World Journal on Educational Technology: Current Issues

Volume 15, Issue 3, (2023) 275-286

www.wj-et.eu

Development of game-based learning media to encourage students' computational thinking

Afra Lathifah *, Sebelas Maret University, Kentingan, Jl. Ir Sutami No.36, Kec. Jebres, Kota Surakarta, Jawa Tengah 57126 , Indonesia

Asrowi Arrow, Sebelas Maret University, Kentingan, Jl. Ir Sutami No.36, Kec. Jebres, Kota Surakarta, Jawa Tengah 57126 , Indonesia

Agus Efendi, Sebelas Maret University, Kentingan, Jl. Ir Sutami No.36, Kec. Jebres, Kota Surakarta, Jawa Tengah 57126 , Indonesia

Suggested Citation:

Lathifah, A., Arrow, A. & Efendi, A. (2023). Development of game-based learning media to encourage students' computational thinking. *World Journal on Educational Technology: Current Issues*. *15*(3), 275-286. https://doi.org/10.18844/wjet.v15i3.7558

Received on March 17, 2022; revised on May 16, 2022; accepted on July 25, 2023.
Selection and peer review under the responsibility of Prof. Dr. Servet Bayram, Medipol University, Turkey

Abstract

Technological developments in the 21st century require educators to teach computational thinking (CT) to their students. Educators must have creative ideas in the learning process, one of which is utilizing learning media. Game-based learning (GBL) media is one of the most popular. In this research, we developed a GBL media which is part of this type of research development. The participants used were junior high school students with a total of 118 students. After testing the effectiveness, it is known that the GBL media developed can be an alternative media that supports students' better CT learning outcomes. This positive response is supported because the games provided have been adapted to the needs of students. Although this research has contributed to the theory of CT and GBL, this research still has some limitations. In the future, other researchers can deepen by differentiating the subjects, the level of participants, or the type of media used.

***Keywords**:* Computational thinking; game-based learning; junior high school; research and development.

* ADDRESS FOR CORRESPONDENCE: Afra Lathifah, Sebelas Maret University, Kentingan, Jl. Ir Sutami No.36, Kec. Jebres, Kota Surakarta, Jawa Tengah 57126, Indonesia
Email Address: afra.lathifah@student.uns.ac.id

1. Introduction

Recently, the growth of information and communication technology has made *computational thinking* (CT) an important capability (Hurt et al., 2023; Liao et al., 2022). Denning (2017) explains the history of the development of CT, which began in the 1940s and bloomed in 2006, which Wing initiated. Cansu and Cansu (2019) have mentioned that CT started in the 1960s, as Papert showed in a study with his colleagues who developed the LOGO programming language to train students to think mathematically and logically. Then came the basic concept of CT, which has a broad meaning that is not limited to computer science but to diverse areas of learning and education (Gouvea, 2023; Taguchi, 2023). In 2011, Wing reconstructed his idea that CT is a method to solve problems by thinking comprehensively in formulating solutions that can be presented and implemented effectively.

CT is concerned with algorithms, either with or without computers (Shute et al., 2017). Haseski et al. (2018) have classified CT into seven themes: problem-solving, technology, thinking, personal, operational, social, and general. According to Lyon and Magana (2020), CT has various definitions: pattern recognition, adding mathematical insight, creative problem solving, sequence and debugging, abstraction, automation, generalization, decomposition, evaluation, programming knowledge, representative data, and data analysis. Meanwhile, Ezeamuzie and Leung (2022) define CT as two important main ideas, the concept of computer science and cognitive skills through problem-solving. Several literature studies have attempted to develop a definition of CT, and it can be concluded that CT is an attempt to figure out problems extensively, rationally, and in an orderly manner.

Even though CT has become popular, educators are still looking for ways to integrate it into class. *Game-based learning* (GBL) is one way to implement CT competencies in grades K–12 (Hsu et al., 2018; Tang et al., 2020). This is due to the similarity of theoretical foundations between computational thinking and GBL, where several studies have shown that game environments also tend to use constructivist theories (Chen et al., 2019; Nadolny et al., 2017; Qian & Clark, 2016; Wang & Zheng, 2020). The concept of GBL often overlaps with gamification and serious games (Al-Azawi et al., 2016; Al Fatta et al., 2018; Krath et al., 2021). GBL is a learning environment provided to students while playing using non-digital or digital media to offer experiences that direct changes in student knowledge (Al-Azawi et al., 2016; Hartt et al., 2020; Plass et al., 2019). GBL media is developed for student learning and contains content according to the curriculum (Al Fatta et al., 2018; Bunt & Gouws 2020). In a similar statement by Karakoç et al. (2020) and Krath et al. (2021), GBL is more about educational content and games to educate so that students as players can improve learning by solving problems and challenges while playing. Meanwhile, gamification and serious games are usually non-educational games that provide training without being entertaining (Karagiorgas & Niemann, 2017). This indicates that GBL can also be called educational games, specifically designed for educational purposes.

