "serious game*" OR "simulation game*" OR "games-based learning" OR "games based learning" OR "game based learning" OR "game-based learning" OR "learning game*"

3) Third: Include relevant studies exclude unrelated studies
4) Fourth: Remove duplicates

The search terms were applied to title, abstract and keywords of the paper. The selected journals and conferences are shown in Table 1.

***Table 1*:** Search Result

Resource Type	Resource Name
Online Database and Online Search Engine	Emerald, Google Scholar, Scopus, ScienceDirect, ieee xplore

2.3 Inclusion and Exclusion Criteria

Articles on the following topics were included:

- Papers come up from the search string
- Journal, conference
- Papers written in English
- Published in or 2015 and after
- Studies that add value to computer science education

Articles on the following topics were excluded:

- Papers that do not focus on computer science education
- Other literature reviews
- PowerPoint presentation
- Blogs or websites

2.4 Quality assessment

QA1: Does the paper elaborates about the use of games in computer science education. in details?
QA2: Does the problem statement clearly stated in the paper?
QA3: Does the research methodology clearly stated in the paper?
QA4: Does the research results are discussed and answering the research questions/objectives.

The questions were scored as follows:

QA1: Y (yes), the study elaborated about the use of games in computer science education in details.
P (partly), the use of games in computer science education is not clearly elaborated in detail in the paper.
N (no), the study did not elaborate about the use of games in computer science education in details at all.

QA2: Y (yes), the study elaborated about the problem statement stated clearly in the paper.
P (partly), the problem statement stated clearly in the paper is not clearly elaborated in detail in the paper.
N (no), the study did not elaborate about the problem statement stated at all.

QA3: Y (yes), the research methodology are clearly elaborated in the paper.
P (partly), the research methodology not clearly elaborated in detail in the paper.
N (no), there are no research methodology stated in the paper at all.

QA4: Y (yes), the paper discusses the research results that answering the research questions/objectives.
P (partly), the prototype or framework and results is not clearly stated in the study.
N (no), there are no prototype or framework that used and also the results of the usability of learning mobile language in the paper at all.

The scoring procedure was Y = 1, P = 0.5, N = 0, or Unknown (i.e. the information is not specified).

2.5 Data Collection

The data extracted from each study were:

- The source (journal or conference) and full reference.
- Main topic area/issues.
- Research methodology.
- Main finding / suggestion / Future research

2.6 Data Analysis

The data was tabulated to show:

- The overview of the results of the review steps 1-4
- The quality score for each SLR.
- Category distribution of games used in computer science education
- Digital vs non digital approach

3. Results

3.1 The search results

Quantitative results achieved after each step can be seen in Table 1. Studies included from digital databases.

Table 1: Number of papers according to the search

Result after inclusion and exclusion	Google Scholar	IEEE	Scopus	ScienceDirect
Step 1	6140	4146		
Step 2	850	300		
Step 3	144	75	58	28
Step 4	10	13	1	2

Having browsed in the online databases, and searched using the strings in Section 2(b), a set of 26 appropriate related works has been gathered. All papers are summarized in a table, in which the contents of the table (as seen in Table 2) include the following information: (a) Study title, (b) Author(s), (c) year of publication.

Table 2: Data Collection of Related Study

Paper ID	Title	Author/citation	Year
1.	Software Engineering Education and Games: A Systematic Literature Review	(Kosa, Yilmaz, O'Connor, & Clarke, 2016)	2016
2.	Computer card games in computer science education: A 10-year review.	(Kordaki & Gousiou, 2016)	2016
3.	Digital game based learning in computer science education.	(Chandel, Dutta, Tekta, Dutta, & Gupta, 2015)	2015
4.	Evaluation of Game-Based Learning Approaches through Digital Serious Games in Computer Science Higher Education: A Systematic Mapping	(Krassmann, Paschoal, Falcade, & Medina, 2015)	2015
5.	Game development for computer science education. (Johnson et al., 2016)	Chris Johnson, Monica McGill,..	2016
6.	Games Programming in Computer Science Education. (Vrajitoru & Toprac, 2016)	.(Vrajitoru & Toprac, 2016)	2016

