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The effect of a digital game-based learning strategy on students' self-efficacy to perform visual analytical reasoning tasks

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Abstract: Educational institutions are incorporating digital game-based learning (DGBL) as a supplementary teaching tool to improve the self-efficacy of students in mathematics and other subject areas. There is, however, a gap in the literature that addresses how to incorporate DGBL into the curriculum to improve students' self-efficacy to perform data tasks. The constructivist lens was utilized and adopted a quantitative pre-post design, rooted in self-efficacy and student-centered digital game-based learning theories. This paper presents the findings of a study that included n=174 respondents that investigated the effect that DGBL had on students' self-efficacy to perform data tasks. The research findings corroborate the hypothesis that students' self-efficacy was improved due to the use of digital game-based learning. The results revealed that using a digital game-based learning strategy impacted significantly students' self-efficacy profiles.

Keywords: self-efficacy, digital game-based learning, student-centered digital game-based learning, data visualization

Introduction

The Fourth Industrial Revolution is distinguished as being the blending of technologies that is smearing "the lines between the physical, digital, and biological spheres" (Xu, David & Kim, 2018:91). This has caused a national and international gap in data skills and individuals must upskill and reskill to become marketable in the employment sector. According to Harvard's Business Review, the most sought-after job of the 21st century is data science (Sajid, Haleem, Bahl, Javaid, Goyal, & Mittal, 2021). The U.S. Bureau of Labor Statistics noted that there will be an increase in the need for expertise in data science and by 2026, it will create 11.5 million job openings (Institute of Data, 2022). More specifically, there is a need for data visualization. Unwin (2020) simplified the definition of data visualization by noting, "of drawing graphic displays to show data (p.1)." Although it sounds simple on paper, there are individuals who struggle with the necessary confidence to learn this skill. Therefore, this intervention of a digital game to increase students' self-efficacy to learn about and perform data visualization tasks provides an alternative means of instruction for improving students' self-efficacy to perform data visualization tasks.

The aim of this research was to measure the effect of a digital game-based learning strategy to support visual analytical reasoning to improve students' self-efficacy to perform visual analytical reasoning with interactive box plots. This research sought to answer three questions:

- What were the self-efficacy levels of undergraduate respondent study respondents when asked to perform visual analytical reasoning with interactive box plots?
- What were the self-efficacy levels of undergraduate respondent study respondents when asked to learn academic topics with digital games?
- Does a digital game to support visual analytical reasoning improve the self-efficacy levels of undergraduate respondents to perform visual analytical reasoning with interactive box plots?

Literature Review

Theoretical frameworks are critical to the interpretation of empirical research on digital game-based learning. The theoretical frameworks for this research build upon the social constructivist learning theory and self-efficacy theory. Without the initial work of constructivist learning theory and the combination of student-centered learning and digital game-based learning, Student-Centered Digital Game-Based Learning (SCDGBL) would not exist. SCDGBL is the name given to the merging of student-centered learning techniques, which are practiced in primary and tertiary education (Thomas, 2021; Wright 2011), that incorporate digital video games as a learning tool instead of traditional techniques. Digital Game-Based Learning (DGBL) is the theory of how learning occurs through the use of primarily digital games (Becker, 2021). Student-centered learning focuses on the student first where the student is encouraged to participate in activities to learn information. Stewart (2021) further noted that pedagogies that arose from constructivist studies place an emphasis on "student-centered, active learning and the role of the teacher as facilitator. (p.11)". Furthermore, Murphy, Eduljee, and Croteau, (2021) also stated "the teacher is involved in the learning process and directs their learning" (p.2). An example is video games that include high activity levels, such as first-person-shooter games. They have been shown to increase a player's real-world vision. The ability to perceive changes in shades of grey improves up to 58 percent (University of Rochester, 2009). This is known as the 'Tetris effect,' which is a form of hypnagogic imagery that players experience from playing a game called Tetris. The 'Tetriminos,' which are shapes, stimulate a person's visual system to recognize low-level patterns. These patterns affect players initially while they are engaged in playing the game and continue on into their sleep (Stickgold, Malia, Maguire, Roddenbury, & O'Connor, 2000). Some even reported trying to mentally interlock real-world objects together while asleep (Earling, 1996).

Second, self-efficacy is described as a person's perceived capabilities to learn or perform behaviors at designated levels (Schunk & DiBenedetto, 2021). Sökmen, (2021:2) noted that there "is a strong relationship between self-efficacy and learner engagement," and Saeid & Eslaminejad (2017) asserted that individuals with high self-efficacy will work towards eliminating obstacles from their path while those with low self-efficacy will not even try. Hamann, Pilotti & Wilson (2021:3) further added that when preparing for an exam, students with low self-efficacy "are unlikely to believe that they have the ability to do well on the exam," whereas students with high self-efficacy may have more motivation to participate in self-regulatory actions because they hold the belief that those actions can lead them receiving what they desire. Instructors have a very important opportunity to positively impact their students' lives by teaching them the importance of not giving up and tackling tasks that seem difficult. The utilization of teaching materials that are wisely prepared can also increase self-efficacy (Tusianah, Sutarsyah, Sukirlan, Ridwan, Nurmalisa, Isnainy, Maydiantoro, Zainaro, & Puja Kesuma, 2021). Teachers play a vital role in shaping students' self-efficacy and have the ability to create and use a number of methods to create self-efficacy in their students (Toharudin, Rahmat, & Kurniawan, 2019). The Perceived Self-Efficacy Theory was developed to explain how individuals think about a situation, motivate themselves, act, and persist in conditions when they are presented with challenges and anxiety-provoking situations (Bandura & Adams, 1977). An individual's perceived self-efficacy is based on four dimensions:

- personal mastery experiences (comprised of successes and failures)
- vicarious experiences (comprised of watching others succeed so that it will strengthen the belief in the person and belief that they can succeed too),
- verbal persuasion (includes feedback and encouragement from others),
- and emotional state (includes one's level of anxiety and stress).

The theory was developed to explain how people think, motivate themselves, behave, and persist in the face of challenges and anxiety-provoking situations (Bandura & Adams, 1977). This theory advances that individuals recognize their own behaviors and compare them to others to determine if they should alter their behavior based on social norms. A study conducted by Alfaiz, Hidayat, Yandri, Sari, Sendayu, Suarja, & Arjoni, (2021:6) noted that "individuals are capable of reconstructing and modifying every experience and knowledge they get, both direct experience and experience through observation processes".

