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A Intelligent Security Power Lab (SPL): The Ultimate Serious Game Training in Cybersecurity

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Abstract: Traditional cybersecurity training methods are ineffective and lack engagement, leading to low retention and limited practical application. Serious games offer an interactive and promising solution to address these issues. However, the literature review reveals a shortage of diverse educational content that is customized to suit users' preferences and different types of learners, as well as a wide range of tasks that promote a diverse learning environment. To address this gap a serious game called Security Power Lab (SPL) is designed and implemented to provide an effective learning platform for individuals, including students and employees and to enhance their technical skills in cybersecurity. The SPL offers real-time feedback on users' performance, allowing them to practice and develop their skills efficiently. Additionally, the SPL offers a wide range of educational content that is customized based on users' preferences and takes into account their knowledge, skills, and abilities (KSAs). The SPL has implemented using the Godot engine, chosen for its essential tools and features that enhance the uniqueness and captivating experience of the game. The game has been evaluated to validate the design concept and objectives through testing the game among participants. Next, the System Usability Scale (SUS) is employed as a commonly used self-administered tool to ensure that products conform to specific quality and usability criteria. Finally, a comparison between the SPL game and the previous games has been presented and discussed. The results indicate that the proposed game serves as a crucial training tool for increasing cybersecurity knowledge and abilities. Furthermore, the game has strong system usability, with a good score of 74.09%. Finally, the SPL distinguishes itself from other serious games through its inclusive range of educational content, tailored to the individual user's knowledge, skills, and abilities (KSAs) as well as their personal preferences.

Keywords: *Serious Game; Game Development; Cyber Security Awareness; Cyber Security Training*

1. Introduction

The internet is being used extensively worldwide for various purposes, creating a global marketplace but also exposing vulnerabilities to cybercrime and misuse. To prevent this, many security tools are available to organizations to ensure the confidentiality, integrity, and availability of information, which is an essential aspect of information systems security [1]. Information security should not only involve technological elements but also consider the human factor, including individuals such as computer users, enforcement team members, and other information system resources. The knowledge, attitudes, skills of these individuals typically influence their involvement in information security [2]. To successfully implement security policies in an organization, it is essential to increase employees' awareness of the policies. Different methods have been used to promote security awareness, but their effectiveness is uncertain. A lack of knowledge and expertise in this field is a significant contributing factor to organizations' struggles to achieve adequate cybersecurity [3]. The primary aim of training is to furnish employees with current information with knowledge about the organization's goals [4]. Researches have shown that serious games have been effective in producing positive outcomes in organizations compared to traditional training methodologies. Organizations are adopting game-based approaches to reduce costs, save time, and increase staff motivation and commitment. To ensure that educational objectives are met, it is crucial to focus on creating serious games with clearly defined educational goals that encourage the development of essential skills, thus improving learners' cognitive and intellectual capacities [5, 6]. The primary aim of this study is to propose a novel serious game called Security Power Lab (SPL), which offers an efficient learning platform for students and employees. The SPL provides an extensive range of educational content tailored to users' preferences, taking into account their knowledge, skills, and abilities (KSAs). Furthermore, the SPL caters to a wide range of tasks to promote a

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varied learning experience, all geared towards achieving the primary goal of the game. This paper is structured as follows: Section 2 provides a review of the literature on previous studies related to the research topic. Section 3 research contributions have been presented. Section 4 introduces the proposed serious game (SPL). In Section 5, the implementation of the game has been presented. In section 6, the evaluation of the game is presented. Finally, Section 7 presents the conclusion of the paper.

2. Literature Review

This section categorizes the most well-established security-related games from the literature based on their primary objective. In term of educating and increasing awareness of the players. In the study by [7], a card game was employed that can be played by all employees in a company, aimed at enhancing their understanding of the threat and documenting security requirements pertaining to social engineering. According to the [8], Anti-Phishing Phil game has been developed to offer a tool that is easy for users to use to learn about phishing attacks. Furthermore, in [9], a 2D educational game named "Bird's Life" was created to educate college students and individuals with general interest about phishing. Moreover, the work conducted by [10] discusses a game called CyberCIEGE, which is designed to be an engaging and interactive way to teach security awareness and support organizational security training goals. Moreover, as per [11], The Hack Space is an integrated game model. The primary aim of The Hack Space is to produce experts who possess the ability to manage security at various levels and have a comprehensive grasp of the processes, functions, and controls essential for security.

In the research discussed in [12], a computer game called BEWARE has been developed with the aim of improving users' cybersecurity awareness through gameplay. The game covers a range of cybersecurity aspects, including social engineering, email phishing, identity fraud, information security, and more. The Cyber Security Lab (NOVA labs) [13] is a game that challenges players to take on the role of a chief technology officer of a start-up social media company and defend against progressively more sophisticated cyber-attacks. The game promotes cyber security awareness by presenting a series of challenges, including coding, password-cracking, social engineering, and other types of cyber battles.