7.	Gamification to Engage and Motivate Students to Achieve Computer Science Learning Goals (Butler & Ahmed, 2016)	(Butler & Ahmed, 2016)	2016
8.	Room escape at class: Escape games activities to facilitate the motivation and learning in computer science (Borrego, Fernández, Blanes, & Robles, 2017)	(Borrego et al., 2017)	2017
9.	Serious Games in Computer Science Learning Goals	(Borna & Rad, 2018)	2018
10.	Serious games: Using abstract strategy games in computer science 2: An experience report and lessons learned	(de Kereki & Adorjan, 2018)	2018
11	Student‟ s Opinions on Online Educational Games for Learning Programming Introductory	(Ibrahim et al., 2018)	2018
12	Conceptualising engagement with digital behaviour change interventions: a systematic review using	(Perski, Blandford, West, & Michie, 2016)	2016
13	Learning Outcome Enhancement via Serious Game: Implementing Game-Based Learning Framework in Blended Learning Environment	(Jing, Yue, & Murugesan, 2015)	2015
14	Programming video games and simulations in science education: exploring computational thinking through code analysis (Garneli & Chorianopoulos, 2018).	(Garneli & Chorianopoulos, 2018)	2018
15	Designing Games for Improving the Software Development Process. In Systems, Software and Services Process Improvement	(Kosa & Yilmaz, 2015)	2015
17	Robot ON!: A Serious Game for Improving Programming Comprehension (Miljanovic & Bradbury, 2016).	(Miljanovic & Bradbury, 2016)	2016
18	Project management game 2D (PMG-2D): A serious game to assist software project managers training	(Lino, Paludo, Binder, Reinehr, & Malucelli, 2015)	2015
19	CMX: The Effects of an Educational MMORPG on Learning and Teaching Computer Programming (Malliarakis, Satratzemi, & Xinogalos, 2017)	(Malliarakis et al., 2017)	2017
20	Serious computer games in computer science education (Rugelj, 2015).	(Rugelj, 2015)	2015
21	Comparative study of the process model of Serious Game Design through the generic model DICE	(Bennis & Benhlima, 2015)	2015

22	Learning analytics through a digital game-based learning environment.	(Cariaga & Feria, 2015)	2015
23	Co Design of Augmented Reality Game-Based Learning Games with Teachers Using Co-CreaARGBL Method (Tobar-Muñoz et al., 2016).	(Tobar-Muñoz et al., 2016)t	2016
24	Discovering the essence of Software Engineering an integrated game-based approach based on the SEMAT Essence specification. In Global Engineering Education Conference (EDUCON),	(Pieper, 2015)	2015
25	Instructor's acceptance of games utilization in undergraduate software engineering education: a pilot study in Turkey. In Games and Software Engineering	(Albayrak, 2015)	2015
26	Programming video games and simulations in science education: exploring computational thinking through code analysis (Garneli & Chorianopoulos, 2018)	Varvara Garneli and Konstantinos Chorianopoulos	2018

3.2 Quality Evaluation of SLRs

The 10 papers selected in this study were evaluated and scored by using the quality assessment questions mentioned above. The results are shown in Table 3 below:

Table 3: Systematic review studies.

Paper ID	**Article Type**	**QA1**	**QA2**	**QA3**	**QA4**	**QA5**	**Total Score**
1	Journal	0.5	1	0.5	1	1	4
2	Journal	0.5	1	0.5	1	1	4
3	Research Article	0.5	1	1	1	1	4.5
4	Conference paper	1	1	1	1	1	5
5	Conference paper	1	1	1	1	1	5
6	Conference paper	1	1	1	1	1	5
7	Conference paper	0.5	1	0.5	1	1	4
8	Journal	1	1	1	1	0	4
9	Conference paper	0.5	0	1	0.5	0	2

10	Journal	1	0	1	0.5	0	2.5
11	Journal	1	1	1	1	1	5
12	Journal	0.5	1	0.5	1	1	4
13	Conference paper	1	1	1	1	0	4
14	Conference paper	1	1	1	1	1	5
15	Journal	1	1	1	1	1	5
17	Journal	1	1	1	1	1	5
18	Conference paper	0.5	1	0.5	1	1	4
19	Journal	0.5	1	0.5	1	1	4
20	Journal	0.5	1	1	1	1	4.5
21	Conference paper	1	1	1	1	1	5
22	Conference paper	1	1	1	1	1	5
23	Conference paper	1	1	1	1	1	5
24	Journal	0.5	1	0.5	1	1	4
25	Journal	0.5	1	0.5	1	1	4
26	Conference paper	0.5	1	1	1	1	4.5