Digital Game-Based Learning supports student learning

Digital game-based learning is characterized by how individuals learn through problem-solving or task completion through the use of devices such as tablets, cell phones, or computers (Chen & Tu, 2021). Well-designed games enable the player to experience competence, autonomy, and relatedness (Ryan, Rigby, & Przybylski, 2006). In game-based learning, continuous competence or self-efficacy is defined as an individual having the opportunity to control a situation based on their position (Hense & Mandl, 2014; Salen et al., 2004). According to Sadler, Romine, Stuart, & Merle‑Johnson's (2013), findings, even with teachers doubting the

effectiveness of gaming to support learning for students at lower academic levels, curricula that are game-based could support the learning of biological content for students who have various academic levels and may provide the most benefit to students who have lower academic levels.

The Student-Centered Digital Game-Based (SCDGB) Framework underpinned this study. The SCDGBL Framework is composed of DGBL and SCL that consists of five components that comprise a system. Each component has a selection of concepts from which to choose. A system process is an ordered set of decisions and actions that users navigate to complete a task using a machine (Koubek, Benysh, Buck, Harvey, & Reynolds, 2003.) The system is iterative with each concept moving into the next and is intertwined by its shared constructs. It is meant to provide a safe environment where players can practice skills as they solve problems while receiving feedback for improvement. Learners are encouraged to try and solve problems while knowing that they learn from each interaction with the system. The feedback is intended to be helpful and to steer the learners to the correct answer. It can be determined if the system works based upon the player's interaction (Koubek, Benysh, Buck, Harvey, & Reynolds, 2003). Safe practice, experiential learning, and interaction are the pillars upon which the theory of game-based learning stands. Learning through games allows students to experiment in non-threatening scenarios and acquire knowledge through practice and social interaction both with the environment and their peers.

Context of the study

For this study, particular components were selected from each of the concepts in the creation of the game by the author, You Deserve a Seat at the Table: Data Visualization Game. The goal of the game was to immerse learners in a learning experience to improve learners' self-efficacy to learn about performing data tasks to create visualizations using box plots, or if the learners already know how to create visualizations using box plots, increase their self-efficacy to apply the skills that they have already acquired. Only undergraduate Freshmen and sophomore students (first-year and second-year) were sampled and the study consisted included n=174 respondents. Of the 174 respondents, 29% (n=51) were male and 71% (n=123) were female. Of the 174 respondents, the majority of the respondents were female who participated in the study and were first-and second-year students. Specific games were applied in the study

Digital Game-Based Learning Strategy

For this research, an intervention of a DGBL strategy was designed to enhance students' self-efficacy to equip and empower them with reasoning skills to perform tasks to create data visualizations in preparation for an ever-changing global economic market. The objectives were:

- To determine undergraduate students' reported levels of self-efficacy when exposed to elements of visual-analytical informal inferential reasoning skills using box plots. (Students' Self-Efficacy to Perform Data Visualization Tasks);
- To measure the effect of the digital games used as a DGBL strategy to enhance students' self-efficacy to learn using box plots. (Digital Escape Room Game/ How Many Tries?);
- To determine undergraduate students' impostor traits when completing learning elements of visuo-analytical informal inferential reasoning skills using box plots. (Clance Impostor Phenomenon Scale)
- To determine the impact of motivational strategies employed in a DGBL strategy by undergraduate students to learn effectively. (Motivational Strategies to Learn Questionnaire)

The digital game-based learning intervention consisted of two digital games. The first game had seven questions with branching choices. The second game had two consisted of two sections: (1) answer the six questions on the website and (2) enter the number of attempts that it took for the player to answer all the questions correctly on a Google Form.

The first game focused on building self-efficacy and overcoming self-doubt to learn about visual analytical reasoning using box plots. The second digital game focused on practicing how to solve problems using box plots for data visualizations.

The first digital game entitled You Deserve a Seat at the Table used a Google form set to quiz mode to allow respondents to move through four levels to ascend to the highest level of attainment. The four levels correspond to four dimensions of perceived self-efficacy (Bandura,1977) which are:

1. Personal mastery experiences
2. Vicarious experiences

3. Verbal persuasion

4. Emotional State

On each of these levels, respondents were asked questions about their self-beliefs regarding learning about box plots and data visualizations. Respondents were given branching choices to determine if they would ascend to the next level. Based on the choice selected, they would either move ahead if they selected the correct choice. If they selected the incorrect choice, they were sent to another section of the game that encouraged them that they could learn the material and redirected them back to the same question to try again by selecting another choice. This would occur until the respondent chose the correct answer which affirmed that they could learn about visual analytical reasoning using box plots.

Methodology

For this exploratory study, a quasi-experimental design (pre- and post-test) was used in response to the research questions. This quasi-experiment Used the dependent variable to be tested before and after an intervention. The study was conducted at a small, private historically Black university located in the southeastern part of the United States. Freshmen and sophomore students enrolled in introductory courses participating in their classroom sessions during the second portion of Phase 1. Of the number of students who were selected to participate, 174 students participated with no regard for gender or major and were selected at random to control for bias.

Data Collection (Phase 1)

The research was conducted using an online platform during the first semester of the academic school year. The study was conducted with structured questionnaires using Likert scales as well as closed-ended questionnaires. Five assessments were administered to both the control and treatment groups, four of them had pre- and post-tests and one, the motivation assessment, only had a pre-test. Only the treatment group received the intervention of two digital games.

The second part of Phase 1 included students enrolled in introductory courses which included two Mathematics classes, one Biology class, and two Freshman Seminar classes. Students in the two Mathematics classes were randomly assigned to a control and experimental group and the students in the Biology and Freshmen Seminar classes were placed in treatment groups using convenience sampling. Professors administered the assessments on the days that the classes were in session in sequential order. Students were administered a combination of three pre-assessments and one pre-test. Students were given the Motivations for Student Learning Questionnaire (MSLQ) to determine their motivations for learning and to inform which game elements to use in the two digital games based on their motivations. The first game entitled You Deserve a Seat at The Table focused on improving students' self-efficacy to learn about visual analytical tasks. The second game is entitled *How Many Tries?* focused on performing visualization tasks. Following the assessments and intervention, a questionnaire was administered to a small number of respondents in the treatment group concerning both games.

Data Analysis and Design (Phase 2 and Phase 3)

A statistical test, box plots, was computed to examine the differences in students' responses due to their demographic backgrounds (Phase 2). Based on the analysis results, a game-based learning intervention was designed (Phase 3). During Phase 1, respondents were given the first assessment to determine students' levels of perceived self-efficacy to perform visualization tasks using box plots. The second assessment was the Motivation Survey (MSLQ) which was used to determine students' motivation to learn. The third assessment was the Clance Impostor Phenomenon Scale (CIPS) to determine if students had impostor tendencies that may affect their ability to learn about and perform data visualization tasks using box plots. Finally, students were given a pre-test to measure their prior knowledge relative to performing data visualization tasks using a box plot. During Phase 2, the data from the MSLQ survey was analyzed to determine which game elements to use in the two digital games during the intervention. Data from the participants' pre- and post-tests were analyzed as well. They included the perceived self-efficacy assessments, box plot tests, and the Clance Impostor Phenomenon Scale assessments.