SECURITY-CyberTechs [14] is an innovative digital gaming platform designed for elementary students to educate them on cybersecurity and privacy topics. The platform is made up of a web-based LCMS and a DGBL app, which are intended to be used alongside traditional teaching methods rather than replacing them. What.Hack [15] is an educational game that helps students learn how to identify and avoid phishing scams. The game presents players with different scenarios that mimic real-life situations and allows them to make decisions and see the consequences of their actions. Pomega [16] is a 2D game aims to increase users' knowledge of cybersecurity awareness. The game covers five cybersecurity awareness topics, including phishing, passwords, social networks, mobile security, and physical security. Users are encouraged to complete the game, as they receive a certificate after finishing the game or a topic. The aforementioned research papers highlight a notable gap in the availability of diverse educational content that can be personalized to cater to users' preferences and accommodate various types of learners. Furthermore, there is a recognized dearth of comprehensive tasks that effectively foster a diverse learning environment. This analysis underscores the need for innovative approaches that address these limitations and enhance the educational experience for a broader range of users.

3. Study Objectives

The major objectives of this work are:

First, designing and implementing a comprehensive and innovative training method called Security Power Lab (SPL) cater to a wide range of users, such as students and employees, with the aim of enhancing their technical expertise in the field of cybersecurity.

Second, the proposed game provides rich content material for users of different skill levels and backgrounds, which is crucial for effective cybersecurity education and makes it a comprehensive and informative tool for cybersecurity education and training.

4. Proposed Security Power Lab Game (SPL)

The proposed serious game designed and implemented based on the player level of awareness, the materials and content should be regularly selected and extended through some game exercises. There should be a large selection of tasks and exercises divided into different security categories. Also, there should also be different types of tasks to attain diversity in the learning environment to achieve main goal of the game which is learning through game. The proposed serious game "Security Power Lab" went through four primary stages: Conceptual, Design, Development, and Achievement. These stages were used to guide the design and development of the game.

Conceptual Phase: During the conceptual phase, it is necessary to identify user preferences, such as the player's abilities, and system preferences, such as instructional content, in order to establish the objectives for playing a serious game. In SPL the user preferences and system preferences (Learning Objectives, Learning Strategy and Educational Content) have been settled based on the user profile that the player filled before starting the game. Additionally, the type of game and the skills needed fall under the category of game genres. The SPL emphasizes the importance of game genres as the initial phase in designing serious games. In the proposed SPL serious game, the genres implemented consists of RPG.

Design Phase: The design of the serious game "Security Power Lab" encompasses various aspects, including experiences, mechanics, components, dynamics, and technology,

which were implemented to cater to user preferences and system preferences. These elements were incorporated into three primary elements of the game's design process:

Actions: Via Learning technique, Instructional content and Game Strategy

Scaffolding: game element such as time, feedback, levels, points and etc.

- Achievements: Learning

Development Phase: The objective of this phase is to outline all of the game elements that are essential and relevant to the context of serious game development. The implementation has been discussed in next section.

Achievement Phase: In this phase, in order to achieve main goal of the proposed serious game throughout the process of selecting the right elements and implementing the correct environment during developing the SPL. the objectives of serious games in educational settings are described as a learning. The proposed serious game framework for the design and implementation of the SPL Security Power Lab game is presented in Figure 1.

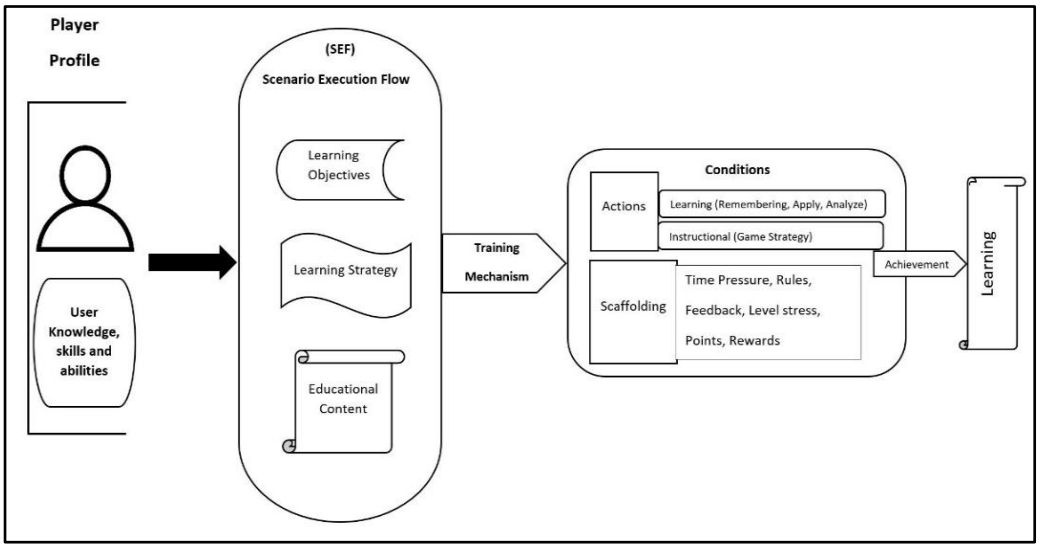

Fig 1: Proposed serious game framework

The proposed serious game framework consists of the followings;

User Profile

The player's profile is analyzed to identify their knowledge, skills, and abilities (KSA) characteristics. The learner's profile includes their learning history, characteristics such as age and retention ability, learning preferences such as experiences, job position, and level of education and certification.

