Enhancing Spatial-Temporal Orientation Skills through a Psychoeducational Serious Game

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***Abstract*—This paper presents the development of a gamified application to enhance spatial-temporal orientation cognitive skills in children aged 3 to 5 years. The initial phase involved determining the specific needs of this age group, which established the scope and motivated the development of our serious game. The application utilized the iPlus methodology and the Scrum framework to ensure an effective and iterative development process. By employing the iPlus methodology, requirements were gathered, and collaborative design activities were conducted. The Scrum framework facilitated agile project management, enabling the development of a serious game comprising five engaging minigames, each designed to target specific cognitive skills. The application also includes features for progress tracking and personalized learning experiences. The successful implementation of the game highlights the effectiveness of combining the iPlus methodology and Scrum framework in developing gamified educational applications.**

Keywords—orientation skills, serious game, iPlus, scrum, education.

I. Introduction

Teaching and learning processes are constantly evolving and adapting due to technological advancements and social changes. New information technologies, particularly smart devices and internet connectivity facilitate learning and give rise to new research, teaching, learning, innovation, and inclusion [1]. However, it is essential to adopt certain behaviors when using these technologies, such as self-discipline, self-evaluation, and self-learning, to prevent their misuse as distractions instead of effective learning tools.

Video games can spark interest and motivation in individuals of all ages, allowing them to immerse themselves in a virtual universe with its language, history, and culture [2]. Serious games, in particular, serve as learning tools that can be both enjoyable and educational. These games are based on theoretical approaches and offer an effective option for learning, working, and enhancing various cognitive skills, such as spatial-temporal orientation.

Cognitive skills are fundamental for individuals to be competent and interact with their environment [3]. These skills undergo a process of learning and change throughout life, resulting in behaviors and actions in individuals due to the deterioration or enhancement of these cognitive abilities. Spatial orientation is a crucial cognitive skill as it enables individuals to coordinate their sensory systems with the movement of their bodies and interact with objects and other people in their surroundings. Spatial and temporal perception are closely related, as movements and actions occur within a specific timeframe. It is essential to be aware of the current moment, such as the day, afternoon, or night, as well as our location, home, workplace, or study place.

By harnessing the power of technology and incorporating serious games, we can create effective and engaging learning experiences that enhance spatial-temporal orientation skills and promote cognitive development [4]. These advancements open up new possibilities for educational interventions that capitalize on video games' inherent motivation and immersive nature. As such, this paper aims to explore the potential of a gamified application in enhancing spatial-temporal orientation skills in children aged 3 to 5 years. Using innovative methodologies and frameworks, we present a comprehensive approach to developing a serious educational game that targets specific cognitive skills and fosters personalized learning experiences.

In the following sections, we will delve into the background and related works of serious games in education, emphasizing their impact on cognitive skill development and their applications in different domains and age groups (Section II). We will then detail the methodologies and frameworks used in the development of our serious game, including the iPlus methodology for requirements gathering and collaborative design and the Scrum framework for agile project management (Section III). Next, we will present the materials and methods employed to create the gamified application, outlining the game's modules, minigames, and usability evaluation (Section IV). Finally, the results of the serious game development, including its effectiveness in enhancing spatial-temporal orientation skills and the feedback from the usability evaluation, will be discussed (Section V).

II. Background and Related Works

A. Serious Games

Education has undergone significant transformations in recent times with the integration of information technologies, enabling innovative approaches to learning and expanding access to education across the globe. In this context, serious games have emerged as a powerful educational tool, captivating children, youth, and adults' interest and

engagement. These games offer immersive and interactive experiences, presenting complex universes that allow players to assume realistic roles, face challenges, and learn as they progress [5].

A serious game is a computer application that combines elements of video games, such as story, gamification, gameplay, art, and software, to enhance the user's experience and engagement. It is used for transmitting educational, informative, persuasive, and subjective messages, as well as for mental and physical training and data exchange in various contexts [6], [7]. Education transcends traditional boundaries and engages learners in dynamic and interactive environments by harnessing the potential of serious games. The effectiveness of serious games in achieving educational objectives has been demonstrated in various fields, including classrooms, training programs, healthcare interventions, and beyond. Their versatility allows for customization to specific learning goals and the integration of diverse content areas, making them valuable tools for educators and learners.