During Phase 3, an intervention was designed based on the results emerging from the analysis in Phase 2, which consisted of two digital games and the reading of an article. The first game entitled *You Deserve a Seat at The Table* was played during round one and focused on impacting students' self-efficacy to learn about and perform

data visualisation tasks using box plots. Respondents were then instructed to visit a website (https://bit.ly/artboxplots301je1f) to learn about box plots. They were instructed to read the information so they could apply the knowledge to the second game. The second game is entitled *How Many Tries?* Allowed respondents to practice their skills. It was played in round two and encouraged respondents to answer questions about box plots on the website until they answered each question correctly. Respondents were instructed to reread the article on box plots to assist them in answering the questions. Respondents were instructed to use the Google form entitled How Many Tries? to list the number of tries it took to answer all questions correctly.

Phase 4: Effects of Intervention of Digital Game-based Learning:

After the intervention, three post-tests were conducted to reveal students' scores on their self-efficacy, impostor phenomenon traits, and box plots knowledge. A post-test on motivation was not administered as it was only necessary to determine which game elements to use in the study. During Phase 4, each student completed a post-test about their current knowledge of box plots. The final phase also included a focus group discussion, where students were asked to answer closed-ended questions about the two digital games.

Measures for Reliability, Validity, and Data Triangulation Trustworthiness

The researcher ensured reliability, validity, and trustworthiness by using instruments that are valid and reliable based on the confidence in truth of the literature. Questionnaires and surveys were tested (Cronbach alpha coefficient, $\alpha = .7$) and retested for reliability to ensure that the questions measured what they were intended to measure (Cronbach, 1951). The overall reliability of the four instruments was 0.86 which means it was highly reliable. The constructivist lens believes in "contextualized (e.g., sensitive to place and situation) perspectives and relies on trustworthiness which refers to dependability, transferability, authenticity and credibility" (Creswell & Miller, 2000:125). Reliability refers to consistency that can be measured over a period of time using similar samples (Cohen, Manion & Morrison, 2007). Data triangulation can enhance the validity of research as it includes collecting data from various sources in an effort to attain different views of the phenomena being studied (Cohen & Manion,1997).

Ethical Considerations

The researcher aimed to conduct the research ethically taking into account the respondents' well-being and minimizing the risk of harm. The researcher obtained informed consent from the University of South Africa (UNISA) (reference number 2021/11/10/69969051/14/AM) and the university (reference number 00772). Respondents were assured of anonymity and confidentiality and were offered the right to withdraw. In this research study, the critically important ethical standards were enforced by providing clear instructions about the procedures of the research and were informed that information would be kept confidential. The respondents were also informed that the information obtained would be kept on a password-protected computer. Furthermore, the respondents were informed in writing about the objectives of the study. After potential respondents received the information, they were requested to sign the consent forms.

Findings

There were 124 respondents (n=124) who took the self-efficacy pre-test and 53 respondents (n=53) who took the self-efficacy post-test. Based on the data presented in the above table, the mean scores for self-efficacy tests (SE pre-test =28.30; SE Post-Test =29.45) show a difference of 1.15. There is an increase in the mean scores and the reliability ($\alpha < 0.91$) SE test is highly reliable completed by the respondents.

Data Collection (Phase 1)

The research was conducted using an online platform during the first semester of the academic school year. The study was conducted with structured questionnaires using Likert scales as well as closed-ended questionnaires.

Data Analysis and Design (Phase 2)

Descriptive statistics, the box plots analysis, was computed to examine the differences in students' responses due to their demographic backgrounds and games played (Phase 2). This section describes the mean differences in the self-efficacy scores for respondents who played one game, game games or no game.

No game

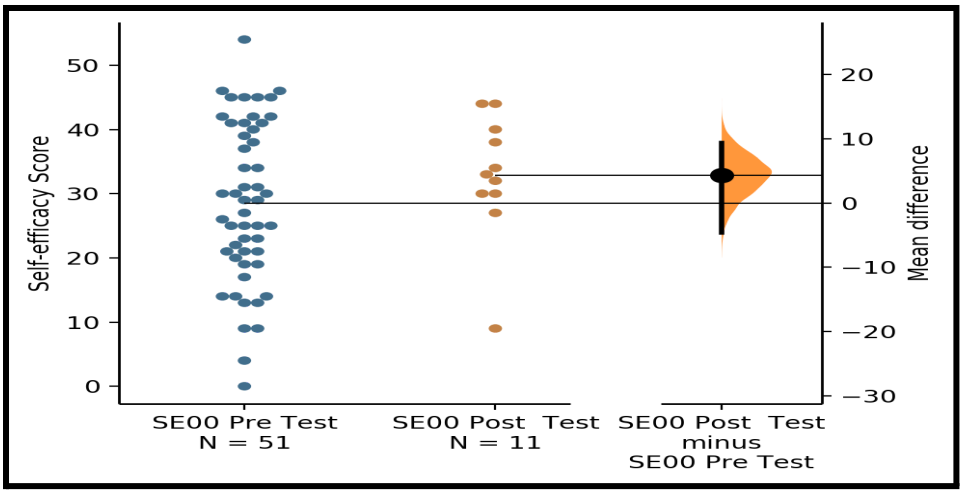

Figure 3: The estimation plot for respondents who did not play either of the games

Figure 1 shows the estimation plot for respondents who did not play either of the games. The unpaired mean difference between SE00 pre-test and SE00 post-test is 4.27. The P value of the two-sided permutation t-test is 0.295 and has a confidence interval of 95%. The effect size is 4.27. The score values ranged from -4.68 and 9.41. A total of n=51 respondents took the SE00 pre-test and n=11 respondents took the SE00 post-test. The respondents who took the SE00 pre-test had a higher mean score than the respondents who took the SE00 post-test. There is a positive effect (effect size 4.27) for respondents who did not play either of the games.

First game only

Figure 4 shows the estimation plot for respondents who played the first game only. The unpaired mean difference between SE10 pre-test and SE10 post-test is 3.55. The P value of the two-sided permutation t-test is 0.511 and has a confidence interval of 95%. The effect size is 3.55. The score values ranged from -5.62 and 12.3.