Scenario Execution Flow (SEF):

The components of the serious game are categorized into three types: assessment (gaming), learning, and instructional, based on the type of activity they facilitate. However, a component may serve more than one type of activity over time. In the SPL framework, scenario execution flow undergoes through three main components:

Learning Objectives: The learning objectives (LOs) are concise descriptions that outline the KSAs (Knowledge, Skills, and Abilities) that a player (such as a student or employee) is supposed to acquire at the conclusion of a game session.

Learning Strategy: The learning strategy refers to the approach taken during a game session to assist learners in achieving the learning objectives.

Educational Content: Educational content represents the information providers in the environment a serious game operates. For the educational content, SPL relies on the one of the standard information security references which is “Computer Security Principles and Practice” by “William Stallings & Lawrie Brown”. Based on the information provided, the proposed serious game has been designed and implemented according to the proposed category that presented Figure (2)

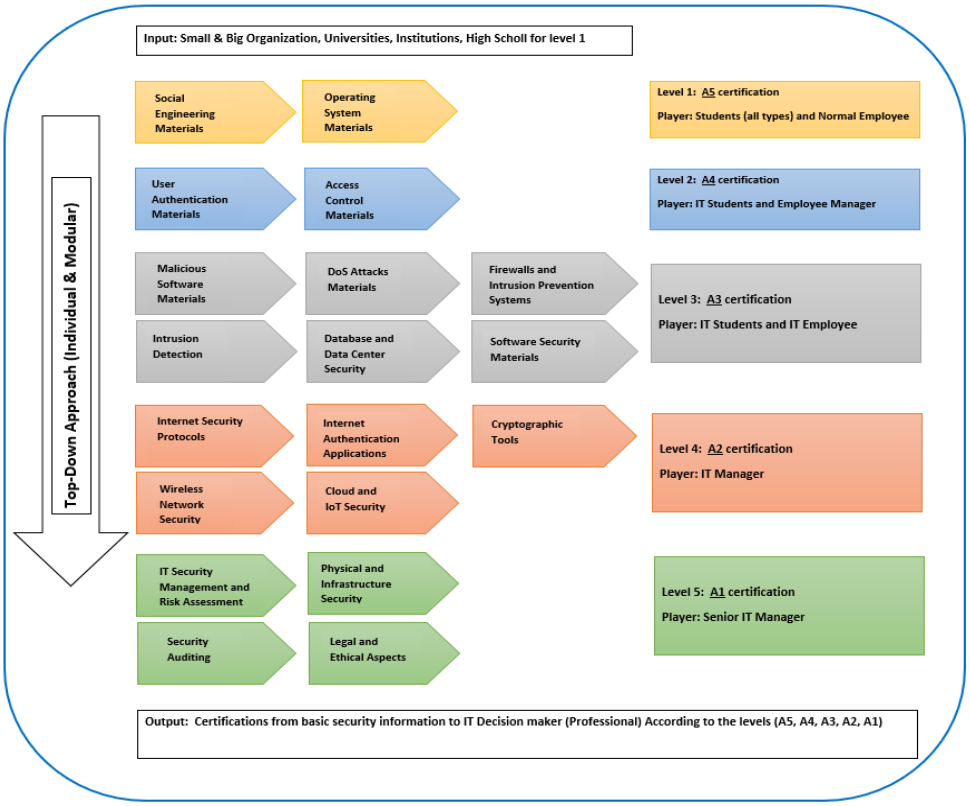

Fig 2: SPL Educational content categories

By incorporating these educational content categories into the game environment as showed in Figure 2, players are able to learn about cyber security in a more practical and hands-on way. They are able to apply the knowledge and skills they have learned to solve problems and challenges, which helps to reinforce learning and increase retention.

Conditions

To design and develop effective cyber security serious games, the SPL framework identifies an important component called conditions. As per condition component, learners must complete a series of tasks in a specific order to successfully execute one or more SEFs (Scenario Execution Flows). These sequences in which tasks have to be performed fulfill game's goals have interdependencies and relations are;

Actions: In the game, learners perform operations called actions that are aimed towards a specific goal. These actions can be broken down into smaller units known as operations. In SPL, the actions decomposed into two main units:

Learning: The SPL framework aims to incorporate a variety of effective learning strategies based on modern theories and innovative techniques in serious games. The framework aims to support continuous learning and training by adopting a layered learning approach, which involves a series of sessions that gradually increase in duration, complexity, and challenge.

Instructional (Game Strategy): The way in which an instructor can provide assistance, guidance and feedback to aid learners in achieving their learning objectives is known as instructional actions. Components in serious games are categorized into gaming, learning and instructional depending on the kind of activity they support. Within SPL, instructional actions (game strategy) are meant to provide help, guidance and feedback to enable learners to achieve the learning objectives of the game and reflect on their progress. The learning strategy perspective requires that learners grasp a SEF and visualize the game plan, while the instructional perspective involves choosing an appropriate game genre that can assist learners by narrowing down the set of SEFs presented to them.

Scaffolding: The SPL framework highlights the importance of scaffolding and adaptability in cyber security serious games. In the beginning, the framework examines the adaptability features of the learners' learning profile and the educational context attributes. The game's adaptive elements, including the interface, scoring, rewards, task duration, game resources, and stress levels, are tailored to better suit the learners' requirements. SPL applies the best game process elements in term of Mechanics, Components, Dynamics and Technology have been selected which are suitable for the proposed serious game.

