Advances in Science, Technology and Engineering Systems Journal Vol. 6, No. 4, 368-375 (2021)

www.astesj.com

Special Issue on Innovation in Computing, Engineering Science & Technology

ASTESJ

ISSN: 2415-6698

Personalized Serious Games for Improving Attention Skills among Palestinian Adolescents

Malak Amro[1] , Stephanny VicunaPolo[2], Rashid Jayousi[1,] Radwan Qasrawi[1,*]

[1]*Department of Computer Science, Al Quds University, Jerusalem, 9103401, Palestine*

[2]*The Center of Innovation Technology, Al Quds University, Jerusalem, 9103401, Palestine*

A R T I C L E I N F O

Article history:
Received: 15 July, 2021
Accepted: 09 August, 2021
Online: 26 August, 2021

Keywords:
Attention
Understanding
Cognitive skills
Serious Games
Game-based learning
Digital Games
Education outcomes

A B S T R A C T

Serious games (SGs) are interactive and entertaining digital games with a special educational purpose. Studies have shown that SGs are effective in enhancing educational skills. Cognitive skills training through serious games have been used in improving students learning outcomes. In this article, we introduce the 'plants kingdom' serious game for improving adolescents' cognitive skills, mainly attention (Focus, selection, and sustained attention) and understanding skills. The game used the grade 8 Science book in designing the game content. The plant kingdom lesson was used for developing the game story and objects, its methods and tools were designed for the purpose of attention and understanding skills improvement. The game was evaluated on 43 students from public schools between the ages of 13-15 years, the study selected data from the students who had completed 5 playing sessions. The attention and understanding skills were assessed using the automatic recording and analysis of the game player's data. The variables utilized from the players' data included player ID, session number, gender, number of trials, level, drag and drop time, distance, reason for failure, position, speed, status, time, and playing tool. Results showed that the game improved the attention and understanding skills of students by 27% and 25 % respectively. The study showed the significant effect of serious games in enhancing students' cognition; thus, integrating serious games into the education system can potentially improve learning objectives and outcomes.

1. Introduction

In a rapidly changing digital environment, and the ever-growing number of persons interacting with digital technologies daily, Digital Games Based Learning (DGBL) have gained momentum in their application as learning aids for informal and formal education. DGBL provides users with the ability to improve decision-making, memory, mathematical, and spatial skills [1]. Digital Games that are used with the aim of educating, instructing, or training have come to be known as serious games (SG) [2]. Serious games were first defined by [1] as activities that "unite the seriousness of thought and problems that require it with the experimental and emotional freedom of active play"[1].

SGs differ from computer games in purpose, while the computer or digital games aim to entertain, serious games seek to achieve a certain educational, medical, or social outcome for the players. SGs have been used in a variety of fields, such as to aid children with Autism Spectrum Disorders (ASD) with Social Emotional Learning (SEL) [3], training the eyes of children with oculomotor dysfunction (OMD) [4], and cognitive training for chronic stroke survivors[5].

Several researchers have studied a further application of serious games whereby games are used to enhance educational skills [6], [7]. Serious games are directly correlated with an increase in the engagement, attraction, and interest of players in learning new skills[8]. Likewise, SGs may also enhance cognitive skills, such as selective attention, an important skill for students' academic performance [9]. Serious games show to increase players' motivation and adaptability to new educational content as the games can create scenarios that aren't easily accessible to them[10].

The ability to focus mental resources on the information most relevant at a given moment is referred to as attention. Students' attention skills are volatile and fluctuate subject to the environment they are in, which may hinder their learning skills or overall academic performance. Nonetheless, serious games allow for the creation of personalized training experiences that match

*Corresponding Author: Radwan Qasrawi, Email: radwan@staff.alquds.edu

https://dx.doi.org/10.25046/aj060441

the student's abilities and training needs and thus aid in the development of skills that enhance their cognitive functions, namely attention [11], [12].

2. Literature Review

Given that serious games aim to utilize new gaming technologies to enhance the skills of users in a particular field [12], this paper aims to study the application of serious games in adolescents' learning skills, particularly attention skills, to improve their educational outcomes. Several studies have explored the correlation of serious gaming and learning skills, and most recently, researchers have begun to focus on specific skills, such as attention and memory in a variety of sectors and applications [13], [14].

2.1. Serious Games and Learning Skills

In the article "Serious Play: Literacy, Learning and Digital Games" [15], the author discussed the Serious Play Project implemented by three Australian universities across two Australian states. The project aimed to learn about how digital games may be incorporated into education, namely the opportunities that games provide for creativity and innovation, and how learning through games challenges multimodal literacy learning. The project introduced games to classrooms between years 1 through 10 in a wide range of subjects, such as Information Technology, English, Literacy, and Social Studies among others. The findings show that serious games support learning skills in all subject areas, particularly in formal curriculum areas like Mathematics and Geography. The games enhanced students' interpersonal collaboration, negotiation, and autonomy.