Students interact actively and have high motivation in the game environment (Żammit, 2022; Acosta-Medina et al., 2021). Educators also show high self-efficacy when using GBL (Akkaya & Kapıdere, 2021). Importantly, GBL is also superior to conventional teaching methods (Hooshyar et al., 2021; López-Fernández et al., 2021; Gyaurov et al., 2022). Therefore, there are several principles when implementing GBL: the teacher must play an active role in fostering students by facilitating games that are under the context or curriculum and must continually update knowledge about GBL from time to time, even if it is necessary to have a professional certificate related to GBL (Foster & Shah, 2020).

GBL found in CT adopts two approaches: plugged and unplugged. *Unplugged* is a game approach that relies on paper or non-digital (Caeli & Yadav, 2020). Kuo and Hsu's (2020) research shows unplugged playing activities using board games. Busuttil and Formosa (2020) used logic gates through twisters, building towers, party magic cars, conditional cards, and binary numbers. Threekunprapa and Yasri (2020) used flow blocks. Meanwhile, *plug* is a game approach that requires a power source, commonly known as digital technology (Lee et al., 2022). Examples of plugged game media used to train CT are the video game 'Penguin Go' (Zhao & Shute, 2019), Robo Builder, Formula Tracing (Winthrop et al., 2016), Zoombinis (Asbell-Clarke et al., 2021), Kodu, Lego (Wu, 2018) and the dominant Dr. Scratch (Altanis & Retalis, 2019; Garneli & Chorianopoulos, 2018; Hoover et al., 2016; Troiano et al., 2019). Sun et al. (2022) and Zhao and Shute (2019) also showed that the Code.org website is a GBL media that can train students' CT. The dissimilarity between unplugged and plugged is the use or non-use of technology. The benefit of unplugged activity is that it can facilitate students without burdening them with computer operating experience (Lee et al., 2022), preventing low interest or self-confidence (Caeli & Yadav, 2020). However, plug-in activities can generate excitement, grab attention, and motivate students (Zhao & Shute, 2019) to learn because of the graphical interface and clear game themes.

1.1. Purpose of study

In the literature, the suggested GBL media are games that are practical, easy to learn, and fun to support CT. However, generating or creating learning media is burdensome for educators (Leonard et al., 2018). Educators find it challenging to create learning media because of technical issues encountered during the process, such as gaming media creator applications requiring programming knowledge (An & Cao, 2017). The constraints of educators' abilities can be solved by allowing educational technologists to assist educators in developing an application product or learning media. This research will provide materials adapted to the learning environment to develop GBL media products. The research and development procedure begins with analyzing]g learning conditions, content planning and development, valid product feasibility from material experts, media, instructional design, and students, as well as product implementation and evaluation. Therefore, what is sought in this study is to identify the efficacy of the developed GBL media. The question that arises in this study is as follows:

1. Does the development of GBL media effectively encourage students' CT?

2. Materials and Methods

2.1. Research model

Research and development are a type of research used by adopting the ADDIE model. This research chose the ADDIE model because it has several benefits for developing products, such as its approach focusing on analyzing interacting components, iterating, creating, and revising.

According to Branch (2009), there are five processes from the ADDIE model based on the acronym: A for the analysis phase to identify what is happening in the learning environment, D for the design phase to verify the plan or product strategy to be produced, D for the development phase is the process of building product (product and product trials will be carried out), I for implementation and E for the evaluation phase will be carried out in conjunction with the goal that the developed media can be widely used and improve CT.

2.2. Participants

Prior to the widespread effectiveness test, the media had received validation from five experts. The class design used is the experimental and the control groups, each of which is 59 junior high school students from 1 city in Indonesia.

2.3. Data analysis

The test was used to determine the effectiveness of student learning when given treatment. Meanwhile, a questionnaire in the form of a questionnaire is used to determine the feasibility of the product. The data obtained from various assessment instruments will be processed using statistical analysis and described descriptively. The hypotheses used in this study are as follows:

H0: The treatment did not make a difference between the CT results before and after the test.