By embracing serious games as an educational tool, we open up new possibilities for enhancing the learning process, making it more engaging, interactive, and enjoyable. By integrating educational content with engaging gameplay, these games provide a dynamic and interactive learning experience that promotes the growth of various cognitive skills.

B. Spatial-temporal Cognitive skills

Cognitive skills are considered abilities that enable individuals to learn and develop new knowledge and thoughts. They are the facilitators of knowledge, working directly on information by acquiring, analyzing, understanding, processing, and storing it for later use [8].

Spatial-temporal orientation is a cognitive function that allows individuals to understand, interpret, and interact with the surrounding environment within a specific time frame [9]. Spatial orientation enables awareness of how people move and relate through their senses and personal experiences. It is fundamental for learning, daily life, and professional activities. Acquiring spatial orientation skills does not follow a specific order; it is developed in parallel through various stimuli individuals receive through sight or touch [9].

C. Related works

The use of serious games as a tool for cognitive skill development has gained considerable attention in recent years, with researchers and practitioners exploring various domains and age groups to design and evaluate their effectiveness. One study [10] focused on improving working memory skills in adolescents through a serious game intervention, resulting in significant enhancements in working memory performance. This study highlights the potential of serious games as effective tools for enhancing cognitive skills in this age group. Further research is recommended to validate and expand upon these findings, particularly in educational and clinical settings.

Another study [11] delved into the role of spatial thinking in STEM education, emphasizing its importance and relevance across disciplines such as geology and chemistry. It examined the relationship between spatial skills and STEM achievement and the impact of spatial training on improving STEM learning. The study concluded that spatial training could benefit novice learners by helping them overcome initial challenges and reducing dropout rates in STEM courses. However, further research is needed to understand the effectiveness and mechanisms of spatial training in improving STEM attainment.

Additionally, another paper [12] explored the impact of serious games on geography, science, and language learning. The study revealed the effectiveness of three-dimensional educational computer games in providing authentic and motivating learning environments, enhancing intrinsic motivation and autonomy in students. A collaborative game-based approach in science education improved student achievements, attitudes, motivation, self-efficacy, and confidence. For language learning, serious games promoted vocabulary training, oral skills development, and communicative competence, positively impacting the learning atmosphere, student motivation, and retention of language skills. These findings demonstrate the potential of serious games to enhance learning outcomes and create interactive and immersive experiences across various educational subjects.

The utilization of innovative methodologies and frameworks has been instrumental in the development and success of serious games for cognitive skill enhancement. The iPlus methodology, for instance, has been applied in different domains. Carrión-Toro [13] focused on using the iPlus methodology to enhance cognitive skills and promote workforce inclusion for individuals with intellectual disabilities, highlighting serious games as valuable learning tools. Santórum [14] investigated the efficacy of serious games designed with the iPlus methodology, emphasizing their effectiveness in training and learning through well-defined game elements. Maldonado [15] explored the use of the iPlus methodology to develop a serious game for improving musical skills in children, showcasing the potential of serious games for knowledge and behavior transfer.

Additionally, Maldonado [16] proposed a gamified application based on the iPlus methodology to enhance reading comprehension in students, demonstrating the methodology's ability to create a motivating and adaptable educational context. The iPlus methodology emphasizes integrating game design principles, educational theories, and user-centered approaches to create engaging and effective serious games. These studies collectively illustrate the versatility and positive impact of the iPlus methodology in different educational contexts.

This current study contributes to the existing literature by focusing on developing a gamified application that explicitly enhances spatial-temporal orientation cognitive skills in children aged 3 to 5 years. By incorporating the principles of serious games, cognitive skill development, and early childhood education, the study aims to provide an effective and engaging tool for promoting spatial-temporal orientation abilities in young children. Integrating the iPlus methodology and the Scrum framework ensures a user-centered and iterative development process, enhancing the effectiveness and user experience of the gamified application. Through developing and evaluating this application, valuable insights can be gained into the potential benefits of serious games in early childhood education and cognitive skill development.

III. Materials and Methods

Our project focuses on developing a web-based serious game to enhance spatial-temporal cognitive abilities through carefully crafted activities. These activities are tailored to

improve cognitive skills for individuals of all ages, specifically focusing on children aged 3 to 5. Guided by experts in Psychology and Education, we recognize the significance of creating resources that foster spatial and temporal awareness, as these abilities are fundamental in pre-literacy learning processes.