In a previous study, a new model for the automatic collection of players' data and analysis of their skills was introduced by [8]. The model used game-learning analytics and robotic process automation for data collection and analysis, the model was tested on a sample of Palestinian public-school students between the ages of 13 and 14 (eighth grade). An automatic analysis model was created within a game focused on improving adolescent's attention and understanding of a given topic. The study found that serious games have the potential to be used as educational tools to ultimately aid in students' learning process and attention skills. Furthermore, the study found that the merging of game analytic tools and robotic process automation can be replicated in serious game development in order to measure players' enhanced skills. Thus, this approach to serious games could replace the traditional pre-post testing methodology currently used in such interventions.

The influence of serious games on formal education by examining their design and deployment was explored by [16]. Although the majority of studies on the topic of SGs have focused on their application in informal learning. In [16] researchers sought to develop a framework for introducing SGs into the formal pedagogical curriculum which pays special attention to the role of the educator. The review finds that serious games have the potential to significantly contribute to students' learning skills, yet, taking into account that game-based environments are rapidly evolving, educators and practitioners must be trained and prepared for the incorporation of new game-based teaching methodologies.

2.2. Serious Games and Attention (Cognitive skills)

In [17], researchers introduced a design for a computerized serious game to increase cognitive skills among the elderly "Smart Thinker." The game aimed to increase cognitive skills, such as memory and attention in elderly adults to fortify their cognitive performance. Their study consisted of 59 older adults playing Smart Thinker under the supervision of social workers. The findings show that the game, "Smart Thinker," had a significant impact in regards to the enhancement of cognitive and attention skills of the intervention group. Thus, serious games show to improve memory and attention skills among the elderly.

Similarly, in [5], the authors aimed to assess the value of "Neuro-World," a serious game, in cognitive training for stroke survivors who, as a result, present mild or moderate cognitive disabilities. The study utilized a hybrid model between ANOVA and Tukey's posthoc tests and found that all outcomes presented significant advancements except for language. Therefore, Neuro-World showed to enhance the cognitive function and decrease depression symptoms among the subjects in the intervention group [5].

In [11], researchers sought to study the assessment step of an SG for attention enhancement. A serious game for enhancing attention skills based on an Open Learned Model (OLM) was developed (Keep Attention), and a study was conducted to evaluate to what extent the OLM influences users' decision-making in attention training [11]. The study concluded that the Open Learner Model is effective in personalizing the user's experience, guaranteeing transparency, and helping users self-regulate their skills.

Furthermore, in [10], the authors took it one step further by approaching SGs for improving cognitive functions through the lens of Virtual Reality (VR). Thus, their study explored Virtual Reality Serious Games (VRSGs) to optimize the cognitive performance of users. To accomplish this, they utilize a combined 'Learning Mechanics –Game Mechanics' (LM-GM) model and further add VR characteristics. The study found that VRSGs improve the presence, immersion, and cognitive performance of users as the VR component reinforces players' embodied cognition through a purposeful and interactive design[10]., VR offers additional gaming experiences that don't translate to traditional computerized games.

In [18], the authors reviewed the use of educational serious games in all educational levels with a focus on knowledge, learning, memory, and attention. The review of the literature shows that a large number of researchers support the use of ICTs [19], in particular serious games, for enhancing attention skills and overall improving academic performance. Moreover, in [1], the authors showed that players demonstrate better selective attention over space, and can focus on one specific object at a given time with less effort than non-players as a result of their gaming activity. Thus, the study concludes that video games, particularly serious games, have the potential of significantly enhancing spatial skills, promote communication, improve memory and attention skills in students from all grade levels, but in particular in children with Attention Deficit Disorders (ADD).

The literature reviewed shows a consensus among researchers about the positive correlation of serious games with learning skills,

https://dx.doi.org/10.25046/aj0400

in particular skills that relate to cognition, such as memory and attention [20]. The impact of SGs in attention skills is increasingly applicable in school-aged children, particularly children with cognitive or intellectual disabilities.

3. Research Methodology

3.1 Serious Game Design

In this research, we developed an educational serious game for improving the basic cognitive processes of memory and attention, such as focus, orientation, recall, and selection, among school children. The game's design provides students with a series of training activities through game playing that would lead to the enhancement of their cognitive abilities, particularly attention skills. The game used a mixture of instructional and interactive video-game-play methods to achieve the proposed objectives.