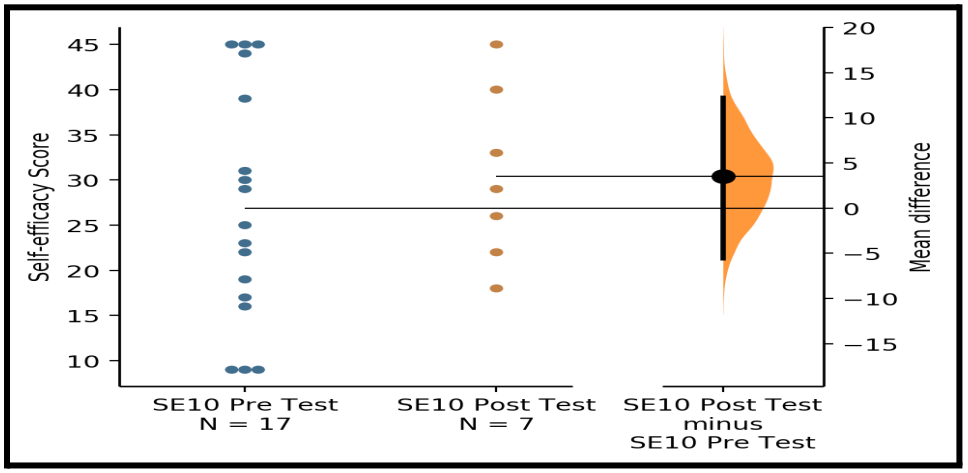

Figure 2: The estimation plot for respondents who played the first game only

A total of n=17 respondents took the SE10 pre-test and n=7 respondents took the SE10 post-test. The respondents who took the SE10 post-test had a higher mean score than the respondents who took the SE10 pre-test. There is a positive effect (effect size 3.55) for respondents who did not play either of the games.

Second game only

Figure 3 shows the estimation plot for respondents who played the second game only. The unpaired mean difference between SE01 pre-test and SE01 post-test is 1.38. The P value of the two-sided permutation t-test is 0.837 and has a confidence interval of 95%. The effect size is 1.38. The score values ranged from -9.86 and 7.81.

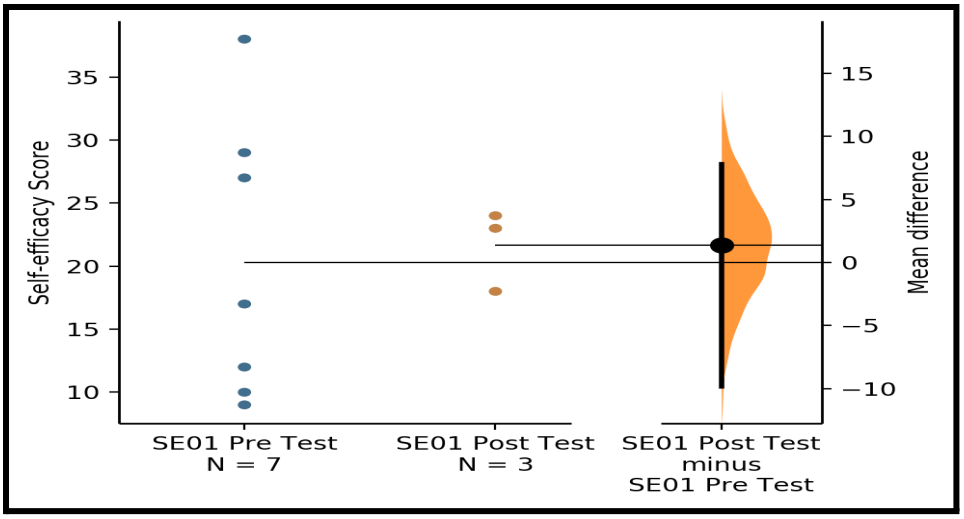

Figure 3: The estimation plot for respondents who played the second game only

A total of n=7 respondents took the SE01 pre-test and n=3 respondents took the SE01 post-test. The respondents who took the SE01 post-test had a higher mean score than the respondents who took the SE01 pre-test. There is an increase in the mean difference for the post-tests. There is a positive effect (effect size 1.38) for respondents who did not play either of the games.

Both games

Figure 4 shows the estimation plot for respondents who played both games (11). The unpaired mean difference between SE11 Pre-Test and SE 11 Post-Test is -0.735. The P value of the two-sided permutation t-test is 0.781 and has a confidence interval of 95%. The effect size is -0.735. The score values ranged from -6.09 and 4.18.

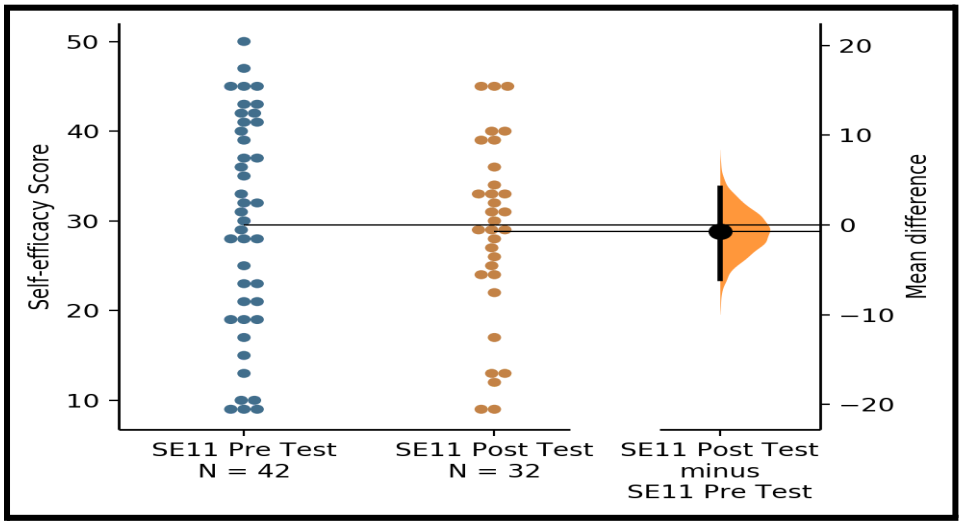

Figure 4: The estimation plot for respondents who played both games

A total of n=42 respondents took the SE11 pre-test and n=32 respondents took the SE11 post-test. The respondents who took the SE11 post-test had a lower mean score than the respondents who took the SE11 pre-test. There is a decrease in the mean difference for the SE11 post-test. There is a negative effect (effect size -0.735) for respondents who played both games.

Data Analysis and Design (Phase 3)

t-Test for three test scores

The paired-sample t-test was performed by comparing the pre-test and post-test scores of the three different tests for 174 respondents. The scores showed a statistically significant difference between the pre-test and post-test in two of the tests.