H1: The treatment gave a difference between the CT results before and after the test.

2.4. Ethics

The participants were anonymous. Participation in this study was not mandatory. Permission was sought from the school authorities before the study was conducted.

3. Results

3.1. Results of needs analysis and design of the GBL media

3.1.1. Analysis phase

Based on the preliminary study at the ADDIE stage, it was concluded that the teacher had not used media that integrated CT during the learning process of informatics subjects. At the time of observation of learning in the classroom, the teacher only relied on the module. Lectures, assignments, and practice are the methods most often used by educators. This is what directs research to create learning innovations by developing GBL media that is integrated with the CT concept.

3.1.2. Design phase

At this stage, the product strategy planning is developed. The product specifications developed include the following:

The developed product can be run using a computer or an Android OS smartphone.

The product contains material and summaries, sample questions and evaluations, games, guides, product information, and developer profiles.

The developed product integrates the CT components adopted by Dagienė et al. (2017), such as abstraction, decomposition, algorithm, evaluation, and generalization.

Meanwhile, the stages carried out in this design process start from 1) planning storyboards and flowcharts, 2) developing product prototypes with software help, and 3) publishing prototypes in the form of .exe or URL links.

3.2. Creating GBL media products

3.2.1. Development phase

At this stage, validation and testing of the developed product prototype are carried out. Several experts tested the feasibility of product development with two media experts, two materials, and one instructional design person. A rating scale of 1–5 was used in the study for each item of the questionnaire. Media assessment aspects consist of the display, navigation, and language. The material assessment consists of the material concept, the quality of the questions, language, and benefits. Meanwhile, the instructional design assessment aspect consists of learning design, navigation, and language.

Table 1

Results of Expert Assessment

Experts	Score	Category
Media I	4.14	Very good
Media II	4.78	Very good
Material I	4.26	Very good
Material II	4.32	Very good
Instructional design	4.39	Very good
Average	4.38	Very good

Based on Table 1, all experts rated it as 'very good' and concluded that the developed GBL media can be tested on students. The ADDIE model has three trial processes: individual, small group, and field trials. The trial was conducted by providing a product feasibility questionnaire with aspects of media content assessment, language, navigation, and usability. The results of the product feasibility assessment, when tested by students, can be seen in Table 2.

After each product trial, there will be a revision so that this leads to an increase in value for the subsequent trial. The final result of the assessment shows that each aspect gets an average score in the 'good' category. The three stages of testing carried out on these students also achieved an average result of 3.92, which was classified as 'good'. Thus, we demonstrate that the developed media can be tested extensively to determine product efficacy.

Table 2

Results of Product Trial Assessment

Aspect	Individual trials	Small group trials	Field trials	Average	Category
Media content	3.78	3.83	3.89	3.83	Good
Language	3.83	4.00	4.03	3.95	Good
Navigation	3.83	3.89	4.05	3.92	Good
Usefulness	3.94	3.96	4.01	3.97	Good
Average	3.85	3.92	4.00	3.92	Good

3.2.2. Implementation and evaluation phase

At the implementation stage, preparations will be made for educators and students. Educators will receive guidance from researchers. Meanwhile, students will be selected as participants who will

evaluate the developed GBL media. The control and experimental classes are research class designs used in the evaluation phase.

At the evaluation stage, the research began when control and experimental group students with conventional learning conditions were given pre-test questions. The pre-test determines the students' initial CT ability. Furthermore, the control group students were not given any treatment, while the experimental group received a different learning treatment using the GBL media that had been developed. The final assessment of learning was based on the post-test.

Before statistical tests, pre-and post-test scores were valid for normality and homogeneity. The statistical test is a paired *t*-test for finding mean comparisons between two paired samples. The results of the CT assessment for each class can be seen in Table 3. The control class did not show any change in the mean scores before and after the test. On the other hand, in the experimental class, the mean before and after changed significantly from 64.70 to 83.51. The value of the experimental class increased by 18.81. This shows that giving treatment using the developed GBL media affects students' CT.