The "Plant Kingdom" SG was developed based on Bloom's hierarchy of cognitive learning [21]. Therefore, the game seeks to aid students in navigating several levels to achieve increased attention skills. The research focused on improving the attention and understanding cognitive skills of adolescents, including logical thinking, intellectual, awareness, observation, knowledge, interaction, intuition, and decision-making. The game content was planned in a way to stimulate the player's recall, concentration, and memory skills through visual and audio activities, and motivation and rewards actions.

The grade eight science book was used in developing the serious game's playing materials and objects. The course learning outcomes were considered as a reference for the game objectives' design. The SG includes eight playing levels with ascending difficulties designed based on the desired skills with the help of gaming tools such as mazes, mix-match, basket-filling, and maps. The levels' difficulty was adjusted by altering game variables, including touch sensitivity, length and complexity of the game pattern, game tool, response time, success and failure, and reasons for failure.

Figure 1: The left side indicates lesson subtopics in Arabic (4 titles: plants characteristics, physical materials, structures of plants, and plants classification. The right side shows plant pictures as described in the students' textbook.

The serious game application utilized the learning contents of the grade 8 science course (specifically: the plant kingdom lesson in the students' science course curriculum) and furthered modeled them in the framework of skills development. To achieve this, objects' shapes, colors, motion, size, location, and other related human-computer interaction standards were considered in the game application development. In addition, the development team considered brain processing measurement features during game design, such as response, response time, and decision making. A group of experts (serious game experts, teachers, and education supervisors) worked on the creation of the game story, scenarios, objects, and characters.

Figure 2. Two game levels (simple and complex). Simple level (left-side) used a standard plan classification tree, and the complex level (right-side) used a recall method of the classification order of plants.

Figure 3. Two game levels with different playing tools. The Maze (left-side) drags plant properties from the upper list onto the corresponding baskets through the maze playing tool. The Tree (right-side) drags the plant properties to the correct location using finger touch movements

Figures 1, 2, and 3 show a sample of game-playing tools that have been used in game design to enhance the development of cognitive skills among adolescents.

3.2 Game Development

The "Plant Kingdom" game was developed following the 'normal serious game' design methodology that achieved the game objectives in enhancing adolescents' cognitive skills. Figure 4 illustrates the methodological steps undertaken during game design, from the definition of game objectives until the game's evaluation. Steps 1-5 include the development of the game's story and scenarios, which reflect the plant kingdom textbook material. The objects and pictures were selected to match those shown in the student textbook.

The scenarios followed the teaching material's learning outcomes and were interactively designed to enhance students' motivation within the learning environment. Step 6 concerns the game tools design, in which Mazes, drag and drop, and mix and were used for the study's purposes. These tools are commonly found in games and are considered efficient tools for enhancing players' concentration, planning, and visual-motor skills integration. Touch sensitivity and movement speed have also been considered in the game design. Sensitivity and speed complexity become increasingly difficult with higher game levels. The final step concerns game evaluation, whereby game player data were automatically collected and managed using robotic process automation and automatic analytical tools for evaluating the serious game objectives [8].

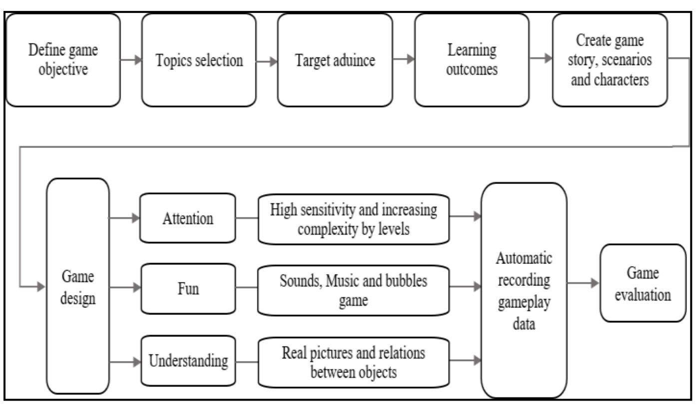


Figure 5. Methodological steps of game design

Utilizing the standard game design procedure, the game development stage for this study included the following aspects: storytelling, goal, feedback, time, rewards, instructional methods, and rules. Storytelling was employed in different ways, such as drag and drop and Mix and match. The maze itself was designed as an aid for players' attention as users were forced to concentrate on the element while moving it across the screen. The elements were shuffled after a certain period of time and players had to withdraw specific images before and during shuffling. Figures 1-3 illustrate the design of game levels using the maze, drag, and drop, and mix and match.

The software development incorporated the use of the Unity 3D mobile App development environment, in addition to free software development tools, such as PHP and MySQL to maintain user records and feedback database. Figures 5 and 6 show screenshots of the game generation stage using the Unity 3D video-game engine (version 2019.3.11), PHP MyAdmin 5.1.1, and MySQL development tools. Microsoft Visual Studio 2019 was used to edit the program code in C#.