Achievements are problems the learner has to solve in the context of the game. The main goal of capabilities classification achievement is to assess the players abilities throughout the game exercises based on the educational content that have been presented in an enjoyable and motivated game environment and to classify their skills and knowledge to determine their levels and employment position in any related organization.

SPL Implementation

Godot engine has been used to implement the SPL because it is a free and open-source game engine that provides a comprehensive set of tools for developing 2D and 3D games. It

supports a variety of platforms, including Windows, Linux, macOS, iOS, Android. The languages used in this implementation consist of GDScript which is the language Godot Engine uses to create games it's close to Python programming but has its different functions and uses, C++ was used as well to get accurate results and the use of the CPU to go against the player. The proposed game is offline which helps the learner to play anywhere at any time without the need of constant internet, all that is required is a PC that can handle the engine which even then it is not demanding. SPL serious game provides guides and rules to the learner and reward them as they play the game and give them a certificate at the end. The flow chart of the SPL presented in Figure 3.

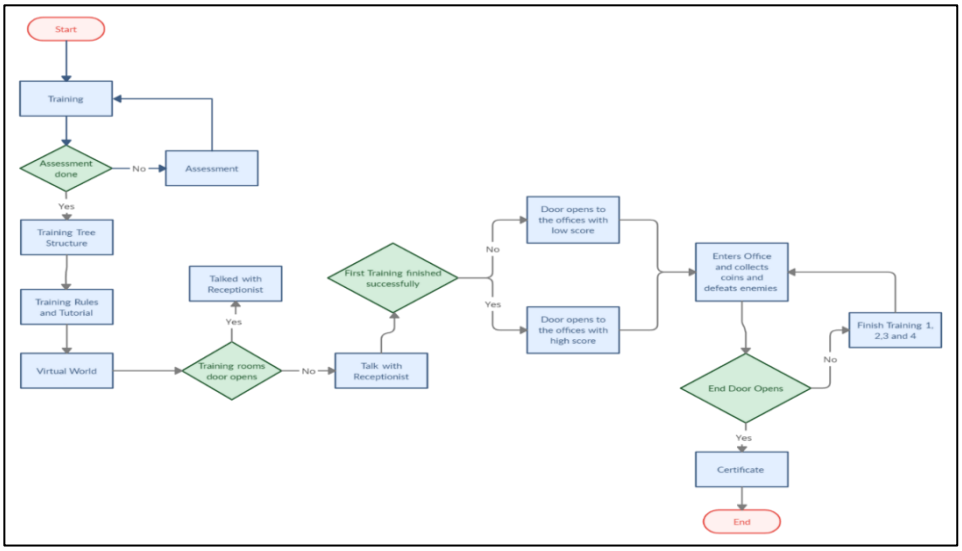

Fig 3: SPL flow chart

The players have to complete a set of challenges in a set amount of time even though if they ascertain a good amount of score, they can retain their constitution for their character and extend the timer. The players can find score by resisting attacker, finishing the trainings successfully and collecting them around the environment. The player must first speak with the receptionist to enter the facility. Afterwards they have to finish each training to access the next one all while resisting or avoiding spread out attackers that will either take score from the player. The player is timed but they can get more time and get constitution back by interacting with the vendor in the map to increase their time. However, doing so will cost them score. On the other hand, there are various ways to get more score aside from just beating the training mini games. After all training modules are done the player can finally exit the facility using the end portal in which they will get another certificate with their final score. After the player created their profile, they can access directly the game. The game might be used by any organization to train and increase their employees. After they enter this section, the player sees the map of the game with dialog and what they have to do as shown in Figure 4.

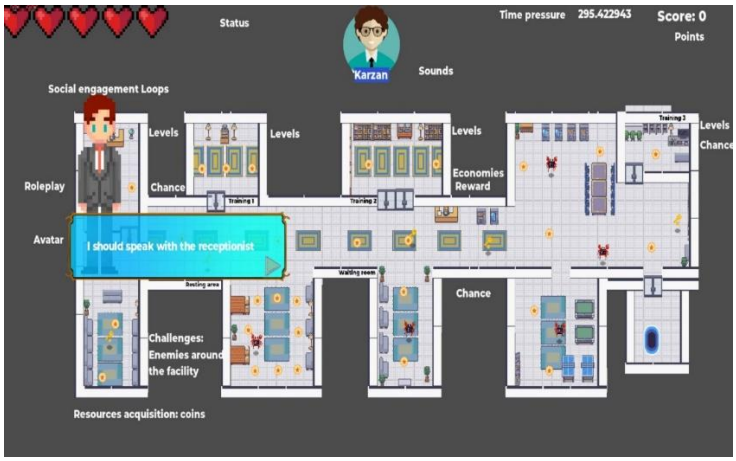

Fig 4: SPL map of the game

Next, when the player speaks with the NPC (Non-Playable Character) an educational, the mini games start that teaches the player about the appropriate information based on the player's KSA. Figure 5 demonstrate some screens of the implemented mini games.