3.3 Category Distribution

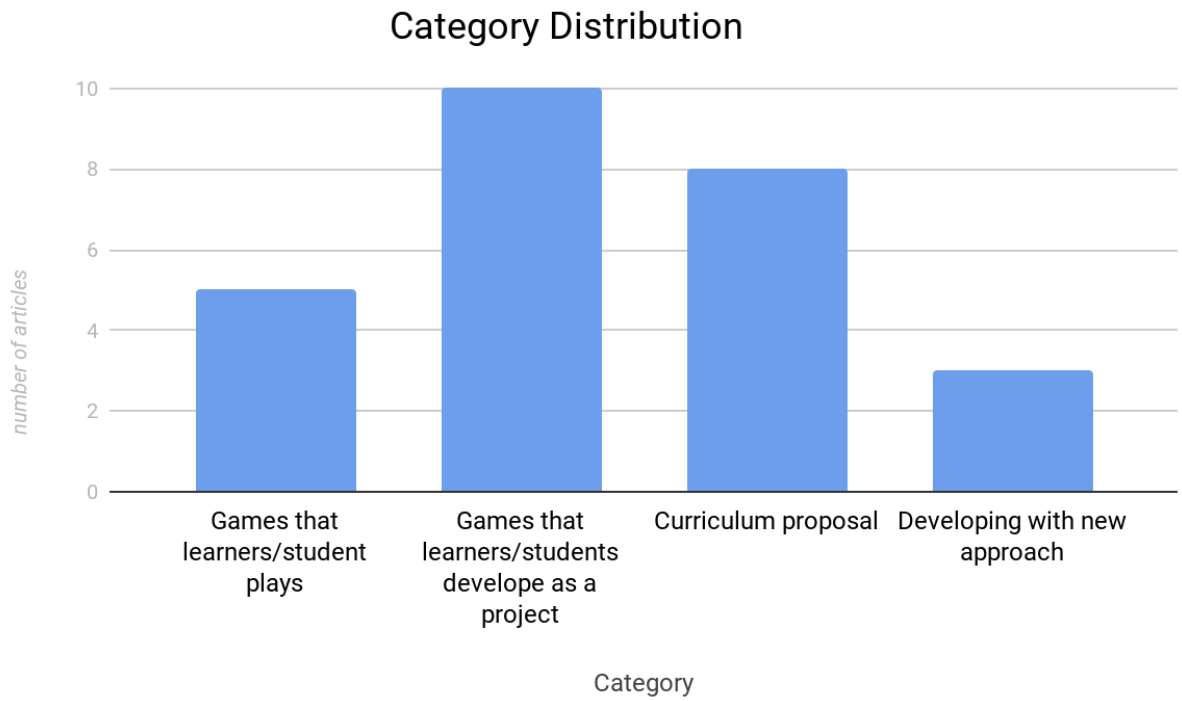
After STEP 4, it has been seen that the remaining studies are accumulated around 4 categories (Figure 2):
1. Games that learners or students play (5): A game is developed for students to play that helps the learning process of computer science education concepts. Studies in this category explain the game will enhance learning.

2. Games that learners or students develop as projects (10): Games are developed by students where they experience the development processes. Games are used as a motivating factor for students to develop projects and expose the students to challenging problems that they cannot generally face with non-game projects. Authors of the papers present the experience they had while using this method or the challenges and benefits of the method.

3. Curriculum proposals (8): Seemingly similar from the second category, authors present curriculums that can be embraced by teachers of project-based courses where students need to develop a system. Gamification in the curriculum approaches are also examined in this category.

4. Developing or coming up with new approaches, tools, frameworks or suggestions (3): Rather than describing a game-based course as in category 2, the studies selected for this category presume a new

approaches, tools, frameworks or suggestions for the acceptance of usage of games in computer science education.



According to the second research question (RQ2), as can be seen from Figure 3, there is a remarkable amount of study on digital games which may not seem to be surprising nowadays.. Figure 3 outlines the numbers of selected papers which have a digital game approach, non-digital game approach or both. Regarding the paper, non digital approach should be used in the teaching method to balancing the uses of digital approach. Bringing its own unique attributes, non-digital games may provide extra benefit. Moreover, educators may utilize them, make a face-to-face interaction, especially in teaching complex subjects that involve social aspects and that are hard to teach without simulating. Using an approach, which includes both digital and non-digital approaches, may also be an option where necessary. One of them can not be left in total.