In addition, a Web-based platform was created to manage users' game data, increase visibility, and deliver information about the SG. Programming and video-game experts were responsible for game design and implementation, as per international guidelines. The prototype was validated by end-users (stakeholders from across several domains) and tested in real-life scenarios with real data in the early development stages.

3.3 Game Testing and Validation

Prior to the release of the final prototype, the game was pilot-tested twice, firstly by 3 teachers and 4 eighth-grade students, and secondly by two groups. The groups comprised the original testing sample and an additional group made up of 2 teachers and 5 eighth-grade students. Test groups were asked to play the game 'as many times as desired' for approximately 30-40 minutes dedicated to each level in order to complete all 8 levels. Pre-post data were collected upon finalization of the pilot-test, analyzed, and considered in the next version of the game. Finally, the game's final version was launched and reviewed by experts and teachers before being given to the student sample.

3.4 Data Collection

The game's target audience was eighth-grade students between the ages of 13 and 14. The study's target population was selected following the recommendations of the Palestinian Ministry of Education (MoE) supervisors. The target age was chosen given that 8th grade proves critical as students transition to adolescence and are increasingly exposed to smart technologies.

A sample of 60 students weighted by gender was selected, however, only 43 students completed the study. The rest of the students failed to complete more than 3 sessions and were

Figure 4. Sample of game programing using Unity

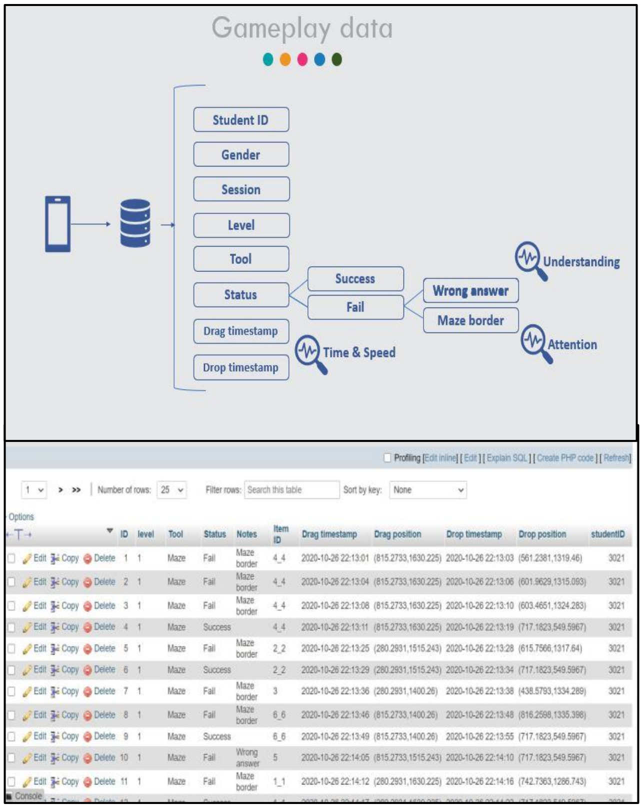


Figure 6. Sample of game programing using PHP and MySQL

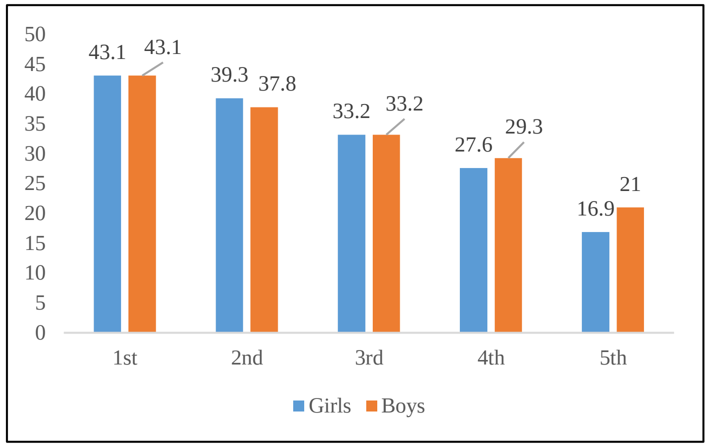
therefore excluded from the analysis. The student's parents signed consent forms before gameplay. Participants were required to have access to a mobile phone with an active internet connection.

The game's application was accessible for download on the Google Play store. A research assistant guided the student in downloading the game into their smartphones. Students were asked to play the game in their homes due to COVID19 pandemic protection procedures. The students' school teachers and science teachers supervised and mentored students throughout game-playing. The player's game data was automatically stored in the game platform. The data included the variables: player ID, gender, number of trials, playing tool, session number, level number, location, drag and drop time, status (Success or Fail), the reason for failure (bumped into the maze border or wrong answer), distance, time, and speed. Moreover, attention and understanding variables were created in the following way:

a) The attention variable: Interpreted as the relationship between the amount of time it takes to complete a task, the player's status (Success or Failure), and the cause of failure.
b) The understanding variable: Interpreted as the ratio between correct and incorrect responses, the number of trials per level, the rise in correct answers, and the decline of incorrect answers.