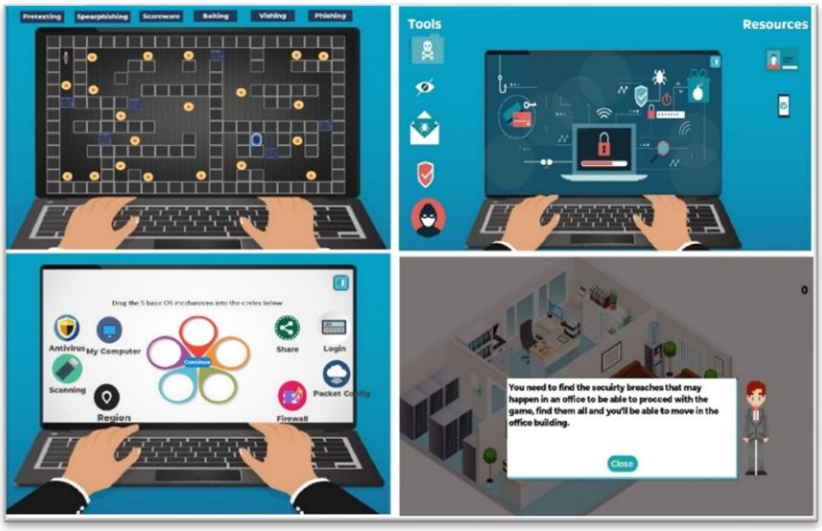

Fig 5: SPL game progresses

5. SPL Evaluation

In this section, the evaluation of the proposed security power lab game (SPL) has been presented. Firstly, the game has been evaluated to validate the design concept and objectives through testing the game among participants. Next, the System Usability Scale (SUS) is employed as a commonly used self-administered tool to ensure that products conform to specific quality and usability criteria. Finally, a comparison between SPL game and the previous games has been presented and discussed.

6.1 Data Collection

For data gathering, a personal demonstration of the game was given, and participants were interviewed during the game to gain insight into their thoughts and feelings about the game. The qualitative feedback obtained was supported by quantitative data, which was collected and conducted with 129 participants, it was found that the users belonged to different positions, including students, employees, employee managers, IT employees, IT managers, and senior IT managers. Moreover, they had varying levels of degrees ranging from Diploma to PhD. This diverse group of users provided valuable insights into the effectiveness of the game in different scenarios and for different types of learners. Details about the participant are shown in Tables 1-5.

Table 1: Gender frequency

Variables	Classes	Frequency	Percentage
Gender	Male	99	76.7%
	Female	30	23.3%

Table 2: Age frequency

Variables	Classes	Frequency	Percentage
Age	Less Than 20	33	25.6%
	20-25	44	34.1%
	26-30	15	11.6%
	31-35	22	17.1%
	36-40	12	9.3%
	More Than 41	3	2.3%

Table 3: Degree of the participants

Variables	Classes	Frequency	Percentage
Certification	High School	20	15.5%
	Diploma	28	21.7%
	BSc	67	51.9%

	Master Degree	9	7%
	PhD	5	3.9%

Table 4: Job Description of participants

Variables	Classes	Frequency	Percentage
Job Description	Student	82	63.6%
	Employee	14	10.9%
	Employee Manager	4	3.1%
	IT Employee	16	12.4%
	IT Manager	6	4.7%
	Senior IT Manager	7	5.4%

Table 5: Years' Experience participants

Variables	Classes	Frequency	Percentage
Years' Experience	Student	83	64.3%
	Less than 5	19	14.7%
	6-10	14	10.9%
	11-15	6	4.7%
	16-20	5	3.9%
	More than 21	2	1.6%

6.2 SPL User Evaluation

The game has undergone thorough evaluation process, taking into consideration the viewpoints of the players and focusing on its well-designed, interactive, and learnability achievements aspects. To gauge the quality of the game, data was collected from a comprehensive survey administered to the players. This survey specifically targeted questions number 5, nubmer 7 and number 9, which were carefully crafted to extract relevant information related to the game's design, interactivity, and its effectiveness in facilitating learning. By focusing on design, interactivity, and learnability achievements,the evaluation aimed to assess how well the game met its intended objectives and how it resonated with the players' expectations. The results of the survey and the participants' responses were organized and presented in Table 6 and Figure 6. Table 6 offers a detailed breakdown of the participants' feedback in relation to the game's well-designed, interactive, and learnability achievements aspects.

Table 6: Years' Experience participants

Rate/questions	Well Designed	Interactive	Learning
Strongly agree	48	48	43
Agree	57	47	51
Neither agree nor disagree	19	22	26
Disagree	3	10	7
Strongly Disagree	2	2	2
Participants	129	129	129