The web application will be accessible on both desktop and mobile devices, utilizing the convenience of web browsers for seamless execution. Within the application, users will engage in mini-games that enable tracking and scoring, facilitating the assessment of progress in spatial-temporal orientation skills. These mini-games will be thoughtfully designed, drawing inspiration from established tests and activities proven effective in developing this specific cognitive ability.

By harnessing the interactive nature of the web application and incorporating engaging mini-games, users will have an enjoyable and accessible opportunity to enhance their spatial-temporal cognitive abilities. Our primary objective in developing this serious game is to provide a valuable resource for educators, parents, and individuals seeking to improve these foundational cognitive skills. Ultimately, our project aims to support learning readiness, including early literacy acquisition, by effectively targeting and strengthening spatial-temporal cognitive abilities.

A. iPlus Methodology

The iPlus methodology was employed to gather requirements, elements, and ideas for designing serious games with an educational purpose while maintaining a collaborative and participatory approach focused on the user-centered development of the serious game. The methodology comprises five phases: Identification, Pedagogical Objectives Definition, Ludic Stories, Gameplay, and Refinement [6]. See Figure 1.

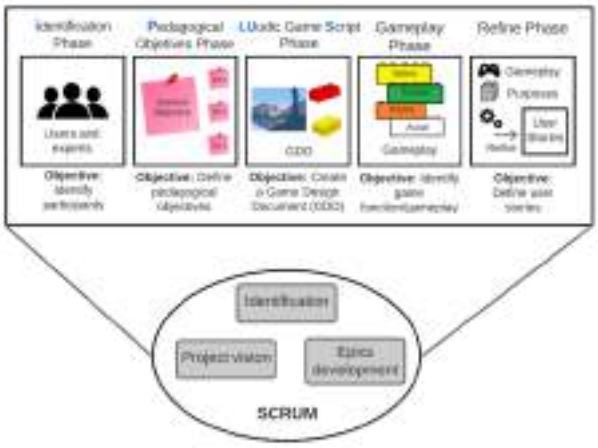


Fig. 1. The iPlus methodology for serious game design.

B. Scrum Framework

The Scrum framework [17], a popular project management approach, was utilized to ensure the delivery of a high-quality product or service that meets customer needs. Scrum is known for its adaptability, speed, flexibility, productivity, and iterative nature, fostering collaboration, self-organization, and accountability among project members. The work is divided into short cycles called Sprints.

C. Implementation of iPlus Methodology

The iPlus methodology, in conjunction with the Scrum framework, was employed for the initial analysis and design of the application. The iPlus methodology facilitated requirements gathering and the design of the serious game in a participatory and collaborative manner, involving a multidisciplinary team. The following results were obtained in the different phases of the methodology [6].

a) *Phase 1: Identification:* During this phase, the participants responsible for defining the objectives and possessing a general understanding of the problem was identified. The roles of the participants were established to ensure effective collaboration and contribution. See Figure 2.

Names	Role
Verónica Maldonado Psic.	Thematic Expert / Educational Psychologist Expert
Marco Santórum G. Ph.D.	Product Owner
Mayra Carrion T. Ph.D.	Expert Game Designe
Luis David Yánez	Developer Expert

Fig. 2. Participants and roles identified.

b) *Phase 2: Pedagogical Objectives Definition:* In this phase, the main educational objective, along with general and specific objectives, was determined. Brainstorming and affinity diagrams were utilized to generate ideas and reach an objective consensus. See Figure 3.

GENERAL OBJECTIVE	
Develop and improve people's spatial-temporal orientation cognitive ability to strengthen learning processes.	
N.°	Specific Pedagogical Objectives
1	Strengthen skills prior to learning to read and write.
2	Evaluate and improve spatiotemporal ability in children from 3 to 6 years of age.
3	Motivate the development of space-time ability through a digital resource.

Fig. 3. General and specific objectives.

c) *Phase 3: Ludic Game Script:* The Ludic Game Script phase aimed to collaboratively develop a design document for the serious game. Multiple proposals and ideas from the participants were considered, and a consensus was reached to finalize the game's design, aligning it with the general objective established in the previous phase.

d) *Phase 4: GamePlay:* During the Gameplay phase, the focus was on identifying the gameplay mechanics to be incorporated into the serious game and determining its genre. A participatory approach was followed, and various gameplay cards were created to capture the desired mechanics. Some evidence of GamePlay card results is shown in Figure 4.

Fig. 4. GamePlay cards.