Table 3

Result of Paired T-test

Variations	Control group	Experiment group
Average pre-test	66.966	64.695
Average post-test	70.983	83.509
t-test [Sig (2-tailed)]	0.051	0.000
Criteria	Sig (2-tailed) > 0.050	Sig (2-tailed) < 0.000
	No difference in the average	*There is an average difference*

4. Discussion

CT has become one of the mandatory competencies learned at the junior high school level in Indonesia, but many still have not implemented it optimally optimal (Yuliana et al., 2021). This is due to the lack of educators' knowledge of the concept of CT and media that can help them implement it in the classroom (Yadav et al., 2017b). At the same time, CT is seen as one of the necessary skills to adapt to the future of rapid technological development (Hsu et al., 2018).

Educators as lesson planners play an important role. This leads to the need to provide teachers with experience in integrating CT into their learning process (Yadav et al., 2017a). This makes the government in Indonesia to continue to disseminate information to educators in all regions to be able to implement CT (Dagienė et al., 2021). Indonesia collaborates with the Bebras community to spread the concept of CT at all levels of education through the *Bebras Challenge* or *Bebas Task*. Then, it is also known that the assessment by adopting the Bebras Task has been introduced to train CT in games (Asbell-Clarke et al., 2021; Kuo & Hsu, 2020).

The findings in the UK Bebras (2017) and the research of Aslina et al. (2020) succeeded in developing a Bebras Task-based game to practice CT skills. Research by Lawanto et al. (2017), Utesch et al. (2020), Chan et al. (2021), Israel-Fishelson et al. (2021), and Guenaga et al. (2021) showed that the type of game that can improve CT is maze game. By following previous findings, the developed GBL media offer questions integrated into CT components while paying attention to the type of game

or game element. The results of this research lead to decisions by media, materials, instructional design professionals, and students that the developed GBL media are proper. Expert evaluation results reached an average score of 4.38 in the 'very good' category. When the experiment was conducted on students, they received an average overall score of 3.92 in the 'good' category. After analyzing the effectiveness, it is known that treatment is affected between the two classes used. The benefit of GBL that has been developed is that materials, questions, and games have been integrated with CT. The integration of CT in GBL can make the media's potential in building students' CT knowledge fun.

The developed GBL also does not require any programming experience. Many studies have linked digital GBL to block-based (Deng et al., 2020; Lawanto et al., 2017) or text-based programming (Grizioti & Kynigos, 2021). Meanwhile, research by Jagušt et al. (2018) and Gresse von Wangenheim et al. (2019) used pen–paper or board games associated with coding. As a result, students can improve their CT but face many obstacles. Educators (An & Cao, 2017) and students (Kynigos & Grizioti, 2020) have difficulty understanding programming. However, it can also be a concern that researchers can start with an unplugged play approach before carrying out GBL or combine it with digital (Caeli & Yadav, 2020; Sun et al., 2022).

In this study, students have shown that the GBL media experimental class can improve CT compared to the control class. The positive response shown by students during GBL can occur because students tend to master technology more than educators (Buss & Gamboa, 2017). This happens because GBL uses various literacies, such as digital literacy, technological literacy, and game literacy (Wu, 2018). Moreover, digital literacy has many similarities with the components of CT (Juškevičienė & Dagienė, 2018). Troiano et al. (2019) also found that CT is a key skill supporting digital literacy and problem-solving development. Hsu et al. (2018) stated that training CT is not only digital literacy but also must take advantage of new technology. Thus, developing GBL media in this study is one of the new technology alternatives that can improve CT.

5. Conclusion

CT is a mandatory skill for everyone in this computing age. CT is a concern worldwide, including in Indonesia, one of the countries in Southeast Asia that continues to spread students' CT. This study experimented with GBL's media development on middle school students. Product development is carried out through several processes, including analysing learning conditions, planning, prototyping, implementing, and evaluating effectiveness. Experts in media, materials, instructional design, and students assessed that the media developed as feasible. After the effectiveness test was carried out on junior high school students, it was found that there were differences in results between the two classes used. The experimental class showed more learning outcomes after being given treatment compared to the control class. GBL structured in such a way is not only concerned with the fun aspect but can also improve students' skills, especially CT. Therefore, developing GBL media is a feasible media innovation to encourage students' CT in the classroom.

Although the GBL media developed showed that it could support the CT of junior high school students compared to conventional classes. This study has limitations, such as games that are only used on specific operating systems, subjects, grade levels, and development research models are encountered. Suggestions for further research can change the CT components used and the role of students in becoming game designers and examine how students behave when playing more deeply.

Acknowledgments

Thanks to the Master's Programme in Educational Technology, Sebelas Maret University, Surakarta, for the support to complete this research.