3.5. Experiment Setting

The research took place under direct supervision and partnership with the Palestinian Ministry of Education (MoE). The MoE approved the testing of the game prototype and was responsible for the nomination of 2 science supervisors and 2 science teachers to oversee the study's implementation. The Ministry was also responsible for identifying and selecting participants. Following parents' approval upon communication with the supervisors, students attended an in-person orientation session to explain the research objectives and aid participants in downloading and installing the SG onto their mobile phones. Additionally, supervisors provided students with detailed instructions for gameplay as participants were to use the game at home. Figure 7 shows participants making use of the "Plant Kingdom" serious game.



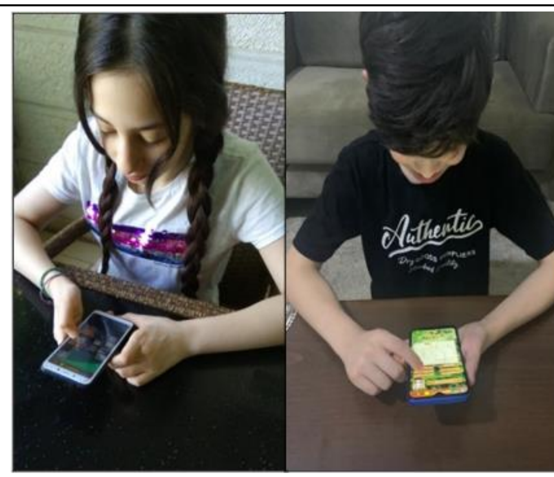


Figure 7. A sample of students playing the game.

The students were asked to play one level per day. To achieve the game objectives, the minimum required number of playing sessions was five. Out of a sample of 60 participants, 43 students successfully completed the 5 sessions required.

4. Results

4.1 Population Studied

The game was tested on 43 grade 8 students (31 girls and 13 boys) aged 13-15 years. The results are shown in Table 1 detail the percentage of participants' distribution by gender and playing sessions. Overall, the number of playing trials for the 43 players was 25,494. The results evidenced that the first session had a higher number of trials than the last session among girls (69.7% and 67.5% respectively). On the other hand, boys reported a higher number of trials in the last session than in the first session (32.5% and 30.3% respectively). However, girls presented a higher overall number of trials than boys (69% and 31% respectively);

this has been attributed to the fact that the girls to boys ratio in the sample is 31:13.

Table 1: Participants distribution of playing trials by gender and playing sessions.

		Gender		
		Girls	Boys	Total
		n (%)	n (%)	N
Session	1	4730 (69.7)	2059 (30.3)	6789
	2	3982 (69.4)	1756 (30.6)	5738
	3	3366 (69.2)	1498 (30.8)	4864
	4	3039 (68.1)	1422 (31.9)	4461
	5	2458 (67.5)	1184 (32.5)	3642
	Total	17575(69)	7919(31)	25494

4.2 Outcomes

Results in Table 2 show the average playing time (minutes) by gender and playing session. Results indicated that the average playing time decreased as the playing sessions increased for both girls and boys. The average playing time for Session 1 compared to Session 5 by gender (in minutes) was 10.7 to 5.9; 3.7 to 2.0 for both girls and boys respectively. Overall, the playing time deviation decreased by 2 minutes while the number of playing sessions increased.

Table 2: Average playing time (minutes) by gender and playing session.

		Player Gender		
		Girls	Boys	Total
Session	1	10.7	3.7	14.4
	2	8.9	3.1	12.0
	3	7.6	2.4	10.0
	4	6.7	2.5	9.2
	5	5.9	2.0	7.9

Figure 8 shows the percentage of player status (success or fail) by gender and playing sessions. The failures decreased as playing sessions increased among both girls and boys. 43.1% of both boys and girls failed in session 1, while only 16.9% of girls and 21% of boys failed in Session 5. The girls reported a failure enhancement of 26.2%, while boys reported an enhancement of 24.8%. The results indicated that girls reported an overall 83.1% success rate in the last session, while boys reported a success rate of 79.0% in the last session.

The status of participants was analyzed through the collection of individual data on the reason for failure at each level. The results shown in Table 3 indicate participants' reported reason for failure as either a wrong movement or simply a wrong answer.

Table 3 compares players by gender. In session 1 (pre-test), girls showed a higher percentage of wrong movements than boys (35.8% and 32.3% respectively). In the fifth session (post-test), girls had a greater decrease in the amount of border touch and wrong movements than boys (7% and 8.4% respectively).