Figure 5 presents the agreed-upon result of our serious game.

History:

There will be a character who will be a Martian in his spaceship, this Martian will have to travel on his ship through different planets. The different planets will have different challenges for the player, who must overcome each challenge and in exchange will be given scores, stars and above all letters that will be used to complete the word "SPACE". The game will end when the challenges of each planet have been completed and all the letters of the word SPACE have been obtained.

Characters:

- Owl
- Martian

How do you win the game?

The game is won when all the letters of the word "SPACE" have been collected.

Gamification mechanics
Scoring Tables

The game presents the scores obtained by the user. Each challenge offers little stars, which are obtained the more points you get.

Home Wizard

The owl is the assistant throughout the game.

Insignia

N/A

sounds

Instruction voice, background music, success or failure sounds.

Challenges and Missions

You must pass several planets; the goal is to pass all the challenges and complete the Word.

Points

Each challenge offers little stars, which are obtained the higher the score is obtained.

levels

About five planets, levels with different difficulty, scenarios and challenges.

Fig. 5. Consensus story of the game.

e) *Phase 5. Refinement:* The Refinement phase aimed to eliminate infeasible or repetitive aspects of the game design. Additionally, epic stories were identified by refining the objectives defined in the Pedagogical Objectives phase and the gameplay concepts from the Gameplay phase. User stories were created, which will be further utilized with the Scrum framework for backlog creation. Figures 6, 7, and 8 present some results of user stories that can be used later with a development methodology, in this case, with the Scrum framework to create the backlog.

User Stories

Identifier: HE 01	**Role:** Player

Title Story:
Register new player

Priority: A (High)

Description:
The player will register in the game to be able to enter the different worlds that will allow him to respond and play in a certain time, thus achieving the development of spatial-temporal orientation cognitive skills.

Ideas:

- The registration data for a new player are: name or nickname, password, parent or guardian email.
- The player's name or nickname must be unique.
- It will be possible to recover the player's name and password in case of forgetting it.
- You can change the password if you wish.
- There will be a single administrator role.

Fig. *6*. Epic user story 1.

User Stories

Identifier: HE 02	**Role:** Player

Title Story:
Develop Cognitive Abilities of space-time orientation

Priority: A (High)

Description:
The player wants to work on the cognitive skills of space-time orientation through a serious game to avoid problems in the learning processes.

Ideas:

- The game will have instructions in a visual and audible way.
- The game will have a greater focus for children from 3 to 6 years old.
- The game will have different activities.

Gameplays:

- **RI 01** The player will move around the space map and will be able to play on a planet if selected.
- **RI 02** The planets will be enabled so that the player can play on the planet they want.
- **RI 03** The player will be able to select each minigame and will be able to respond to each challenge in a given time.
- **RI 04** The player will have a certain time to play and finish the game.
- **RI 05** When the player selects a correct or incorrect answer, a sound will be emitted.
- **RI 07** In order for the player to pass the game on the selected planet, he will have to obtain a minimum of 4 stars out of 5.
- **RI 08** The player must collect letters of the word "SPACE" after beating each minigame.
- **RI 09** The player will have a counter so that he can play for a determined time in each minigame.
- **RI 10** The assistant will be available to give written and audible instructions in each minigame.
- **RI 11** The player must follow the instructions to select the squares, which will be painted when selected.
- **RI 12** The player will respond by joining the upper image with the arrow with a line according to the direction he is looking.
- **RI 15** The player must select and drag the image to place it on a number to order the sequence of actions.
- **RI 16** The player must paint the different arrows according to the direction and color of the sample.
- **RI 17** The player must place the image following the instructions inside a square in a matrix.

Fig. 7. Epic user story 2.

User Stories

Identifier: HE 03	**Role:** Player

Title Story:
View game history

Priority: M (Medium)

Description:
The player wants to view his stored game history to control the progress he has in each activity carried out in the different space worlds.

Ideas:

- After finishing a game the game data will be stored.
- All players will be able to view game history by player name.
- You can filter the data you want to see.
- There will be a search for different data.

Fig. 8. Epic user story 3.

D. Implementation of the Scrum Framework

After obtaining the requirements using the iPlus methodology, the Scrum framework was employed for sprint planning and the subsequent development of the serious game. The following artifacts were generated to support the development process.

a) *Product Backlog*: The Product Backlog consisted of a comprehensive list of tasks to be accomplished during the project's development. The user stories generated during the iPlus methodology were included in the Product Backlog and prioritized by the Product Owner to facilitate release planning. See Figure 9.