References

Acosta-Medina, J. K., Torres-Barreto, M. L., & Cárdenas-Parga, A. F. (2021). Students' preference for the use of gamification in virtual learning environments. *Australasian Journal of Educational Technology*, *37*(4), 145–158. https://doi.org/10.14742/ajet.6512

Akkaya, S., & Kapıdere, M. (2021). How do digital games utilization levels predict a teacher's digital material development self-efficacy? *World Journal on Educational Technology: Current Issues, 13*(2), 322-335. https://doi.org/10.18844/wjet.v13i2.5716

Al Fatta, H., Maksom, Z., & Zakaria, M. H. (2018). Game-based learning and gamification: Searching for definitions. *International Journal of Simulation: Systems, Science and Technology, 19*(6), 1-5. https://doi.org/10.5013/IJSSST.a.19.06.41

Al-Azawi, R., Al-Faliti, F., & Al-Blushi, M. (2016). Educational gamification vs. game-based learning: Comparative study. *International Journal of Innovation, Management and Technology, 7*(4), 132-136. https://doi.org/10.18178/ijimt.2016.7.4.659

Altanis, I., & Retalis, S. (2019). A multifaceted students' performance assessment framework for motion-based game-making projects with Scratch. *Educational Media International, 56*(3), 201-217. https://doi.org/10.1080/09523987.2019.1669876

An, Y. J., & Cao, L. (2017). The effects of game design experience on teachers' attitudes and perceptions regarding the use of digital games in the classroom. *TechTrends, 61*(2), 162-170. https://doi.org/10.1007/s11528-016-0122-8

Asbell-Clarke, J., Rowe, E., Almeda, V., Edwards, T., Bardar, E., Gasca, S., . . . Scruggs, R. (2021). The development of students' computational thinking practices in elementary-and middle-school classes using the learning game, Zoombinis. *Computers in Human Behavior, 115*, Article 106587. https://doi.org/10.1016/j.chb.2020.106587

Aslina, Y. R., Mulyanto, A., & Niwanputri, G. S. (2020). Designing "Bebras" Serious Games Interaction for Indonesian Upper Elementary School Students. In 2020 7th International Conference on Advance Informatics: Concepts, Theory, and Applications (ICAICTA), Japan. https://doi.org/10.1109/ICAICTA49861.2020.9429039

Branch, R. M. (2009). Instructional Design: The ADDIE Approach. Springer.

Bunt, B., & Gouws, G. (2020). Using an artificial life simulation to enhance reflective critical thinking among student teachers. *Smart Learn. Environ, 7*, 12. https://doi.org/10.1186/s40561-020-00119-6

Buss, A., & Gamboa, R. (2017). Teacher transformations in developing computational thinking: Gaming and robotics use in after-school settings. In *Emerging research, practice, and policy on computational thinking* (pp. 189-203). Springer. https://doi.org/10.1007/978-3-319-52691-1_12

Busuttil, L., & Formosa, M. (2020). Teaching Computing without Computers: Unplugged Computing as a Pedagogical Strategy. *Informatics in Education, 19*(4), 569-587. https://doi.org/10.15388/infedu.2020.25

Caeli, E. N., & Yadav, A. (2020). Unplugged approaches to computational thinking: A historical perspective. *TechTrends, 64*(1), 29-36. https://doi.org/10.1007/s11528-019-00410-5

Cansu, F. K., & Cansu, S. K. (2019). An overview of computational thinking. *International Journal of Computer Science Education in Schools, 3*(1), 17-30. https://doi.org/10.21585/ijcses.v3i1.53

Chan, S. W., Looi, C. K., & Sumintono, B. (2021). Assessing Computational Thinking Abilities Among Singapore Secondary Students: A Rasch Model Measurement Analysis. *Journal of Computers in Education, 8*(2), 213-236. https://doi.org/10.1007/s40692-020-00177-2

Chen, C. H., Law, V., & Huang, K. (2019). The roles of engagement and competition on learner's performance and motivation in game-based science learning. *Educational Technology Research and Development, 67*(4), 1004-1024. https://doi.org/10.1007/s11423-019-09670-7

Dagienė, V., Jevsikova, T., Stupurienė, G., & Juškevičienė, A. (2021). Teaching computational thinking in primary schools: worldwide trends and teachers' attitudes. *Computer Science and Information Systems, 19*(1), 1-24. https://doi.org/10.2298/CSIS201215033D