Table 1: Computed t-tests for the three instruments

Paired Differences					t-test	df	Significance
Mean	Std. Deviation	Std Error	95% Confidence Interval of the Difference				One-Sided p
			Lower	Upper			
23.54	8.31	1.58	-5.95	17.84	0.17	156	0.01*
24.87	9.01	1.53					
28.30	12.39	2.63	-7.99	16.75	0.25	175	0.01*
29.45	9.88	2.34					
56.28	13.70	2.52	-13.84	2.55	0.09	144	0.13
53.04	13.98	2.49					

Note: t-test $p > 0.05$

Based on the information in Table 1, a statistically significant test result ($P \leq 0.05$) showed that the one-sided tailed test for both Test 1 ($p < 0.01$) and Test 2 ($p < 0.01$) are accepted but Test 3 is rejected.

Three Test Scores

This table shows the pre-tests and post-tests, mean, median, and mode scores. It also shows that the standard deviation and Cronbach's Alpha for the three instruments were highly reliable.

Table 2: Respondents' results pertaining to three tests scores

	Groups	N	Mean	Median	Mode	Std. Deviation	Cronbach's Alpha
Test 1	Pre-test Box Plot Test	88	23.54	24	23	8.31	0.81
	Post-test Box Plot Test	70	24.87	27.5	34	9.01	
Test 2	Pre-test Self-efficacy Test	124	28.30	29	45	12.39	0.91
	Post-test Self-efficacy Test	53	29.45	30	33	9.88	
Test 3	Pre-test Clance Impostor Phenomenon Test	94	56.28	57	45	13.70	0.90
	Post-test Clance Impostor Phenomenon Test	52	53.04	56	58	13.98	

Note: These were applied Test 1 = Box Plots, Test 2 = Self-efficacy, and Test 3 = Impostor Phenomenon
*Cronbach's alpha coefficient, $\alpha = 0.7$

Based on the computations in Table 2 determining the reliability of the tests applied in this study, the alpha coefficient for the four items is ranging from .81; .91 and .90 respectively, suggesting that the tests have relatively high internal consistency. Note that a reliability coefficient of .70 or higher is considered "acceptable" in most social science research situations.

The Box Plot test (BP)

There were 88 respondents (n=88) who took the box plot pre-test and 70 respondents (n=70) who took the box plot post-test. The mean score for the pre-test was 23.54 and the mean score for the post-test was 24.87. Based on the data presented in the above table, the mean scores for box plots tests (BP pre-test =23.54; BP Post-Test =24.87) show a difference of 1.33. There is an increase in the mean scores and the reliability ($\alpha < 0.81$) for the BP test completed by the respondents.

Self-efficacy test (SE)

There were 124 respondents (n=124) who took the self-efficacy pre-test and 53 respondents (n=53) who took the self-efficacy post-test. Based on the data presented in the above table, the mean scores for self-efficacy tests (SE pre-test =28.30; SE Post-Test =29.45) show a difference of 1.15. There is an increase in the mean scores and the reliability ($\alpha < 0.91$) SE test is highly reliable completed by the respondents.

Discussion

First, the results of the study showed that undergraduate students, who were exposed to visual-analytical reasoning skills using box plots, performed significantly well in their self-efficacy. Therefore, the self-efficacy scores showed an increase in the mean difference post-test scores (SE pre-test =28.30; SE Post-Test =29.45) which is a difference of 1.15. There is an increase in the mean scores for the participants' self- efficacy and the reliability ($\alpha < 0.91$) of the SE test is highly reliable that was completed by the respondents. This has a positive effect and demonstrates that after respondents engaged with the DGBL intervention, their mean self-efficacy test scores increased. Based on the empirical findings for the self-efficacy test, scholarly works confirmed that using box plots increased the performance of applying self-efficacy tests in the study. A study reported by Blanco et al. (2020) on the relationship between students' self-confidence and self-efficacy while learning online during the COVID-19 pandemic, found a high correlation between self-confidence and self-efficacy and recommend that schools establish policies that will "augment students' self-confidence and self-efficacy levels to guarantee optimal learning outcomes" (Blanco et al., 2020:16). The findings of this study point to the need for an intervention to improve students' self-efficacy to perform tasks. This instrument can be used in similar studies. A further study confirmed similar results by Alfaiz et al., (2021:6) who used a self-efficacy awareness test for career readiness and noted that "individuals are capable of reconstructing and modifying every experience and knowledge they get, both direct experience and experience through observation processes." In conclusion, the findings reveal that students that were exposed to elements of visuo- analytical informal inferential reasoning skills using box plots, showed an increase in the mean difference post-tests. This has a positive effect and demonstrates that after respondents engaged with the DGBL intervention, their mean self-efficacy test scores increased.

Second, the effect of the digital games used as a DGBL strategy to enhance students' self-efficacy to learn using box plots showed significant changes in scores. The results reported demonstrate that the students who participated in the digital games using a DGBL strategy enhanced their self-efficacy scores in learning using box plots activities in the study. This was another positive effect of the DGBL teaching strategy to increase students' self-efficacy levels. Hence, the empirical results revealed that a total of 8 out of 12 respondents (67%) stated that playing the DGBL on self-efficacy helped to increase respondents' confidence to learn how or to perform data visualization tasks. A research study by Erhel and Jamet (2013) found that digital game-based learning (DGBL) can be described in two categories: it can be a learning activity where learners compete in games to acquire knowledge and meet academic goals, or it can be a simulation where learners practice their skills in a virtual setting. Additionally, an undergraduate study reported that students can experience motivational benefits from using classroom economics games (van Wyk, 2013). There is a dearth of quasi-experimental research on the added value and the effectiveness of game-based learning (Vandercruysse et al., 2012, cf. 2.6; Tahir & Wang, 2022, et al., 2021) as well as the effect that digital game-based learning can have on students' self-efficacy to perform data visualizations. Other studies have focused on game-based learning and self-efficacy, but not as it relates to performing data visualizations (Punyasettro, & Yasri, 2021 conducted a study on self-efficacy to learn evolutionary biology and Wang and Zheng (2021:77) conducted a study on the effects of game-based learning on

Chinese middle school students' learning concerning science and the students' self-efficacy, cf. 2.6). It can be concluded that the findings in this empirical study uncovered that there is a positive effect size of playing a minimum of one game for unpaired groups of pre-and post-tests as it relates to improving respondents' self-efficacy, increasing their box plot scores and decreasing their impostor traits.