Table 3: The game-play status by gender and playing session.

		Player Gender					
		Female		Male		Total	
		Wrong Touch	Wrong Answer	Wrong Touch	Wrong Answer	Wrong Touch	Wrong Answer
		n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Session	1	980 (35.8)	1057 (32.6)	455 (32.3)	433 (33.1)	1435 (34.6)	1490 (32.8)
	2	706 (25.8)	859 (26.5)	358 (25.4)	306 (23.4)	1064 (25.7)	1165 (25.6)
	3	494 (18.1)	623 (19.2)	256 (18.2)	242 (18.5)	750 (18.1)	865 (19.0)
	4	363 (13.3)	476 (14.7)	220 (15.6)	197 (15.0)	583 (14.1)	673 (14.8)
	5	192 (7.0)	224 (6.9)	118 (8.4)	131 (10.0)	310 (7.5)	355 (7.8)

Table 4: Average time difference of player fails per gender and playing session (minutes).

		Player Gender					
		Female		Male		Total	
		Wrong Touch	Wrong Answer	Wrong Touch	Wrong Answer	Wrong Touch	Wrong Answer
		X^2	X^2	X^2	X^2	X^2	X^2
Session	1	.15	.13	.12	.11	.14	.13
	2	.12	.13	.12	.09	.12	.12
	3	.13	.13	.10	.08	.12	.12
	4	.16	.13	.10	.10	.14	.12
	5	.18	.17	.10	.10	.15	.14

Table 5: Deviation percentage in attention and understanding using pre-posttest analysis by gender and player status.

	Girls	Boys	Total	P-Value
Attention	27.1	23.5	26	0.0001
Understanding	25.7	23.1	25	0.0001

The average playing time was reported for each level and playing session. The average time of game completion was 2.5 minutes, while the average time per session was 34 minutes. Table 4 shows the players' fail average time difference, the results show an increase in the average time difference between sessions one and five. The girls' fail time increased from 0.15 minutes to 0.18 minutes from sessions 1 to 5. Therefore, girls spent more time making use of their focus and attention skills while game-playing, which explains the decrease of fails from 35.8% to 7% as shown in Table 3. For boys, the time difference decreased from 0.12 minutes to 0.1 minutes.

The serious game effectiveness was assessed by evaluating the changes in-game players' results. The percentage of deviation in fails rate, average playing time, and fails between sessions one and five indicates the effectiveness of the proposed game in improving students' attention and understanding skills. Results in Table 5 show the deviation percentage for attention and understanding skills by gender. Attention skills improved by 26% (27.1% girls and 23.5% Boys) and understanding skills improved by 25%. Girls reported a higher improvement than boys for both skills.

5. Discussions and Recommendations

Towards our goal of enhancing cognitive skills training among school children, we have created a serious game titled "plant-kingdom" and measured its impact on attention skills improvement through a random sample of grade 8 students. We used the game players' data for analyzing the game results and evaluating the outcomes. The average playing time per session leading to improvements in attention skills was 34 minutes a day, two times a week. The analysis of data considered every student who completed a minimum of five playing sessions. The results obtained were positive, we observed a statistically significant improvement in attention skills through the increase of average playing time, decrease in playing fails, and increase in sessions' success rate. Our results were found to be consistent with other similar studies [22, 23].

The study also yielded a statistically relevant reduction of 'fails' as playing sessions increased. Hence, the data analyzed indicated that the total number of trials decreased as the number of sessions increased. Likewise, the success rate increased while the failure rate and average playing time per level decreased. The above indicators reflect that students attained higher levels of attention and understanding of the science lesson as they continued to play the 'plant kingdom's serious game.

In the same manner, a comparison of players' outcomes indicates that the skills of sustained and selective attention grew among players as sessions increased. This is evidenced in the fact that as game-playing continued, students, girls to a larger extent, developed the ability to stay within the playing borders on the touch screen while dragging and dropping the game object.

Moreover, a notable advancement in understanding skills was observed during the answer activities. The students obtained a lesser amount of wrong answers as the game sessions progressed. Thus, the understanding of the game's content, and of the lesson plan by extension, has remarkably improved after game-play. Self-correction skills, understanding, and attention are all skills that the students had to improve on during game-play in order to decrease the 'fail' rate.

Given that the game was designed based on the students' 8^{th}-grade Science material, the 'Plant-kingdom' serious game proved to be useful in the achievement of the course's educational outcomes. Therefore, our study's results evidence the effectiveness of serious games in improving students' cognitive skills. The skills enhancement reported in other studies [24], [25] is consistent with the results obtained. The reported improvement in players' outcomes reflects the value of serious games in educational contexts, particularly attention skills (focus, selection, and sustained attention). Furthermore, the current study, in resonance with similar previous studies [16], [26], [27], demonstrates that serious games are able to promote the enhancement of attention and understanding skills among adolescents.

