Disciplinary integration of digital games for science learning

[1]Haidy A. Newer, [2]Aliaa M. Shalaby, [2]Farah A. Farouk, [2]Fatma I. El-dawy, [2]Mariam M. Sayed, [2]Mareen M. Gergis, and [2]Sara A. Abdel Aziz

[1]Department of Mathematics, Faculty of Education, Ain shams university, Cairo, Egypt
[2]Department of Science, Faculty of Education, Ain shams university, Cairo, Egypt

Abstract:
A better way to help students acquire information and skills is through game-based learning, which involves creating learning environments with digital or nondigital games. This study looks into how science learning and self-efficacy are affected by game-based learning in primary school. To compare the effects of digital and non-digital game-based learning, we ran an experiment. Our results show that scholars with the game-based learning organization finished notably higher on content tests and stated better self-efficacy than the conventional lecture organization. When observing science learning performance, no significant differences were found between Students in the digital game group had considerably stronger self-efficacy than those in the non-digital game group.

Keywords:
Digital game-based learning, Non-digital game-based learning, Self -efficacy, Egyptian primary school students, primary science learning.

1. Introduction:

The primary component of game-based learning is the use of games in education to help students acquire information and skills, (Qian and Clark 2016). Students must solve puzzles and accomplish tasks related to the course material while playing the game. According to earlier research (Yien et al. 2011; Lin et al. 2013), employing game-based learning in scientific education has favorable impacts. Researchers have generally looked at two categories of games: non-digital and digital. A game that is played on a computer, mobile device, or any other electronic device is referred to as a digital game. Digital games can help pupils study science more effectively, according to earlier research. For example, Sung and Hwang (2013) conducted an experiment including the integration of instructional computer games into primary school science classes and discovered that students' learning outcomes increased. Meluso et al. (2012) found significant improvements in science topic comprehension were shown in both collaborative and single-player situations. Non-digital games include any board, card, or other form of game that may be played in a physical setting

(Uzun et al. 2013). Non-digital games, unlike digital games, do not require electronic equipment and may be used in a variety of situations. Thus, Non-digital games are frequently utilized in STEM education and have been shown to improve learning outcomes (Mustafa et al. 2011; Liu and Chen 2013). Cook (2014) found that incorporating a role-playing game into chemistry classrooms helped students absorb science information about the chemistry of plastics. Another study utilizing Lego bricks to teach primary school kids science topics found that playing Lego cube increased both students' knowledge and problem-solving abilities (Li et al., 2016). Morris (2011) made a research using a card game to assist students remember chemical formulae and discovered that it efficiently enhanced learning. Although the effectiveness of employing educational games to help students learn has been studied in the past, few studies have compared the learning impacts of digital and non-digital games. Researchers made a comparison between standard educational methodologies and game-based learning. See Brom et al. (2011) and McLaren et al. (2017). The effects of the solitary player condition and the cooperative condition were compared in earlier studies on a particular game type, such as digital games (Chen et al., 2015; Chen and Law, 2016). However, little empirical study has been undertaken to compare the impact of digital and non-digital games on learning. Our study sought to determine if digital games had a greater impact on students' science learning than non-digital games (RQ). The purpose of this research was to look at how digital game-based learning affected primary school kids' scientific learning and self-efficacy in the process of learning . We conducted an experiment to assess the impact of digital versus non-digital game-based learning. The research questions that led to the study were as follows: 1. Do digital games outperform non-digital games in terms of student science learning? 2. Do students who play digital games have stronger self-efficacy than students who play non-digital games when learning about science?

Self-efficacy and game-based learning:

A great instructional game should have appropriate hurdles that offer pupils a feeling of self-efficacy. Self-efficacy is the belief that one is inherently capable of achieving one's goals. It demonstrates how confident pupils are in their capacity to control their own motivation, emotions, and behavior. Research has shown that learners with a high level of self-efficacy get higher learning results. The impact of game-based learning on students' self-efficacy has been studied by many researchers. For example, including computer games into science in schoolroom primary schools increased students' confidence in their ability to use computers for learning. discovered that role-playing games improved students' self- efficacy in performing health instruction in a study of nursing students utilizing schoolroom simulation. When contrasted to the conventional teacher-directed lecture technique, game-based learning can successfully increase students' self-efficacy in learning. Thus, effective integration of educational games into the classroom can enhance students' learning outcomes and sense of self-efficacy. Previous research indicates that when compared to standard lecture methods, game-based learning boosts students' self-efficacy in learning. There might be several benefits to educating through educational games. In contrast, little research has investigated how digital and non-digital games improve learners' self-efficacy. Although game-based learning methodologies may be used for both digital and non-digital games, the gameplay and gaming experience differ significantly.