Dagienė, V., Sentance, S., & Stupurienė, G. (2017). Developing a Two-Dimensional Categorization System for Educational Tasks in Informatics. *Informatica, 28*(1), 23-44. https://doi.org/10.15388/Informatica.2017.119

Deng, W., Pi, Z., Lei, W., Zhou, Q., & Zhang, W. (2020). Pencil Code improves learners' computational thinking and computer learning attitude. *Computer Applications in Engineering Education, 28*(1), 90-104. https://doi.org/10.1002/cae.22177

Denning, P. J. (2017). Remaining trouble spots with computational thinking. *Communications of the ACM, 60*(6), 33-39. https://doi.org/10.1145/2998438

Ezeamuzie, N. O., & Leung, J. S. (2022). Computational thinking through an empirical lens: A systematic review of literature. *Journal of Educational Computing Research, 60*(2), 481-511. https://doi.org/10.1177/07356331211033158

Foster, A., & Shah, M. (2020). Principles for advancing game-based learning in teacher education. *Journal of Digital Learning in Teacher Education, 36*(2), 84-95. https://doi.org/10.1080/21532974.2019.1695553

Garneli, V., & Chorianopoulos, K. (2018). Programming video games and simulations in science education: exploring computational thinking through code analysis. *Interactive Learning Environments, 26*(3), 386-401. https://doi.org/10.1080/10494820.2017.1337036

Gouvea, J. S. (2023). Integrating Computation into Science Education. *CBE—Life Sciences Education*, *22*(3), fe2. https://www.lifescied.org/doi/abs/10.1187/cbe.23-05-0093

Gresse von Wangenheim, C., Araújo e Silva de Medeiros, G., Missfeldt Filho, R., Petri, G., da Cruz Pinheiro, F., Ferreira, M. N., & Hauck, J. C. (2019). SplashCode – A Board Game for Learning an Understanding of Algorithms in Middle School. *Informatics in Education, 18*(2), 259-280. https://doi.org/10.15388/infedu.2019.12

Grizioti, M., & Kynigos, C. (2021). Code the mime: A 3D programmable charades game for computational thinking in MaLT2. *British journal of educational technology, 52*(3), 1004-1023. https://doi.org/10.1111/bjet.13085

Guenaga, M., Eguíluz, A., Garaizar, P., & Gibaja, J. (2021). How do students develop computational thinking? Assessing early programmers in a maze-based online game. *Computer Science Education, 31*(2), 259-289. https://doi.org/10.1080/08993408.2021.1903248

Gyaurov, D., Fabricatore, C., & Bottino, A. (2022). Features of Entertainment Digital Games for Learning and Developing Complex Problem-Solving Skills: A Protocol for a Systemic Review. *International Journal of Qualitative Methods*, *21*. https://doi.org/10.1177/16094069221128491

Hartt, M., Hosseini, H., & Mostafapour, M. (2020). Game on: Exploring the effectiveness of game-based learning. *Planning Practice & Research, 35*(5), 589-604. https://doi.org/10.1080/02697459.2020.1778859

Haseski, H. İ., Ilic, U., & Tugtekin, U. (2018). Defining a New 21st Century Skill-Computational Thinking: Concepts and Trends. *International Education Studies, 11*(4), 29-42. https://doi.org/10.5539/ies.v11n4p29

Hooshyar, D., Malva, L., Yang, Y., Pedaste, M., Wang, M., & Lim, H. (2021). An adaptive educational computer game: Effects on students' knowledge and learning attitude in computational thinking. *Computers in Human Behavior, 114*, 106575, 1-13. https://doi.org/10.1016/j.chb.2020.106575

Hoover, A. K., Barnes, J., Fatehi, B., Moreno-León, J., Puttick, G., Tucker-Raymond, E., & Harteveld, C. (2016). Assessing computational thinking in students' game designs. In CHI PLAY Companion '16: Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts, USA. https://doi.org/10.1145/2968120.2987750

Hsu, T. C., Chang, S. C., & Hung, Y. T. (2018). How to Learn and How to Teach Computational Thinking: Suggestions Based on A Review of The Literature. *Computers & Education, 126*, 296-310. https://doi.org/10.1016/j.compedu.2018.07.004

Hurt, T., Greenwald, E., Allan, S. *et al.* (2023). The computational thinking for science (CT-S) framework: operationalizing CT-S for K–12 science education researchers and educators. *IJ STEM Ed, 10*, 1. https://doi.org/10.1186/s40594-022-00391-7