Nonetheless, it is worthy to note that the study had several limitations. Firstly, with only 43 students studied, the research possessed a small sample size. Although the preliminary results presented here were enough to examine the effect of the Plant-Kingdom game in improving attention and understanding skills, we recommend the replication of this study with a larger and more significant population.

Secondly, the experiment was conducted under COVID-19 restrictions and Ministry of Health guidelines, therefore challenging the safe and correct implementation of the research. For this reason, a virtual platform was used for game supervision, thus limiting the game's evaluation. We recommend future researchers deliver their proposed intervention in person to facilitate the evaluation process, and supervise the correct use of the serious game, especially for children.

Finally, the game used the automatic recording and analysis of game players' data instead of the traditional pre-post testing measure. Thus, the number of variables used in the evaluation of game effectiveness was limited. We recommend that future studies consider the evaluation of a larger number of variables

6. Conclusions

Firstly, the preliminary results presented in this study could be used in larger-scale research to further investigate the impact of SGs in achieving learning outcomes and enhancing student's cognitive skills development. The expansion of this research could bring about innovative change to the field of education and technology.

The unification of serious games in formal education is just at its onset, but as evidenced in this research, could be greatly beneficial for students' learning outcomes. Thus, this study concludes that utilizing serious games as a learning tool informal education settings (i.e. schools, academies, universities), would enhance students' cognitive skills and improve their learning outcomes by extension, all the while providing a fun, innovative, and interactive learning methodology.

Furthermore, the serious game methodology in formal education could prove even more beneficial than evidenced in this paper for students diagnosed with Attention Deficit Disorders, Autism, or other learning disabilities.

7. Abbreviations

Digital Games Base Learning (DGBL), Serious Games (SG), Autism Spectrum Disorder (ASD), Social Emotional Learning (SEL), Oculomotor Dysfunction (OMD), Open Learner Model (OLM), Virtual Reality (VR), Virtual Reality Serious Games (VRSG), Learning Mechanics- Game Mechanics (LM-GM), Attention Deficit Disorders (ADD), Hypertext Pre-Processor (PHP), Ministry of Education (MoE).

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgment

The authors wish to thank and acknowledge all participants, their families, and the schools that contributed to the success of this study. The authors acknowledge the role of the l thanks to the Palestinian Ministry of Education, the INTETECH company, and Al Quds University for aiding in the implementation of this research project.

References

[1] G. Papanastasiou, A. Drigas, C. Skianis, M.D. Lytras, “Serious games in K-12 education: Benefits and impacts on students with attention, memory and developmental disabilities,” Program, **51**(4), 424–440, 2017, doi:10.1108/PROG-02-2016-0020.

[2] P. Wouters, H. van Oostendorp, Overview of Instructional Techniques to Facilitate Learning and Motivation of Serious Games, 2017, doi:10.1007/978-3-319-39298-1_1.

[3] C. Wu, Q. Zheng, Simulation and Serious Games for Education, 2016.

[4] I. Heldal, C. Helgesen, Q. Ali, D. Patel, A.B. Geitung, H. Pettersen, “Supporting school aged children to train their vision by using serious games,” Computers, **10**(4), 2021, doi:10.3390/computers10040053.

[5] H.T. Jung, J.F. Daneault, T. Nanglo, H. Lee, B. Kim, Y. Kim, S.I. Lee, “Effectiveness of a serious game for cognitive training in chronic stroke survivors with mild-to-moderate cognitive impairment: A pilot randomized controlled trial,” Applied Sciences (Switzerland), **10**(19), 2020, doi:10.3390/APP10196703.

[6] J.I. Navarro, E. Marchena, C. Alcalde, G. Ruiz, I. Llorens, M. Aguilar, “Improving attention behaviour in primary and secondary school children with a Computer Assisted Instruction Procedure,” International Journal of Psychology, **38**(6), 359–365, 2003, doi:10.1080/00207590244000042.

[7] D.K. Ramos, H.M. Melo, “Can digital games in school improve attention? A study of Brazilian elementary school students,” Journal of Computers in Education, **6**(1), 5–19, 2019, doi:10.1007/s40692-018-0111-3.

[8] R. Qasrawi, M. Amro, R. Jayousi, “Automatic analytics model for learning skills analysis using game player data and robotic process automation in a serious game for education,” Proceedings - 2020 International Conference on Promising Electronic Technologies, ICPET 2020, 94–98, 2020, doi:10.1109/ICPET51420.2020.00026.