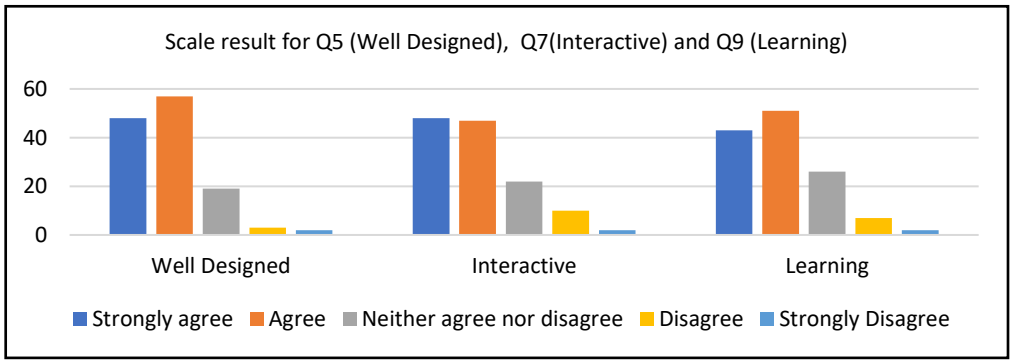

Fig 6: SPL game progresses

Based on the feedback gathered from a sample of 48 participants, it is evident that there is a strong consensus regarding the high quality of the proposed game in terms of its design and interactivity. A significant majority of the participants expressed strong agreement with regards to these aspects, highlighting the game's effectiveness in facilitating quick and efficient learning. The positive response from such a substantial number of participants lends credibility to the claim that the game is not only visually appealing but also fosters an interactive environment that promotes rapid comprehension and skill development.

Also, a majority of the participants, numbering 57, expressed agreement regarding the game's well-designed nature, highlighting the thoughtful attention given to its visual aesthetics, user interface, and overall presentation. Additionally, 47 participants specifically acknowledged the game's interactive elements, affirming its ability to facilitate rapid learning.

Furthermore, the feedback obtained from a subset of 19 participants, it can be observed that there is a level of ambiguity regarding the perception of the proposed game's design. These participants neither agreed nor disagreed on the game's design, indicating a lack of a clear consensus. Similarly, 22 participants expressed a neutral stance on the game's interactivity for quick learning, neither agreeing nor disagreeing with its effectiveness in facilitating rapid comprehension.

Based on the feedback gathered from a small subset of 3 participants, it is evident that there are individuals who disagree with the notion that the proposed game has been well designed. These participants expressed their dissatisfaction with the game's design, indicating potential areas of improvement that need to be addressed. Similarly, 10 participants disagreed with the game's interactivity for quick learning, suggesting that they found the game lacking in terms of effectively promoting rapid comprehension. These dissenting views highlight the importance of considering diverse perspectives and opinions in the evaluation process.

Based on the feedback received from a small subset of 2 participants, it is evident that there are individuals who strongly disagree with the assertion that the proposed game has been well designed and interactive for quick learning. These participants expressed their strong dissatisfaction with both the design and interactivity aspects of the game, suggesting significant areas of concern. The feedback from these participants highlights the need for careful examination and analysis of their specific criticisms to identify potential shortcomings or issues that may have led to their strong disagreement.

In another hand, based on the feedback received from a diverse group of participants, it is evident that the proposed game has largely succeeded in achieving its intended goals of facilitating learning. A significant number of 43 participants expressed strong agreement, while an additional 51 participants agreed that the game effectively contributes to their learning objectives. These responses highlight the positive impact of the game in supporting and enhancing the learning experience. However, it is worth noting that 26 participants neither agreed nor disagreed on the game's effectiveness in achieving learning goals, indicating a level of uncertainty or mixed opinions within this subset. Additionally, a small number of participants, comprising 7 individuals, disagreed that the proposed game successfully achieves the intended learning goals. Among them, 2 participants strongly disagreed with the game's ability to meet the desired learning outcomes.

Overall, these findings serve as valuable evidence of the game's success in meeting its intended goals and substantiate its reputation as a well-designed and interactive learning tool. These collective findings suggest that the proposed game successfully combines a visually appealing design with interactive features, creating an engaging learning environment that effectively captures the attention and promotes quick comprehension. Moreover, the evaluation provided valuable feedback and actionable recommendations for further improvements. This player-centric evaluation methodology ensures that the game is aligned with the expectations and preferences of its intended audience, ultimately enhancing the overall gaming experience.

6.3 System Usability Scale (SUS)

The System Usability Scale (SUS) is a survey scale that can be used to evaluate the usability of a product or service in a simple and efficient manner. This tool is effective in assessing the usability of various user interfaces, including software interfaces, web pages, web applications, cell phones, networking equipment, pagers, speech systems, and video delivery hardware and software. It is particularly useful in the context of serious game testing [17]. Additionally, the SUS possesses various qualities that make it an appropriate selection for usability professionals [18]:

- The questionnaire is not specific to any technology, making it suitable for different products and services.
- It can be completed quickly and easily by users.
- Providing a single score that can be easily understood by different professionals, from project managers to computer programmers.
- Also, the survey is non-proprietary, making it cost-effective.

The System Usability Scale (SUS) consists of 10 statements that are rated by respondents on a 5-point Likert scale, where the strength of their agreement is indicated. Figure 7 shows these statements. The SUS is widely used to evaluate the learnability and usability of various products [19].