Summary:

Game-based learning is to improve students' knowledge and skill development by creating learning environments with digital or non-digital games. According to earlier studies, students' performance or efficacy in learning was positively impacted by game-based learning. Additionally, game-based learning has been shown to increase students' learning efficacy. The majority of earlier research examined the benefits of game-based learning over traditional teaching methods, whether digital or analog games were used. Few people have compared the two categories of games. This study investigated how game-based learning affected the science knowledge and learning self-efficacy of Egyptian primary school pupils. To investigate the effects of digital and non-digital game-based learning, we performed an experiment.

2. Methods of research and the tools used:

Participants:

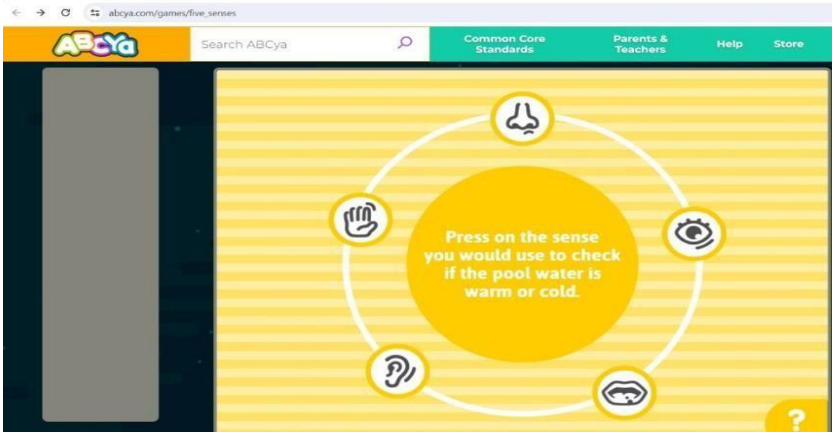
This research involved three classes of fourth-grade students from Cairo. At this primary school, the fourth grade was split into eight classrooms. In this research, selected at random three classes as research subjects, each with around 40 students (see Table 1), and we recruited 10 students from each class. The average age of students was between nine and ten years old. They all had some prior experience with game-based learning (approximately once or twice every term). In this study, the scientific concept taught to students was the Senses, which includes three major parts: (1) Identify the number of senses (2) Mention the five senses (3) Recognize the function of each senses.

Research design and procedures:

This research followed a Design experimentation. Students in the three classes had various educational techniques. (see Table 1). Students in class A utilized a digital game, whereas students in class B utilized a non-digital one. Class C served as a command group, utilizing the standard lecture style. The same instructor taught all three classes .The digital game by class A was called five senses. It is a free online website (see Fig.1) . This science game for students explore the concept of the five senses. Players see a brief introduction discussing the five senses. After the introduction, students are asked to identify the function of each sense. (Figure1. presents screen shots of five senses. In this study, students of class A played this game in class. The non-digital game utilized by class B was learn the five senses game from the Egypt Company Nilco. This game uses puzzles and other game tokens to teach your child about their five senses and what they do. (see Fig. 2).

Table 1: Groups and interventions

Natural class	**Class A**	**Class B**	**Class c**
Number of students	40	40	40
Type of game	Digital	Non-digital	Non



https://www.abcya.com/games/five_senses

Fig. 1 Screen shots of five senses game

Fig. 2 Nilco non digital game

The two games both have pictures about senses and information about the function of each sense. The fundamental idea of the two games is similar,the player needs to use a game card to reach the function of the senses. Both of these games are excellent for imparting scientific understanding about senses, including how the ear, nose, and eyes work. The method of obtaining information is the primary distinction between the two games. While the digital game Five Senses requires players to click on the appropriate sense, the non-digital game Nilco lets players discover the function by installing the puzzle. A control group also learned about the senses through conventional lecture instruction. The same teacher gave a 30minute class on the senses to each of the three student groups. Prior to class, students completed the pre-test. Second, the class began to be attended by pupils. The teacher spent around 10 minutes explaining the subject, learning objectives, and learning exercises, and game rules to the two game-based learning groups. Students then began to play the game and learn about the functions of the senses. The teacher offered assistance when needed during the game session. The teacher played the game with the students for about fifteen minutes, at which point they had a discussion about what they had learned and a summary of the course material. The instructor also spent roughly ten minutes outlining the subject, learning goals, and assignments regarding the functions of the senses for the control group, which was the traditional lecture group. The instructor next gave some illustrations of how senses work. Afterwards, the instructor gave a brief overview of the course material and spent ten minutes talking with the students about the role of the senses. Students took the post-test following class.