[9] T. Moore, M. Zirnsak, “Neural Mechanisms of Selective Visual Attention,” Annual Review of Psychology, **68**, 47–72, 2017, doi:10.1146/annurev-psych-122414-033400.

[10] M. Alcañiz, S. Göbel, M. Ma, M. Fradinho, J. Baalsrud, H. Tim, M. Eds, D. Hutchison, Serious Games, 2017, doi:10.1007/978-3-319-70111-0.

[11] N. Hocine, “Personalized Serious Games for Self-regulated Attention Training,” ACM UMAP 2019 Adjunct - Adjunct Publication of the 27th Conference on User Modeling, Adaptation and Personalization, (ExHUM), 251–255, 2019, doi:10.1145/3314183.3323458.

[12] J. Mishra, D. Bavelier, A. Gazzaley, “How to Assess Gaming-Induced Benefits on Attention and Working Memory,” Games for Health Journal, **1**(3), 192–198, 2012, doi:10.1089/g4h.2011.0033.

[13] H.-L. Chan, W. V. Giannobile, R.M. Eber, J.P. Simmer, J.C. Hu, “ Characterization of Periodontal Structures of Enamelin -Null Mice ,” Journal of Periodontology, **85**(1), 195–203, 2014, doi:10.1902/jop.2013.120651.

[14] N. Akshoomoff, “Selective attention and active engagement in young children,” Developmental Neuropsychology, **22**(3), 625–642, 2002, doi:10.1207/S15326942DN2203_4.

[15] ا. سينا, No Title1386 ,قانون در طب.

[16] S. Arnab, R. Berta, J. Earp, F. de Sara, M. Popescu, M. Romero, I. Stanescu, M. Usart, “Framing the adoption of serious games in formal education,” Electronic Journal of E-Learning, **10**(2), 159–171, 2012.

[17] H. Chi, E. Agama, Z.G. Prodanoff, “Developing serious games to promote cognitive abilities for the elderly,” 2017 IEEE 5th International Conference on Serious Games and Applications for Health, SeGAH 2017, 2017, doi:10.1109/SeGAH.2017.7939279.

[18] G. Papanastasiou, A. Drigas, C. Skianis, M.D. Lytras, “Serious games in K-12 education,” Program, **51**(4), 424–440, 2017, doi:10.1108/PROG-02-2016-0020.

[19] I.D. Danilov, “Geological and paleoclimatic evolution of the Arctic during Late Cenozoic time,” The Arctic Seas, **10**, 759–760, 1989, doi:10.1007/978-1-4613-0677-1_27.

[20] V. Bolón-Canedo, A. Alonso-Betanzos, Intelligent Systems Reference Library 147 Recent Advances in Ensembles for Feature Selection.

[21] H.A. Efe, R. Efe, “Evaluating the effect of computer simulations on secondary biology instruction: An application of Bloom’s taxonomy,” Scientific Research and Essays, **6**(10), 2137–2146, 2011, doi:10.5897/sre10.1025.

[22] C. Alonso-Fernández, I. Martínez-Ortiz, R. Caballero, M. Freire, B. Fernández-Manjón, “Predicting students’ knowledge after playing a serious game based on learning analytics data: A case study,” Journal of Computer Assisted Learning, **36**(3), 350–358, 2020, doi:10.1111/jcal.12405.

[23] Y. Wang, P. Rajan, C.S. Sankar, P.K. Raju, “Let Them Play: The Impact of Mechanics and Dynamics of a Serious Game on Student Perceptions of Learning Engagement,” IEEE Transactions on Learning Technologies, **10**(4), 514–525, 2016, doi:10.1109/tlt.2016.2639019.

[24] C. Boletsis, S. McCallum, “Smartkuber: A Serious Game for Cognitive Health Screening of Elderly Players,” Games for Health Journal, **5**(4), 241–251, 2016, doi:10.1089/g4h.2015.0107.

[25] M.H. Chen, W.T. Tseng, T.Y. Hsiao, “The effectiveness of digital game-based vocabulary learning: A framework-based view of meta-analysis,” British Journal of Educational Technology, **49**(1), 69–77, 2018, doi:10.1111/bjet.12526.

[26] P. Cardoso-Leite, D. Bavelier, “Video game play, attention, and learning: How to shape the development of attention and influence learning?,” Current Opinion in Neurology, **27**(2), 185–191, 2014, doi:10.1097/WCO.0000000000000077.

[27] J.M. Halperin, D.J. Marks, A.C. V. Bedard, A. Chacko, J.T. Curchack, C.A. Yoon, D.M. Healey, “Training Executive, Attention, and Motor Skills: A Proof-of-Concept Study in Preschool Children With ADHD,” Journal of Attention Disorders, **17**(8), 711–721, 2013, doi:10.1177/1087054711435681.