Third, undergraduate students' impostor traits had shown increases when completing learning elements of visual-analytical informal inferential reasoning skills using box plots. The results demonstrated that the students who participated in the digital games using a DGBL strategy had a decrease in their impostor traits. The results revealed that respondents' impostor trait scores decreased in the mean difference for the IP11 post-test. Consequently, there was a total of n=23 respondents who took the Clance Impostor Phenomenon (IP11) pre-test and n=33 respondents who took the Clance Impostor Phenomenon (IP11) post-test. There was a mean difference and effect size of 3.58. The scores ranged between -4.52 and 12.51. A total of 8 out of 12 respondents (67%) stated that playing the DGBL on self-efficacy helped to increase respondents' confidence to learn how or to perform data visualization tasks. A total of 10 out of 12 respondents stated that seeing a person of color helped to increase respondents' confidence to learn how or to perform data visualization tasks. This is 83% of the respondents who responded to the questionnaire. Overall, the respondents enjoyed the game. Academic studies determined that approximately 40% of Blacks and 50% of Hispanics who enroll in college will earn a degree yet, a large number of "successfully matriculating students may experience a sense of intellectual phoniness known as the impostor phenomenon (IP)" (Peteet, Montgomery & Weekes, 2015:1). Another study revealed that reduced self-confidence and self-efficacy have been cited as accompanying imposter tendencies (Dahvlig, 2013). Finally, the findings concluded that due to the Clance Impostor Phenomenon scores showing a decrease in the mean difference for the IP11 post-test, it has a positive effect. Respondents experienced high traits of feeling like impostors. After the intervention, respondents experienced fewer traits of feeling like impostors.

Finally, the motivational strategies employed by undergraduate students' had enjoyed and supported learning effectively. The results indicated that the motivational strategies of control, challenge, fantasy and curiosity were used to help respondents learn effectively. The results revealed that of the 44 questions listed on the motivational strategies for learning questionnaire (MSLQ), the questions yielded a similar response rate with a minimum of 80% game mechanics. The sentences included question numbers 8,14,23 and 43. These responses were used to determine which of the 4-game mechanics to use in the digital game-based learning strategy. Question number 8 stated "I expect to do well in this class" generated an average response of 6 and was paired with challenge as the game mechanic. Question number 14 stated "Even when I do poorly on a test, I try to learn from my mistakes" yielded an average response of 6.43 and was paired with control as the game mechanic. Question number 23 stated "When I study for a test, I try to put together the information from class and from the book. It had an average response score of 5.86 and was paired with curiosity as the game mechanic. The last question was number 43 which stated "I work hard to get a good grade even when I don't like a class" and had a response score of 5.86. It was paired with challenge as the game element. Scholarly works showed that digital games have the power to attract players because of the motivational factors that are built into their design (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012). Based on the study conducted by Asigigan and Samur (2021:47), the gamified STEM activities and contended that data acquired from the intrinsic motivation inventory and student interviews showed an increase in students' motivation and interest in the activities. Another article stated that outside of how people feel when they can classify "pursuing an activity as more like "fun" than "work," or as more like reaching (versus pursuing) a goal," one can infer that those individuals are intrinsically motivated to engage in an activity (Fishbach & Woolley, 2022:343). A student's level of motivation can be influenced by their curiosity. "Curiosity is the most direct intrinsic motivation for learning" (Ciampa, 2014:84). Lepper and Malone (1987) noted that intrinsic motivations that impact motivation are control, curiosity, challenge, and fantasy (Lepper & Malone, 1987). Furthermore, Kim & Lee (2015) included the four elements of intrinsic motivation curiosity, challenge, fantasy, and control in their dynamical model for gamification of learning (DMGL).

Based on the findings, academic works confirm that digital game-based learning elements improve students' motivation. GBL would wield a positive influence on intrinsic motivation. This stems from students being motivated by the learning activity itself because they construe it as fun and interesting (Gopalan, Bakar, Alwi, & Mat, 2017; Wouters & van der Meulen, 2020; cf. 2.5.1). Manzano-León, Camacho-Lazarraga, Guerrero, Guerrero-Puerta, Aguilar-Parra., Trigueros, & Alias, (2021:2) argued that "applying educational gamification promotes student participation in the classroom, especially if the game elements used in gamification have established objectives and rewards". In addition, several notable responses from the open-ended responses to question 11 in the online MSLQ questionnaire about motivational strategies of using game mechanics helped students to learn effectively. Many respondents wrote positively about how they had benefitted from the digital games played. They viewed the games as helpful to them to learn effectively. They echoed sentiments such as "fun learning experience with digital games". One respondent wrote: It was a great opportunity to be part of the

digital gaming sessions". This respondent said: "The Digital Escape Room Game was very insightful." Additionally, this respondent narrated that "The game helped reinforce concepts that I was already exposed to". Finally, this respondent alluded the "The game was fun, and it was informative. It also made me feel confident in my skills." Studies reported that emanating from EVT is the ARCS model of motivational design which was developed by John Keller to enhance the learning process by adding motivation (Malik, 2014). Pappas (2015) explained that the ARCS model has four dimensions: attention, relevance, confidence, and satisfaction that are utilized to design instruction. According to research by Aşıksoy and Özdamlı (2016:1591), the model is significant "in increasing the effectiveness of teaching conditions and is the only motivation model."

Furthermore, there are four conditions that must be met for individuals to become and remain motivated which include: (1) attention – it is necessary to acquire and maintain the learner's attention; (2) relevance – the instruction must be relevant to the learners present and/or future career opportunities; (3) confidence – it is important to incorporate strategies that build confidence in learners, and (4) satisfaction – it is imperative to foster experiences that cause learners to feel good about their accomplishments (Keller, 1987:3).

The results of the study showed that undergraduate students, who were exposed to visual-analytical reasoning skills using box plots, performed significantly well in their self-efficacy. Therefore, the self-efficacy scores showed an increase in the mean difference in post-test scores (SE pre-test =28.30; SE Post-Test =29.45) which is a difference of 1.15. There is an increase in the mean scores for the participants' self-efficacy and the reliability ($\alpha < 0.91$) of the SE test is highly reliable that was completed by the respondents. This has a positive effect and demonstrates that after respondents engaged with the DGBL intervention, their mean self-efficacy test scores increased. Based on the empirical findings for the self-efficacy test, scholarly works confirmed that using box plots increased the performance of applying self-efficacy tests in the study. A study reported by Blanco, Carlota, Nasibog, Rodriguez, Saldaña, Vasquez, & Gagani, 2020 on the relationship between students' self-confidence and self-efficacy while learning online during the COVID-19 pandemic, found a high correlation between self-confidence and self-efficacy and recommend that schools establish policies that will "augment students' self-confidence and self-efficacy levels to guarantee optimal learning outcomes" (Blanco et al., 2020:16). The findings of this study point to the need for an intervention to improve students' self-efficacy to perform tasks. This instrument can be used in similar studies. A further study confirmed similar results by Alfaiz, Hidayat, Yandri, Sari, Sendayu, Suarja, & Arjoni, 2021:6 who used a self-efficacy awareness test for career readiness and noted that "individuals are capable of reconstructing and modifying every experience and knowledge they get, both direct experience and experience through observation processes."