Measurements:

The test employed in this study served as an assessment tool. Because this research only focused on one subject, the senses, the assessment instrument was solely comprised of questions related to the concept it taking into consideration the individual differences between students, this study used a test to measure the efficiency of the method used. The test consists of a set of 15 questions about the explained concept “senses” -multiple choice, true or false, fill in the blank -Five of them are simple questions, seven intermediate questions, and three questions are advanced questions. One of the three questions is essay question to evaluate the self-efficacy. So, all the students of the three groups took the same test to assess the effectiveness that each method achieved, see Table 2.

Table 2: Achievements of the methods

Student’s score	**Achieving level of the method**
1:2 out of 15	Below Low achieving level
3:5 out of 15	Low achieving level
6:12 out of 15	Moderate achieving level
13:15 out of 15	Advanced achieving level

Results:

In this study 30 students took a test about the senses concept as mentioned before they all have the same test but they performed differently. when the results were collected from the students and compared to each other. It was found that the highest score percentage belonged to students of the (A) group. Show in (table 5). As for group (c), their results were lowest in the exam results, as shown in (table 4).

Table 3: Traditional lecturing group

Number of students	score	**Achieving level**
2 (20%)	1:2	Below Low achieving level
5 (50%)	3:5	Low achieving level
2 (20%)	6:12	Moderate achieving level
1 (10%)	13:15	Advanced achieving level

Table 4: non-Digital games group

Number of students	score	**Achieving level**
1 (10%)	3:5	Low achieving level
6 (60%)	6:12	Moderate achieving level
3 (30%)	13:15	Advanced achieving level

Table 5: Digital games group (A)

Number of students	score	**Achieving level**
1 (10%)	6:12	Moderate achieving level
9 (90%)	13:15	Advanced achieving level

Compared to traditional teaching methods, game-based learning methods have been shown to have positive effects on students' learning in science.

5. Discussion:

Based on game through, our results showed that that both groups were in a better position than the average conference group. This agrees with previous research findings. Many empirical research have demonstrated that students do better in game-based learning courses than in traditional lectures. According to constructivism, learning is more successful when new information is actively produced than when it is passively absorbed. This point of view holds that game-based learning creates an environment where students can improve their understanding of scientific subjects. Students use their knowledge to solve problems and complete tasks while they play games. Conventional lectures can cause students to learn passively and not acquire new information. to apply problem-solving techniques. In light of this, game-based learning fosters a learning environment where students can actively construct the meaning of scientific findings. Students must use what they have learned to overcome obstacles and solve problems when they are playing. On the other hand, most students at a lecture are passive learners who do not need to apply new information to solve issues. It follows that the lowest learning outcomes were attained by the traditional reading group. Our research also showed that there were no appreciable variations in students' scientific learning between the digital game group and the non-digital game group. According to the results, digital and non-digital game have similar positive effects on students' learning of scientific concepts. Whether a game is played on an electronic device is the primary way that digital and non-digital games differ from one another. The rules and content of a digital educational game could be the same as those of a non-digital one. The study found that the game material, laws, and other aspects of the non-digital Nilco senses game and the digital Five Senses game were remarkably similar. Therefore, it's likely that both exercises will be adequate to assist pupils in understanding and gaining the science concept of the senses. The effectiveness of digital and non-digital games is similar in this situation.

Implications:

Based on our results, We provide two suggestions for academics and educators who are interested in game-based learning: First, given the benefits of digital games, we urge that academics and educational game developers create and develop additional digital games to aid in the teaching of scientific information. Today, students and teachers have access to digital devices. As digital natives, students are used to using digital devices. Our results suggest that digital games can have a favorable impact on both students' academic performance and self-efficacy. Therefore, We believe that producing more digital games for scientific instruction would improve educational quality. Based on our findings, We offer two techniques to creating digital learning games. First, it is vital to provide kids with immediate feedback so that they may reflect on their play and learning. Second, digital games should have features for Automated data collecting and analysis, allowing teachers to monitor students' learning progress in the present moment. We believe that digital games with these elements can enhance scientific education and learning. Second, we advocate creating Educational development programs centered on incorporating instructional games into the classroom. In comparison with traditional education, game-based learning has several advantages, including increased student self-efficacy, improved academic achievement, and so on. However, instructors may lack expertise about how to incorporate game-based learning into their instruction. Incorporating educational games into lectures is difficult since it involves not just fundamental information but also understanding about games and how they might be integrated. That is why we feel that professional development programs for learning games are critical for instructors who intend to employ educational games. Ongoing professional development courses should focus on game-based learning to help teachers acquire the knowledge and skills needed to effectively introduce educational games into the classroom.