Code	User Story	Priority	Duration (h)
HU01-01	Record player data	high	8
HU02-01	game choice	high	8
HU02-04	Score Screen	high	3
HU02-05	Develop game squares	high	twenty
HU02-06	Development matchmaking game by position	high	twenty
HU02-07	Logical sequence game development	high	twenty
HU02-08	Arrow painting game development	high	twenty
HU02-09	game development position	high	twenty
HU01-03	player login	Half	5
HU02-02	Game Menu	Half	4
HU02-10	Achievement Screen	Half	10
HU03-01	Keep punctuation	Half	18
HU01-02	Recover password	Low	6
HU02-03	help screen	Low	4
HU03-02	history screen	Low	12
HU03-03	Search by name player	Low	3
HU03-04	Search by several data	Low	8

Fig.9. Product Backlog.

b) *Release Planning:* The release planning phase commenced once the Product Backlog was defined. The duration of each sprint was determined, with a maximum duration of three weeks. In this project, four sprints were planned, each lasting two weeks (five days per week and six hours per day). The fourth sprint included error correction, testing, and other tasks that arose during development. See Figure 10.

Sprint 1	Sprint 2	Sprint 3	Sprint 4
HU01-01	HU02-06	HU02-08	HU02-10
HU02-01	HU02-07	HU02-09	HU03-01
HU02-04		HU01-03	HU03-02
HU02-05		HU02-02	HU02-03
HU03-04			HU03-02
			HU03-03

Fig. 10. Release Planning.

IV. RESULTS

This section presents the study's results, including the development of a serious game and the assessment of its effectiveness in improving cognitive skills related to spatial-temporal orientation.

The study's results include a high-level figure depicting the game's modules and interactions. The "Game Interface" serves as the central hub, allowing access to player information, game selection, and mini-games targeting cognitive skills. Scores from each mini-game contribute to the overall score. Additional features like password recovery and user data access are available. See Figure 11.

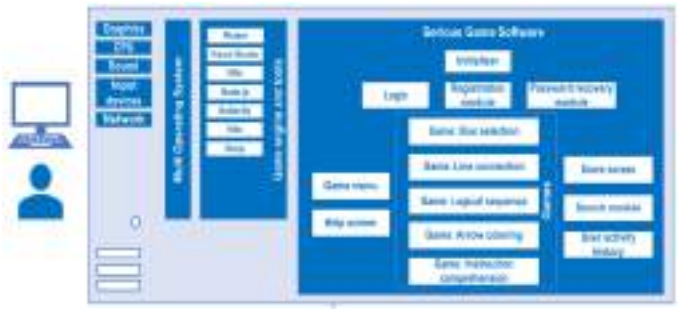


Fig. 11. Serious game structure.

A. Serious Game Development

The serious game developed for this study consists of various modules to provide players with an engaging experience. The initial screen of the game, as shown in Figure 12, provides an appealing and user-friendly interface.

Fig. 12. Initial screen of the game.

The game comprises the following modules:

- New Player Registration Module: This module allows new players to create an account within the game, providing essential information for personalized gameplay.
- Login Module: Players can log into the game using their registered credentials to access their profiles and progress.
- Password Change Module: A secure and convenient module lets players change their passwords when necessary.
- Score Module: This module keeps track of players' scores and achievements, providing a competitive element to enhance motivation and engagement.
- Minigames Module: The core component of the serious game, this module offers five different minigames specifically designed to target and develop cognitive skills related to spatial-temporal orientation.

B. Effectiveness Assessment

The effectiveness of the serious game in improving cognitive skills was evaluated through a series of assessments and observations. Each of the five minigames within the game focused on a specific aspect of spatial-temporal orientation. The following is a summary of the minigames and their objectives:

a) Box Selection Minigame. Designed to enhance spatial awareness and decision-making skills, this minigame challenges players to help the spaceship build a path by selecting the boxes in the matrix according to the instructions shown on the right. See Figure 13.

Fig.13. Box Selection Minigame.

b) Line connection mini-game: To improve visual-spatial coordination and logical thinking, this mini-game requires players to connect the figures shown at the top with the arrows at the bottom, aligning them according to their direction. See Figure 14.