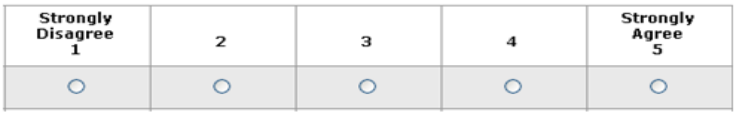

Fig 7: SUS response format

The SUS survey employs the following response format:

1. I would use this system frequently.
2. The system seemed unnecessarily complex.
3. The system was easy to use.
4. A technical person's assistance would be necessary for me to use this system.
5. The various functions in the system were well integrated.
6. There was too much inconsistency in the system.
7. Most people would learn to use the system quickly.
8. The system was cumbersome to use.
9. I felt confident using the system.
10. A lot of learning was required before I could get going with the system.

The SUS generates a score between 0 to 100 to indicate the level of usability, with higher scores representing better usability. However, since the statements in the survey alternate between positive and negative, one must be careful when scoring it [20]. The SUS score is computed based on a formula created by Brooke [20], which involves several steps:

- For odd-numbered statements, one is subtracted from the user response.
- For even-numbered statements, the user response is subtracted from 5.
- The converted responses for each statement are added up for each user. The total is multiplied by 2.5, which rescales the possible range of values from 0-40 to 0-100.

Although SUS scores range from 0 to 100, they should not be interpreted as percentages. To assess how a product performs compared to others, its percentile ranking needs to be examined. An above-average SUS score would be anything above 68, while a score below 68 would be considered below average [21]. Although originally designed to assess only the perceived ease-of-use of a system, recent studies have demonstrated that SUS can also serve as a comprehensive measure of overall system satisfaction [22]. In addition, SUS can be divided into two separate subscales that measure usability and learnability. The Usable subscale includes 8 items, while the Learnability subscale includes only two items, specifically, Items 4 and 10.

The feedback received through qualitative methods was corroborated by quantitative data that was gathered using a standardized questionnaire grounded on the system usability scale (SUS). There were 129 individuals who expressed interest in participating in the survey. These individuals were required to fill out questionnaires after playing the game, as part of their role as quality testers for the thesis. Participants were instructed to test the game and after completion, they were asked to answer questions about the "Security Power Lab (SPL)" application using the SUS standard survey. The questionnaire consists of ten questions that the participants are required to respond to. Each question was rated on a scale ranging from strongly agree to strongly disagree. Figure 8 and 9 depict the outcomes of the system usability scale questionnaire for each question, illustrated using a histogram.

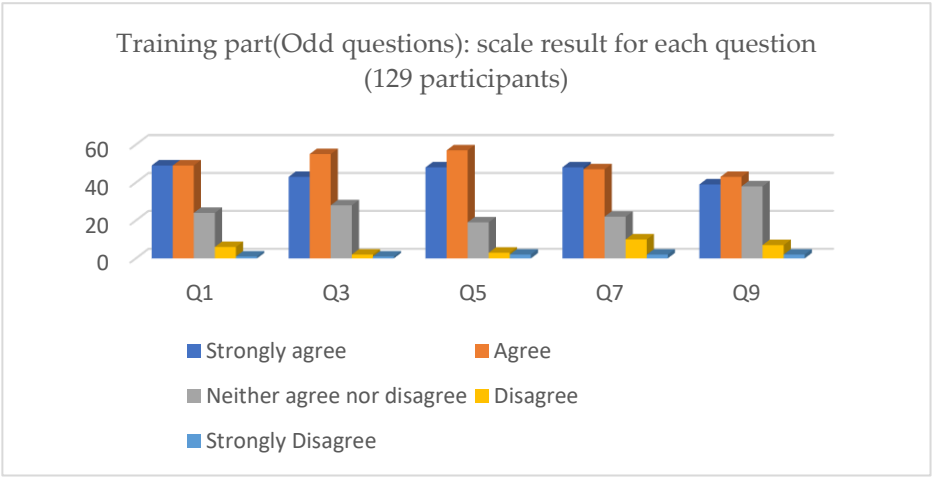

Fig 8: scale result for each question (odd questions)

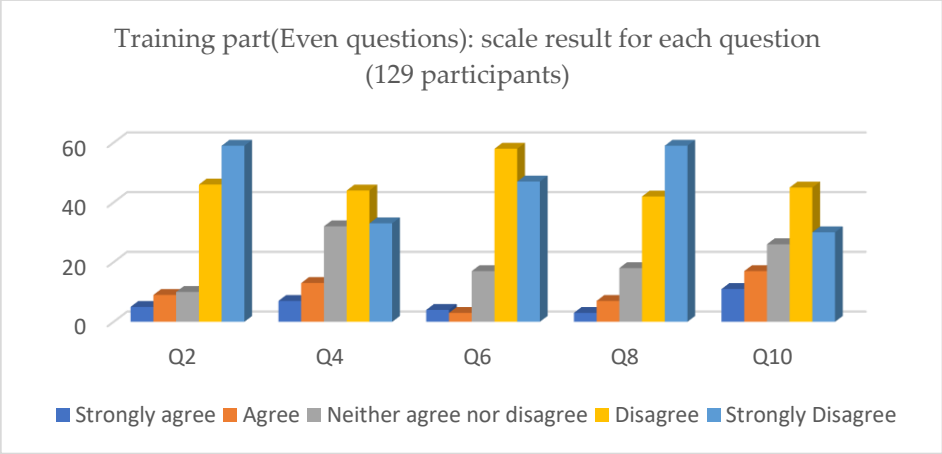

Fig 9: scale result for each question (even questions)

The score for system usability is computed by taking into account the rating for each item, ranging from 1 to 5. If the item is odd-numbered, the score is obtained by subtracting the rating from the scale position; if the item is even-numbered, the score is obtained by subtracting the scale position from the rating. Table 6 outlines the scoring for each item based on its scale position.