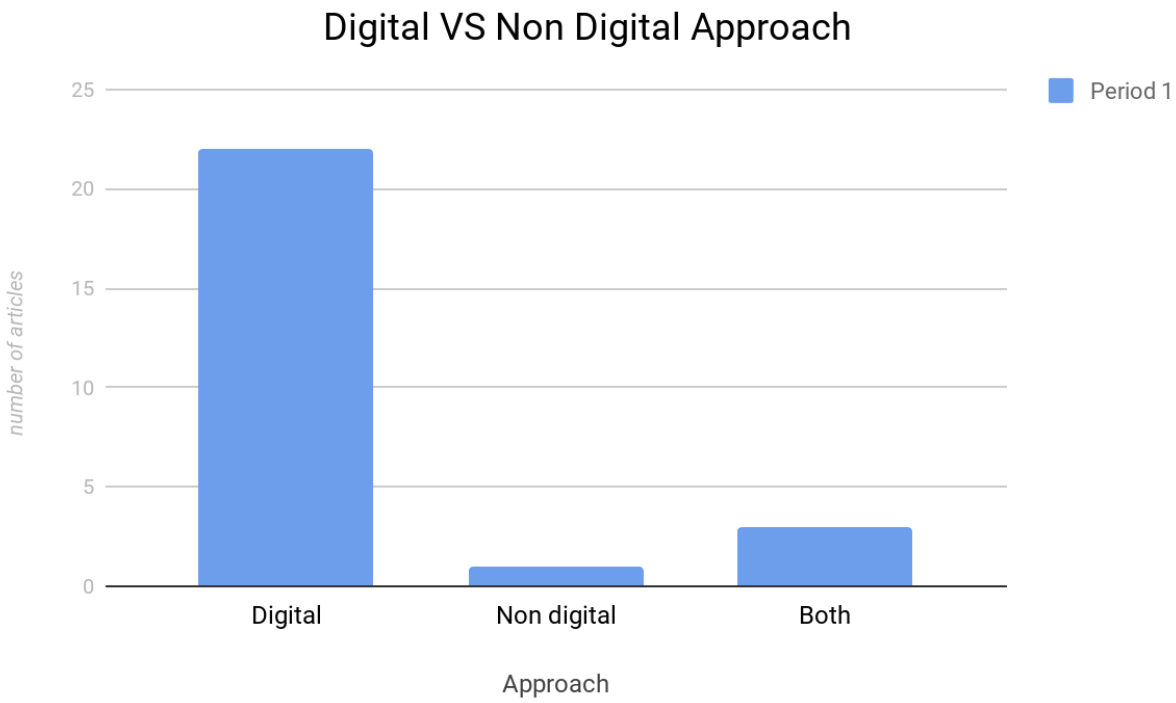


Figure 3

4. Discussion

The most obvious finding to emerge from the analysis is that the studies that are being carried out in the intersection of computer science education and games are accumulated around 4 main categories. Figure 2 articulates those categories and gives the number of papers included in each category. Returning to the research question (RQ1) posed at the beginning of the study, it is now possible to state that game is used both for playing and designing.

Most of the empirical studies in this review suggest that a game-based learning approach enhances positive experiences for participants and ultimately improve the learning levels of students. It has been also reported that the game-based learning approaches are more favored by the computer science students with respect to traditional teaching methods. In addition, when we have a look at the categories 1 and 2 (where they constitute most of the studies of the review), games are being utilized because of their instant feedback mechanisms and their ability to create or improve motivation and skills (Shim, Kwon, & Lee, 2017) (Borna & Rad, 2018) In general, this review showed that games provide extra motivation and positive experiences which both creates an entering point to the learning process for unmotivated individuals and adds value to the learning process for already motivated ones making it more effective. The results are significance with the studies by Kocaman & Cumaoglu (2014), Levy & O'Brien(2006), Neville etc. al((2009) and Berns etc. al. (2013).

Another observation of this review is that, there are no solid longitudinal studies in the area which shows that learning is more sustainable with game-based approaches with respect to traditional methods. Some effort should also be put from this point of view to show if games provide more lasting learning.

5. Conclusions and Future Work

In conclusion, this review study shows that computer science education and games are being approached from several angles that are categorized above. Although there studies on non digital in-class approaches lack empirical evidence which might be a good starting point for the new researchers in the area. For instance, development of non-digital games by the students as a learning intensifier after they have educated by traditional methods, was not reported in any of the studies which might be a novel approach. None of the studies should propose to change the traditional education to a whole new game-based teaching at this level, however a smooth transition into a more game-like environment blending with conventional methods seems to be the prevalent strategy as of now. Investment in the computer science education domain will greatly affect the future computer science which in result will be helping to achieve the overarching goal of software process improvement.

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