Fig. 14. Line Connection Minigame.

c) Logical Sequence Minigame: This minigame aims to develop sequential thinking and pattern recognition. Players must drag the images onto the squares according to their numbering to arrange them in the correct logical sequence. See Figure 15.

Fig. 15. Logical Sequence Minigame.

d) Focusing on visual discrimination and attention to detail, this minigame prompts players to select a colored arrow from the model and then color the other blank arrows that are similar to the model. See Figure 16.

Fig. 16. Arrow Coloring Minigame.

e) Instruction Comprehension Minigame: This minigame enhances cognitive flexibility and problem-solving skills. Players are tasked with dragging the images and placing them in the matrix according to the instructions provided on the right side of the matrix. See Figure 17.

Fig. 17. Instruction Comprehension Minigame.

C. *Usability Evaluation*

The usability of the developed serious game was a key aspect of this project. In order to evaluate the usability of the game, a comprehensive usability assessment was conducted using a usability testing protocol [18], a questionary, and a task list for evaluation. See Table 1.

The participants were given specific tasks to perform within the game while their interactions and feedback were observed and stored. The tasks were designed to cover various aspects of gameplay and interface usage, allowing for a thorough evaluation of the game's usability.

Usability testing was conducted with a diverse group of participants representing the target user population. To ensure a proper evaluation of the application, the participant group was multidisciplinary and considering that the end-users of these games are individuals with cognitive impairments in spatial and temporal orientation. A total of 16 participants were selected, including computer engineering students, psychologist, pedagogic expert, software engineers, and representatives of end-users who are experts in the field.

TABLE I. TASK LIST FOR EVALUATION

Task	*Description*
New player registration	In the registration interface, enter the username, email, and password selected from the images in the matrix.
Log in	In the login interface, enter the username and password in the matrix.
Mute music	n the main interface of the game, mute the music.
Display the main instructions of the game.	Select the question button in the main game interface to display and listen to the instructions.
Select the black hole game.	In the arrows coloring interface, play the game for one minute.
Select the sun game	In the game interface, order logical sequence, and play for one minute.
Observe the score ranking.	In the scoring interface, observe the top three players.
View the scores of a player.	In the scoring interface, view the scores by any player's name.
Logout	Log out to go to the home screen.
Enter the game as a guest	In the home interface, enter the game as a guest.

The usability evaluation survey used was the Computer System Usability Questionnaire (CSUQ) proposed by IBM [19]. The level of acceptance for the 16 questions, ranging from 1 (totally disagree) to 7 (totally agree), was collected. To provide a rate representation of users' perceptions for specific aspects of usability, an average score (y-axis) for each question (x-axis) is calculated (Figure 19). This calculation involves summing up the individual responses and dividing the total by the number of respondents. After combining the average scores from all the questions, the overall rate is determined to be 90.36%. Moreover, in terms of usability, this rate corresponds to "acceptable" on the Bangor [20] scale (Figure 18).

During the usability testing, participants encountered some challenges in understanding certain game mechanics and navigating the interface. Their feedback provided valuable insights into areas that needed improvement. For example, participants expressed confusion regarding the instructions for certain activities and suggested providing clearer instructions to enhance user understanding.

The game's rating on the Bangor [20] scale was "Acceptable," achieving 90.36% acceptance (see Figure 18). This indicates a high level of acceptance for the application's interfaces, suggesting that they are appropriate and intuitive for effective use. In the discussion of the heuristic evaluation results, it was observed that participants agreed on most of the questions, with higher acceptance for questions 1 and 6. The evaluation affirmed the game's usability, concluding that it is easy to understand and navigate. The quality of the information provided by the application was also positively evaluated, as participants deemed it sufficient for proper use. Additionally, the application's interface received high acceptance, demonstrating its suitability and intuitiveness for effective usage.