6. Conclusion:

To sum up, teaching science and assisting students' learning are greatly enhanced by game-based learning. Few studies have examined the differences in impacts between digital and non-digital games, despite prior studies reporting that game-based learning had favorable effects on students' learning performance and self-efficacy when compared to other methods. The impacts of game-based learning on scientific learning and learning self-efficacy among Egyptian primary school pupils were investigated in this study. Our goal is to determine how students' performance is affected by digital game-based learning through an experiment. Based on our findings, students in both digital and non-digital game groups engaged in game-based learning considerably outperformed the traditional lecture group in topic knowledge assessment and self-efficacy. Self-efficacy was substantially greater among the students in the digital gaming group than the non-digital group.

Future research directions:

This research has significant restricted. First and foremost, the sample was quite modest size. We had an average of 40 pupils in each class. We use a modest sample size to ensure that our study is sufficient; nonetheless, the applicability of our findings may be limited. In the future, we plan to duplicate our experiment in other schools with more children. Second, our trial focused just on one scientific idea and did not investigate the long-term consequences of other types of games. In this study, we looked at students' sensory learning and evaluated their learning and self-efficacy. However, if game-based learning is utilized to teach many scientific topics, the two types of games may have distinct impacts.

Reference:

Amineh, R. J., & Asl, H. D. (2015). Review of constructivism and social constructivism. Journal of Social Sciences, Literature and Languages, 1(1), 9–16.

Anseel, F., Lievens, F., & Schollaert, E. (2009). Reflection as a strategy to enhance task performance after feedback. Organizational Behavior and Human Decision Processes, 110(1), 23–35. https://doi.org/10.1016/j.obhdp.2009.05.003.

Bandura, A. (1994). Self-efficacy. In V. S. Ramachandran (Ed.), Encyclopedia of human behavior (Vol. 4, pp. 71–81). New York: Academic Press.

Berland, M. (2011). Understanding strategic boardgames as computational-thinking training machines. Tabletop analog game design (pp. 167–173). Pittsburgh: ETC Press.

Brom, C., Preuss, M., & Klement, D. (2011). Are educational computer micro-games engaging and effective for knowledge acquisition at high-schools? A quasiexperimental study. Computers & Education, 57(3), 1971–1988. https://doi.org/10.1016/j.compedu.2011.04.007.

Cardinot, A., & Fairfield, J. A. (2019). Game-based learning to engage students with physics and astronomy using a board game. International Journal of Game-Based Learning, 9(1), 42–57. https://doi.org/10.4018/IJGBL.2019010104.

Chen, C.-H., Wang, K.-C., & Lin, Y.-H. (2015). The comparison of solitary and collaborative modes of game-based learning on students' science learning and motivation. Educational Technology & Society, 18(2), 237–248.

Cook, D. H. (2014). Conflicts in chemistry: The case of plastics, a role-playing game for high school chemistry students. Journal of Chemical Education, 91(10), 1580–1586. https://doi.org/10.1021/ed4007277.

Dahlin, B., & Watkins, D. (2000). The role of repetition in the processes of memorizing and understanding: A comparison of the views of German and Chinese secondary school students in Hong Kong. British Journal of Educational Psychology, 70(1), 65– 84. https://doi.org/10.1348/000709900157976.

Dunning, D. (2011). The Dunning–Kruger effect: On being ignorant of one's own ignorance. In Advances in experimental social psychology (Vol. 44, pp. 247–296). New York: Academic Press.

Gao, H., He, W., Zhang, C., & Ren, L. (2016). Building scientific literacy in China: Achievements and prospects. Science Bulletin, 61(11), 871–874. https://doi.org/10.1007/s11434-016-1076-0.

Goldenberg, D., Andrusyszyn, M.-A., & Iwasiw, C. (2005). The effect of classroom simulation on nursing students' self-efficacy related to health teaching. Journal of Nursing Education, 44(7), 3-10.

Hamari, J., Shernoff, D. J., Rowe, E., Coller, B., Asbell-Clarke, J., & Edwards, T. (2016). Challenging games help students learn: An empirical study on engagement, flow and immersion in game based learning. Computers in Human Behavior, 54, 170–179. https://doi.org/10.1016/j.chb.2015.07.045.

Hung, C. M., Huang, I., & Hwang, G. J. (2014). Effects of digital game-based learning on students' self-efficacy, motivation, anxiety, and achievements in learning mathematics. Journal of Computers in Education, 1(23), 151–166. https://doi.org/10.1007/s40692-014-0008-8.