Conclusions

In conclusion, the findings reveal that students that were exposed to elements of visuo-analytical informal inferential reasoning skills using box plots, showed an increase in the mean difference post-tests. This has a positive effect and demonstrates that after respondents engaged with the DGBL intervention, their mean self-efficacy test scores increased.

Recommendations

The undergraduate students' reported levels of self-efficacy when exposed to elements of visuo-analytical informal inferential reasoning skills using box plots.

- Teachers, online facilitators, researchers, curriculum, and instructional designers should recognize the importance of self-efficacy when planning to teach elements of visuo-analytical informal inferential reasoning skills using box plots.
- It is important when planning to teach elements of visuo-analytical informal inferential reasoning skills using box plots to view self-efficacy as the first step in triggering learners' active contributions to their learning process.
- It is considered pertinent that teachers, online facilitators, researchers, curriculum and instructional designers make a willful decision to include game mechanics when teaching the elements of visual-analytical informal inferential reasoning skills using box plots to increase interaction and engagement in class thereby allowing for increased levels of participation and students' efficacy.
- Teachers, online facilitators, researchers, curriculum, and instructional designers must be cognizant of the fact that there needs to exist an adaptation phase that targets self-efficacy for learners prior to teaching the elements of visual-analytical informal inferential reasoning skills using box plots.

Limitations

This exploratory study revealed several limitations:

The sample size for the research design selected only a small number of respondents for the study and the findings can be generalized. The same self-efficacy instrument can be employed to a larger sample of final-year students which maybe yield different results. This is valuable and important issue for further research.

References

Alfaiz, A., Hidayat, H., Yandri, H., Sari, A.T.L., Sendayu, F.S., Suarja, S. & Arjoni, A., 2021. Identification of perceived self-efficacy to predict student's awareness in career readiness. *Islamic Guidance and Counseling Journal,* 4(1), 124-132. https://doi.org/10.25217/igcj.v4i1.933

Alqurashi, E. 2016. Self-efficacy in online learning environments: A literature review. Contemporary Issues in Education Research (CIER), 9(1):45-52.

Asigigan, S.İ. & Samur, Y., 2021. The Effect of Gamified STEM Practices on Students' Intrinsic Motivation, Critical Thinking Disposition Levels, and Perception of Problem-Solving Skills. *International Journal of Education in Mathematics, Science and Technology,* 9(2):332-352.

Aşıksoy, G. & Özdamlı, F. 2016. Flipped Classroom adapted to the ARCS Model of Motivation and applied to a Physics Course. *Eurasia Journal of Mathematics, Science and Technology Education*, 12(6):1589-1603. doi: 10.12973/eurasia.2016.1251a

Bandura, A., 1977. Self-efficacy: toward a unifying theory of behavioral change. Psychological Review, 84(2):191. doi: 10.1037//0033-295x.84.2.191.

Bandura, A., 1993. Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist,* 28(2):117-148.

Bandura, A. & Adams, N.E., 1977. Analysis of self-efficacy theory of behavioral Cognitive *Therapy and Research,* 1(4), 287-310. https://doi.org/10.1007/BF0 1663995

Becker, K., 2021. What's the difference between gamification, serious games, educational games, and game-based learning. *Academia Letters,* 209, pp.1-4.

Blanco, Q.A., Carlota, M.L., Nasibog, A.J., Rodriguez, B., Saldaña, X.V., Vasquez, E.C. & Gagani, F. 2020. Probing on the relationship between students' self-confidence and self-efficacy while engaging in online learning amidst COVID-19. *Journal La Edusci,* 1(4),16-25. https://doi.org/10.1016/j.teln.2021.03.001

Chen, C.C. & Tu, H.Y., 2021. The effect of digital game-based learning on learning motivation and performance under social cognitive theory and entrepreneurial thinking. *Frontiers in psychology,* 12:750711.

Ciampa, K. 2014. Learning in a mobile age: an investigation of student motivation. *Journal of Computer Assisted Learning,* 30(1), 82-96. doi: 10.1111/jcal.12036

Cohen, L., Manion, L. and Morrison, K., 2017. Validity and reliability. In Research methods in education (pp. 245-284). Routledge: London

Cohen, L., Manion L., & Morrison, K. 2007. Research methods in education. (6th ed.). London: Routledge.

Cohen, L & Manion, L. 1997. Research in education. (4th ed.). New York: Routledge.

Coleman, Thomas & Money, Arthur. (2020). Student-centred digital game–based learning: a conceptual framework and survey of the state of the art. 10.1007/s10734-019-00417-0.

Connolly, T.M., Boyle, E.A., MacArthur, E., Hainey, T., & Boyle, J.M. 2012. A systematic literature review of empirical evidence on computer games and serious games. *Computers & Education*, 59(2), 661–686. https://doi.org/https://doi.org/10.1016/j.compedu.2012.03.004connolly

Creswell, J.W. 2014. Research design: Qualitative, quantitative, and mixed methods approaches. Thousand Oaks, CA: Sage Publications

Creswell, J.W. & Miller, D.L. 2000. Determining validity in qualitative inquiry. *Theory into Practice,* 39(3), 124-130). https://doi.org/10.1207/s15430421 tip 39032

Cronbach, L.J. 1951. Coefficient alpha and the internal structure of tests. *Psychometrika,* 16(3), 297-334.

Crotty, M.J., 1998. The foundations of social research: Meaning and perspective in the research process. London: Routledge.

Earling A. 1996. The tetris effect: do computer games fry your brain? Philadelphia Citypaper. Available at: http://archives.citypaper.net/articles/ 032196/ ,article038.shtml

Erhel, S. & Jamet, E. 2013. Digital game-based learning: Impact of instructions and feedback motivation and learning effectiveness. *Computers & Education,* 67, 156-167. doi:10.1016/j.compedu.2013.02.019

Fishbach, A. & Woolley, K., 2022. The structure of intrinsic motivation. *Annual Review of Organizational Psychology and Organizational Behavior,* 9:339-363.

Gopalan, V., Bakar, J.A.A., Zulkifli, A.N., Alwi, A. & Mat, R.C. 2017, October. A review of the motivation theories in learning. In Aip conference proceedings (Vol. 1891 (1):020043). AIP Publishing LLC.

Hamann, K., Pilotti, M.A. & Wilson, B.M., 2021. What lies beneath: The role of self- efficacy, causal attribution habits, and gender in accounting for the success of college students. *Education Sciences,* 11(7):333.

Hense, J. & Mandl, H. 2014. Learning in or with games? In In Sampson, D.G., Spector, J.M., Ifenthaler, D., Isaias, P. (Eds.) Digital systems for open access to formal and informal learning (pp. 181-193). *Proceedings of the IADIS International Conference on Cognition and Exploratory Learning in the Digital Age* (pp.19-26) Madrid (Spain): IADIS.