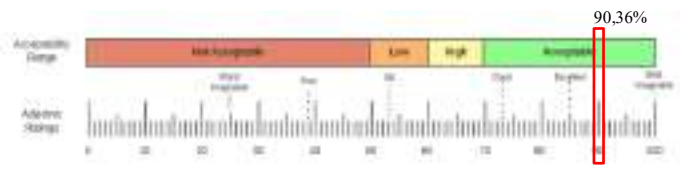
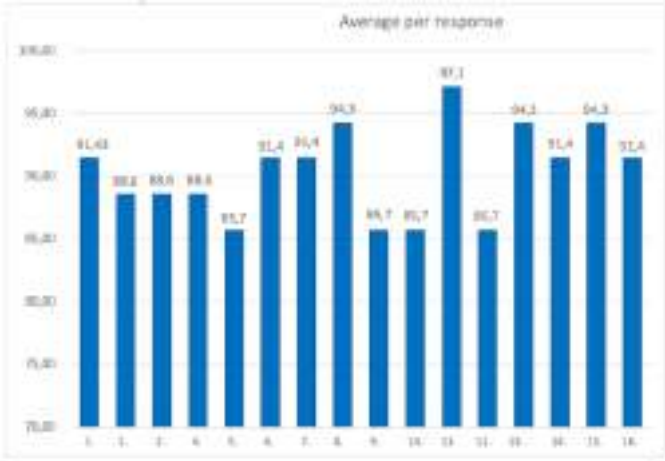


Fig. 18. SUS Score.

The game's usability received high ratings, suggesting that the application is easy to understand and use. It can be concluded that individuals can use the application without significant difficulties in a short amount of time. The results show a high degree of homogeneity in terms of the usability of the serious game.



1	Overall, I am satisfied with how easy it is to use system.
2	It was simple to use system.
3	I am able to complete my work quickly using system.
4	I feel comfortable using system.
5	It was easy to learn to use system.
6	I believe I became productive quickly using system.
7	The system gives error messages that clearly tell me how to fix problems.
8	Whenever I make a mistake using system , I recover easily and quickly.
9	The information (such as online help, on-screen messages, and other documentation) provided with system is clear.
10	It is easy to find the information I needed.
11	The information provided whit the system is effective in helping me complete my work.
12	The organization of information on system screens is clear.
13	The interface of system is pleasant.
14	I like using the interface of system.
15	This system has all the functions and capabilities I expect it to have.
16	Overall, I am satisfied with this system.

Fig. 19. Average answers per question.

D. Overall Findings

The development of the serious game proved successful, with the game offering an engaging and interactive platform for players to improve their cognitive skills related to spatial-temporal orientation. Each minigame provided a unique activity with diverse scenarios, clear instructions, and configurable playtime.

Applying the iPlus methodology facilitated the gathering of requirements, ensuring the game design met the target audience's needs. The agile SCRUM methodology facilitated efficient project management, allowing for iterative development and continuous improvement.

The serious game demonstrated its potential to support the development of cognitive skills among users. The varied and targeted nature of the minigames offered within the game allowed for specific skill improvement in spatial-temporal orientation. The game's tracking system enabled players and tutors to monitor progress and performance over time.

The usability evaluation conducted on the developed serious game highlighted its strengths and improvement areas. The usability testing and heuristic evaluation findings provided valuable insights into the game's usability and user experience.

The evaluation revealed that while the game was generally engaging, participants encountered challenges in understanding certain game mechanics and navigating the interface. These findings indicate the need for improvements in providing clearer instructions and enhancing the interface's intuitiveness.

Conclusions

In this study, a serious game was designed and developed to improve cognitive skills related to spatial-temporal orientation. The game consisted of five minigames, each targeting specific aspects of cognitive abilities. The following conclusions can be drawn from the findings:

- Successful Development of the Serious Game: The designed serious game proved successful, providing an enjoyable and engaging experience for players. Incorporating diverse modules, such as registration, login, password change, scores, and minigames, contributed to a comprehensive gaming experience.
- Methodology and Agile Development: Applying the iPlus methodology proved valuable in gathering requirements from the product owner. It enabled the identification of user stories, gameplays, gamification elements, characters, and scenarios, which served as the foundation for the development process. The agile SCRUM methodology facilitated efficient project management, allowing for iterative development and continuous improvement.
- Cognitive Skill Enhancement: The five developed minigames targeted specific cognitive skills related to spatial-temporal orientation. The Box Selection, Line Connection, Logical Sequence, Arrow Coloring, and Instruction Comprehension minigames provided opportunities for players to enhance their spatial awareness, decision-making, visual-spatial coordination, logical thinking, sequential thinking, pattern recognition, visual discrimination, attention to detail, cognitive flexibility, and problem-solving skills. The clear instructions and configurable playtime within each minigame further contributed to the effectiveness of skill improvement.
- Tracking and Progress Monitoring: The serious game included a tracking system that allowed players and tutors to monitor individual progress and performance. The tracking system facilitated the identification of strengths and areas for improvement, providing valuable insights for personalized learning and intervention strategies.

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