Johnson, C. I., & Mayer, R. E. (2010). Applying the self-explanation principle to multimedia learning in a computer-based game-like environment. Computers in Human Behavior, 26(6), 1246–1252. https://doi.org/10.1016/j.chb.2010.03.025.

Khan, A., Ahmad, F. H., & Malik, M. M. (2017). Use of digital game based learning and gamification in secondary school science: The effect on student engagement, learning and gender difference. Education and Information Technologies, 22(6), 2767–2804. https://doi.org/10.1007/s10639-017-9622-1.

Kiili, K. (2005). Digital game-based learning: Towards an experiential gaming model. The Internet and Higher Education, 8(1), 13–24. https://doi.org/10.1016/j.iheduc.2004.12.001.

Li, Y., Huang, Z., Jiang, M., & Ting-Wen, C. (2016). The effect on pupils' science performance and problem-solving ability through Lego: An engineering design-based modeling approach. Journal of Educational Technology & Society, 19(3), 143–156.

Liang, L. L., Liu, X., & Fulmer, G. W. (Eds.). (2017). Chinese science education in the 21st century: Policy, practice, and research. Dordrecht: Springer. https://doi.org/10.1007/978-94-017-9864-8

Lin, C. H., Liu, E. Z. F., Chen, Y. L., Liou, P. Y., Chang, M., Wu, C. H., et al. (2013). Game-based remedial instruction in mastery learning for upper-primary school students. Journal of Educational Technology & Society, 16(2), 271–281.

Liu, E. Z. F., & Chen, P. K. (2013). The effect of game-based learning on students' learning performance in science learning-A case of ''conveyance go''. Procedia-Social and Behavioral Sciences, 103, 1044–1051. https://doi.org/10.1016/j.sbspro.2013.10.430.

Lu, Y. L., & Lien, C. J. (2019). Are they learning or playing? Students' perception traits and their learning self-efficacy in a game-based learning environment. Journal of Educational Computing Research. https://doi.org/10.1177/0735633118820684.

McLaren, B. M., Adams, D. M., Mayer, R. E., & Forlizzi, J. (2017). A computer-based game that promotes mathematics learning more than a conventional approach. International Journal of Game- Based Learning (IJGBL), 7(1), 36–56. https://doi.org/10.4018/ IJGBL.2017010103.

Meluso, A., Zheng, M., Spires, H. A., & Lester, J. (2012). Enhancing 5th graders' science content knowledge and self-efficacy through game-based learning. Computers & Education, 59(2), 497–504. https://doi.org/10.1016/j.compedu.2011.12.019.

Mustafa, J., Khan, A., & Ullah, A. (2011). Investigating student's achievement in mathematics through non technological game based teaching. International Journal of Scientific Research in Education, 4(3–4), 151–164.

Naik, N. (2014). A comparative evaluation of game-based learning: Digital or nondigital games In European Conference on Games Based Learning (Vol. 2, p. 437). Academic Conferences International Limited. century skills: A review of recent research. Computers in Human Behavior, 63, 50–58. https://doi.org/10.1016/j.chb.2016.05.023.

Sung, H. Y., & Hwang, G. J. (2013). A collaborative game-based learning approach to improving students' learning performance in science courses. Computers & Education, 63, 43–51. https://doi.org/10.1016/j.compedu.2012.11.019.

Tan, P. H., Ling, S. W., & Ting, C. Y. (2007). Adaptive digital game based learning framework. In Proceedings of the 2nd international conference on Digital interactive media in entertainment and arts (pp. 142–146). New York: McGraw-Hill.

Uzun, L., Cetinavci, U. R., Korkmaz, S., & Salihoglu, U. M. (2013). Developing and applying a foreign language vocabulary learning and practicing game: The effect of Voicework. Digital Culture & Education, 5(1), 50–70.

Von Gillem, S., & Alaswad, Z. (2016). Games and game-based learning in instructional design. International Journal of Technologies in Learning, 23(4), 1–7.

Wang, S. Y., Chang, S. C., Hwang, G. J., & Chen, P. Y. (2018). A microworld-based role-playing game development approach to engaging students in interactive, enjoyable, and effective mathematics learning. Interactive Learning Environments, 26(3), 411–423. https://doi.org/10.1080/10494820.2017.1337038.

Yien, J. M., Hung, C. M., Hwang, G. J., & Lin, Y. C. (2011). A game based learning approach to improving students' learning achievements in a nutrition course. Turkish Online Journal of Educational Technology-TOJET, 10(2), 1–10.

Yukselturk, E., Altiok, S., & Baser, Z. (2018). Using game-based learning with Kinect technology in foreign language education course. Journal of Educational Technology & Society, 21(3), 159–173.