Institute of Data, 2021. Data science job opportunities continue to grow in 2022. Accessed at: https://www.institutedata.com/blog/data-science-job-opportunities-in-2022/#:~:text=By%202026%2C%20the%20US%20Bureau % 20of%20Labor%20Statistics,not%20come%20as%20too%20much%20of%20a %20surprise.

Keller, J. M. 1987. Development and use of the ARCS model of instructional design. *Journal of Instructional Development,* 10(3), 2. https://doi.org/10.1007/ BF02905780

Kim, J.T. & Lee, W.H. 2015. Dynamical model for gamification of learning (DMGL). *Multimedia Tools and Applications,* 74:8483-8493.

Kivunja, C. & Kuyini, A.B. 2017. Understanding and applying research paradigms in educational contexts. *International Journal of Higher Education*, 6(5), 26-41. doi:10.5430/ijhe.v6n5p26

Koubek, R.J., Benysh, D., Buck, M., Harvey, C.M. & Reynolds, M. 2003. The development of a theoretical framework and design tool for process usability assessment. *Ergonomics,* 46(1-3):220-241.

Lepper, M. R. & Malone, T.W. 1987. Intrinsic motivation and instructional effective- ness in computer-based education. In R. E. Snow, & M. J. Farr (Eds.), *Aptitude, Learning and Instruction* (Vol. 3:255-285). Hillsdale, NJ: Erlbaum.

Malik, S. 2014. Effectiveness of ARCS model of motivational design to overcome non-completion rate of students in distance education. *Turkish Online Journal of Distance Education,* 15(2):194-200. DOI: 10.17718/tojde.18099

Manzano-León, A., Camacho-Lazarraga, P., Guerrero, M.A., Guerrero-Puerta, L., Aguilar-Parra, J.M., Trigueros, R. and Alias, A., 2021. Between level up and game over: A systematic literature review of gamification in education. *Sustainability,* 13(4):2247.

Miller, S. & Hughes, D. 2017. The quant crunch: How the demand for data science skills is disrupting the job market. Business Higher Education Forum. https://www.bhef.com/publications/quant-crunch-how-demand-data-science- skills-disrupting-job-market

Murphy, L., Eduljee, N.B. and Croteau, K., 2021. Teacher-centered versus student- centered teaching: Preferences and differences across academic majors. *Journal of Effective teaching in Higher education,* 4(1):18-39.

Panhwar, A.H., Ansari, S. and Shah, A.A., 2017. Post-positivism: An effective paradigm for social and educational research. I*nternational Research Journal of Arts and Humanities,* 45(45):.253-259.

Pappas, C., 2015. Instructional design models and theories: Keller's ARCS model of motivation. *Pridobljeno*, 18(9):2017. https://elearningindustry.com/arcs-model- ofmotivation

Pintrich, P.R., Smith, D.A., Garcia, T. & McKeachie, W.J. 1993. Reliability and predictive validity of the Motivated Strategies for Learning Questionnaire (MSLQ). *Educational and Psychological Measurement,* 53(3), 801-813.

Punyasettro, S. & Yasri, P., 2021. A Game-Based Learning Activity to Promote Conceptual Understanding of Chordates' Phylogeny and Self-Efficacy to Learn Evolutionary Biology. *European Journal of Educational Research,* 10(4):1937-1951.

Ryan, R.M., Rigby, & Przybylski, A., 2006. The motivational pull of video games: A self-determination theory approach. *Motivation and Emotion,* 30, pp.344-360.

Saeid, N. & Eslaminejad, T. 2017. Relationship between student's self-directed-learning readiness and academic self-efficacy and achievement motivation in students. *International Education Studies,* 10(1), 225-232. http://dx.doi.org /10.5539/ies.v10n1p225

Sajid, S., Haleem, A., Bahl, S., Javaid, M., Goyal, T. & Mittal, M., 2021. Data science applications for predictive maintenance and materials science in context to Industry 4.0. Materials Today. *Proceedings,* 45, 4898-4905. DOI:10.1016/J.MATPR.2021.01.357

Salen, K., Tekinbaş, K.S., & Zimmerman, E. 2004. Rules of play: Game design

fundamentals. Cambridge, Maaa.: MIT press.

Schunk, D.H. & DiBenedetto, M.K., 2021. Self-efficacy and human motivation. In Advances in motivation science (Vol. 8:153-179). Elsevier.

Sökmen, Y., 2021. The role of self-efficacy in the relationship between the learning environment and student engagement. *Educational Studies,* 47(1):19-37.

Stewart, M., 2021. Understanding learning: Theories and critique. In University teaching in focus (pp. 3-28). Routledge.

Stickgold R., Malia A., Maguire D., Roddenbury D. & O'Connor M. 2000. Replaying the game: hypnagogic images in normals and amnesics. *Science* 290, 350–353 10.1126/science.290.5490.350

Thomas E.C. 2021. Student centred digital game-based learning. Doctoral dissertation: Brunel University London.

Toharudin, U., Rahmat, A. and Kurniawan, I.S. 2019, February. The important of self-efficacy and self-regulation in learning: How should a student be? *Journal of Physics: Conference Series,* 1157(2), 022074. DOI:10.1088/1742-6596/1157/ 2/022074

Tusianah, R., Sutarsyah, C., Sukirlan, M., Ridwan, R., Nurmalisa, Y., Isnainy, U.C., Maydiantoro, A., Zainaro, M.R. & Puja Kesuma, T.A.R., 2021. An Integrative Review of Self-efficacy: What Factors Enhance and Impair It?. *WSEAS Transactions on Business and Economics,* 18:1057-1072.

Unwin, A., 2020. Why is data visualization important? what is important in data visualization?. *Harvard Data Science Review,* 2(1):1.

Van Wyk, M.M. 2013. The use of economic games as a participative teaching strategy to enhance student learning. *Journal of Social Sciences,* 35(20), 125-133. DOI: 10.1080/09718923.2013.11893153

Wright, G.B. 2011. Student-centered learning in higher education. *International Journal of Teaching and Learning in Higher Education,* 23(1), 92-97. http://www.isetl.org/ijtlhe/

Wouters, P. & Van Der Meulen, E.S. 2020. The role of learning styles in game- based learning. *International Journal of Game-Based Learning* (IJGBL), 10(1):54-69.

Xu, M., David, J.M. & Kim, S.H. 2018. The fourth industrial revolution: Opportunities and challenges. *International Journal of Financial Research,* 9(2):90-95. https://doi.org/10.5430/ijfr.v9n2p90

Zheng, P. & Leung, L. 2016. Linking psychological attributes, gratifications and social networking site use to social capital of the net generation in China. *International Journal of Cyber Behavior, Psychology and Learning,* 6(3), 17-

33. doi:10.4018/ijcbpl.2016070102