Israel-Fishelson, R., Hershkovitz, A., Eguíluz, A., Garaizar, P., & Guenaga, M. (2021). The associations between computational thinking and creativity: The role of personal characteristics. *Journal of Educational Computing Research, 58*(8), 1415-1447. https://doi.org/10.1177/0735633120940954

Jagušt, T., Krzic, A. S., Gledec, G., Grgić, M., & Bojic, I. (2018). Exploring different unplugged game-like activities for teaching computational thinking. In 2018 IEEE Frontiers in Education Conference (FIE), USA. https://doi.org/10.1109/FIE.2018.8659077

Juškevičienė, A., & Dagienė, V. (2018). Computational thinking relationship with digital competence. *Informatics in Education, 17*(2), 265-284. https://doi.org/10.15388/infedu.2018.14

Karagiorgas, D. N., & Niemann, S. (2017). Gamification and game-based learning. *Journal of Educational Technology Systems, 45*(4), 499-519. https://doi.org/10.1177/0047239516665105

Karakoç, B., Eryılmaz, K., Turan Özpolat, E., & Yıldırım, İ. (2020). The effect of game-based learning on student achievement: A meta-analysis study. *Technology, Knowledge and Learning, 27*, 207-222. https://doi.org/10.1007/s10758-020-09471-5

Krath, J., Schürmann, L., & Von Korflesch, H. F. (2021). Revealing the theoretical basis of gamification: A systematic review and analysis of theory in research on gamification, serious games, and game-based learning. *Computers in Human Behavior, 125*, Article 106963. https://doi.org/10.1016/j.chb.2021.106963

Kuo, W. C., & Hsu, T. C. (2020). Learning Computational Thinking Without a computer: How Computational Participation Happens in A Computational Thinking Board Game. *Asia-Pacific Education Researcher, 29*(1), 67-83. https://doi.org/10.1007/s40299-019-00479-9

Kynigos, C., & Grizioti, M. (2020). Modifying games with ChoiCo: Integrated affordances and engineered bugs for computational thinking. *British journal of educational technology, 51*(6), 2252-2267. https://doi.org/10.1111/bjet.12898

Lawanto, K., Close, K., Ames, C., & Brasiel, S. (2017). Exploring strengths and weaknesses in middle school students' computational thinking in scratch. In *Emerging Research, Practice, and Policy on Computational Thinking* (pp. 307-326). Springer. https://doi.org/10.1007/978-3-319-52691-1_19

Lee, S. J., Francom, G. M., & Nuatomue, J. (2022). Computer science education and K-12 students' computational thinking: A systematic review. *International Journal of Educational Research, 114*, 102008, 1-13. https://doi.org/10.1016/j.ijer.2022.102008

Leonard, J., Mitchell, M., Barnes-Johnson, J., Unertl, A., Outka-Hill, J., Robinson, R., & Hester-Croff, C. (2018). Preparing Teachers to Engage Rural Students in Computational Thinking Through Robotics, Game Design, and Culturally Responsive Teaching. *Journal of Teacher Education, 69*, 386-407. https://doi.org/10.1177/0022487117732317

Liao, C.H., Chiang, CT., Chen, IC. *et al.* (2022). Exploring the relationship between computational thinking and learning satisfaction for non-STEM college students. *Int J Educ Technol High Educ, 19*, 43. https://doi.org/10.1186/s41239-022-00347-5

López-Fernández, D., Gordillo, A., Alarcón, P. P., & Tovar, E. (2021). Comparing traditional teaching and game-based learning using teacher-authored games on computer science education. *IEEE Transactions on Education, 64*(4), 367-373. https://doi.org/10.1109/TE.2021.3057849

Lyon, J. A., & Magana, A. J. (2020). Computational thinking in higher education: A review of the literature. *Computer Applications in Engineering Education, 28*(5), 1174-1189. https://doi.org/10.1002/cae.22295

Nadolny, L., Alaswad, Z., Culver, D., & Wang, W. (2017). Designing with game-based learning: Game mechanics from middle school to higher education. *Simulation & Gaming, 48*(6), 814-831. https://doi.org/10.1177/1046878117736893

Plass, J. L., Mayer, R. E., & Homer, B. D. (2019). Handbook of Game-Based Learning. The MIT Press.

Qian, M., & Clark, K. R. (2016). Game-based Learning and 21st century skills: A review of recent research. *Computers in Human Behavior, 63*, 50-58. https://doi.org/10.1016/j.chb.2016.05.023

Shute, V. J., Sun, C., & Asbell-Clarke, J. (2017). Demystifying Computational Thinking. *Educational Research Review, 22*, 142-158. https://doi.org/10.1016/j.edurev.2017.09.003

Sun, L., Hu, L., & Zhou, D. (2022). Single or Combined? A Study on Programming to Promote Junior High School Students' Computational Thinking Skills. *Journal of Educational Computing Research, 60*(2), 283-321. https://doi.org/10.1177/07356331211035182

Taguchi, N. (2023). Game-based instruction of pragmatics: Learning request-making through perlocutionary effects. Language Learning & Technology, 27(1), 1–18. http://hdl.handle.net/10125/73519

Tang, X., Yin, Y., Lin, Q., Hadad, R., & Zhai, X. (2020). Assessing Computational Thinking: A Systematic Review of Empirical Studies. *Computers & Education, 148*, 1-22, Article 103798. https://doi.org/10.1016/j.compedu.2019.103798

Threekunprapa, A., & Yasri, P. (2020). Unplugged Coding Using Flowblocks for Promoting Computational Thinking and Programming among Secondary School Students. *International journal of instruction, 13*(3), 207-222. https://doi.org/10.29333/iji.2020.13314a

Troiano, G. M., Snodgrass, S., Argımak, E., Robles, G., Smith, G., Cassidy, M., . . . Harteveld, C. (2019). Is My Game OK Dr. Scratch? Exploring Programming and Computational Thinking Development via Metrics in Student-Designed Serious Games for STEM. In IDC '19: Proceedings of the 18th ACM International Conference on Interaction Design and Children, USA. https://doi.org/10.1145/3311927.3323152

UK Bebras. (2017). Bebras: A Perfect Day. Retrieved 21 July 2022 from https://www.bebras.uk/index.php?action=content&id=38

Utesch, M. C., Faizan, N. D., Krcmar, H., & Heininger, R. (2020). Pic2Program - an Educational Android Application Teaching Computational Thinking. In 2020 IEEE Global Engineering Education Conference (EDUCON), Portugal. https://doi.org/10.1109/EDUCON45650.2020.9125087

Wang, M., & Zheng, X. (2020). Using game-based learning to support learning science: a study with middle school students. *The Asia-Pacific Education Researcher, 30*(2), 167-176. https://doi.org/10.1007/s40299-020-00523-z

Weintrop, D., Holbert, N., Horn, M. S., & Wilensky, U. (2016). Computational thinking in constructionist video games. *International Journal of Game-Based Learning (IJGBL), 6*(1), 1-17. https://doi.org/10.4018/IJGBL.2016010101

Wing, J. (2011). Research notebook: Computational thinking—What and why. *The link magazine*, *6*, 20-23. https://people.cs.vt.edu/~kafura/CS6604/Papers/CT-What-And-Why.pdf

Wu, M. L. (2018). Educational Game Design as Gateway for Operationalizing Computational Thinking Skills among Middle School Students. *International Education Studies, 11*(4), 15-28. https://doi.org/10.5539/ies.v11n4p15

Yadav, A., Good, J., Voogt, J., & Fisser, P. (2017). Computational Thinking as an Emerging Competence Domain. *Competence-based Vocational and Professional Education*, 1051-1067. https://doi.org/10.1007/978-3-319-41713-4

Yadav, A., Stephenson, C., & Hong, H. (2017). Computational Thinking for Teacher Education. *Communications of the ACM, 60*(4), 55-62. https://doi.org/10.1145/2994591

Yuliana, I., Hermawan, H. D., Prayitno, H. J., Ratih, K., Adhantoro, M. S., Hidayati, H., & Ibrahim, M. H. (2021). Computational Thinking Lesson in Improving Digital Literacy for Rural Area Children via CS Unplugged. *Journal of Physics: Conference Series, 1720*(1), 012009. https://doi.org/10.1088/1742-6596/1720/1/012009

Żammit, J. (2022). Is mobile game-based learning effective for international adults learning Maltese?. *Asian. J. Second. Foreign. Lang. Educ,* 7, 29. https://doi.org/10.1186/s40862-022-00157-2

Zhao, W., & Shute, V. J. (2019). Can Playing a Video Game Foster Computational Thinking Skills? *Computers & Education, 141*, 1-13, Article 103633. https://doi.org/10.1016/j.compedu.2019.103633