Table 7: System Usability Scale Scoring

Item	Scale	Score
Odd number item (Q1, Q3, Q5, Q7, Q9)	1	0
	2	1
	3	2
	4	3
	5	4
Even number item (Q2, Q4, Q6, Q8, Q10)	1	4
	2	3
	3	2
	4	1
	5	0

To calculate the overall value of the system usability, the score for each of the 129 participants was added together and the result was over 40. This score was then multiplied by 2.5 to obtain a number between 0 and 100. The total score for all participants was then calculated by summing each individual's score. The final outcome was based on the total score collected from 129 participants. The average score was determined by dividing the total score, which was 129, by the number of responses. According to reference [23], if a System Usability Scale score is 68% or higher, the system has strong usability. This statement is supported by reference [24], which categorizes a score of 68% as average, 68% to 80.3% as good, and 80.3% to 100% as excellent. Consequently, the game designed in this section received an average SUS score of 74.09%, indicating good usability in terms of effectiveness, efficiency, and user satisfaction.

6.4 Comparison with Previous Works

The comparison between the proposed SPL game and other games has been presented based on some significant criteria as shown in Table 8.

Table 8: SPL vs other works

Games / Criteria	BE-WARE	GHOST	Game Card	Cyber CIEGE	What. Hack	Pomega	Proposed game (SPL)
User type	Young, Employee (Non-technical)	all employees who use digital systems	Employee (Non-technical)	Employee (Technical) Not specify the level of user ability	young professionals at least 18 years old (Non-technical)	Any user (Technical or Non-technical) users aged 15-25 years old	Students, employees based on KSA

Education content	Some specific information on cybersecurity threats	Basic information security such as screen lock, Phishing-Mails and Backups	Social engineering	Network security	Anti-Phishing attacks	Some specific topics: password, phishing, social network, mobile security.	Rich topics. Refer to Figure 5.4 Chapter 5
Learning Objectives	YES	YES	YES	YES	YES	YES	YES
Game Strategy	role-play and simulation	role-play and simulation	role-play and simulation	role-play and simulation	role-play and simulation	role-play, simulation and Test	role-play, simulation; Puzzle
Domain Achievement	YES	YES	YES	YES	YES	YES	YES
Interaction	Single player	Single player	Single player	Single player	Single player	Multi player	Single player
knowledge requires	NO	NO	NO	YES	YES	NO	Based on KSA
User Preferences	NO	NO	NO	NO	NO	NO	YES
Leadership board	YES	YES	YES	NO	NO	YES	YES

Table 8 assesses the SPL with the aforementioned games:

✓ In term of leadership board and learning objectives, the SPL system assesses learners' performance by tracking their progress during gameplay and providing feedback at the end of each session. It checks if learners have completed the specific tasks associated with the session's learning objectives (LOs).

✓ Also, in term of game strategy, the SPL framework models' multiple aspects of a game, such as the learners' tasks based on role paly, simulation environment, puzzle that allow the supervision of learners' actions. This feature cannot be found in the literature studies.

✓ Moreover, in term of education content, the SPL have a rich educational content that can be used for educating university students in IT specialty and for all type of employee in any related organization.

✓ In addition, the SPL is the only serious game that provides the education content of the game based on the user preference which depend on the player KSAs.

✓ In term of the user type, students and employees based on KSA level can use the SPL. The proposed SPL game have much more user types compared with the other games.

✓ Furthermore, the security training component of the SPL addresses the challenges of live competitions, by providing multiple exercise scenarios that cover various aspects of a cybersecurity curriculum. These scenarios are designed based on the educational program, including learning objectives, teaching content, and educational context, and eliminate organizational and functional issues associated with live competitions.

6.5 Findings

- The proposed serious game successfully combines a visually appealing design with interactive features, creating an engaging learning environment that effectively captures the attention and promotes quick comprehension.
- The game yielded exceptional results, as evidenced by the average System Usability Scale (SUS) score of 74.09%. This score indicates a high level of usability in terms of effectiveness, efficiency, and user satisfaction.
- The results of the evaluation revealed that the participants were comfortable with the game and found it to be interactive and enjoyable. It demonstrates that serious games can be an engaging and enjoyable tool for cybersecurity education and that participants of various skill levels and degree backgrounds can benefit from them.
- The proposed game provides a tailored learning experience for users of different skill levels and backgrounds, which is crucial for effective cybersecurity education. Furthermore, the rich content materials of the proposed game make it a comprehensive and informative tool for cybersecurity education.

- Moreover, the evaluation provided valuable feedback and actionable recommendations for further improvements. This player-centric evaluation methodology ensures that the game is aligned with the expectations and preferences of its intended audience, ultimately enhancing the overall gaming experience.
- Finally, these findings demonstrate the uniqueness of the proposed game compared to previous works. Overall, by contrasting the proposed game with prior works, it becomes evident that proposed serious game is an efficient method of educating individuals on cybersecurity.

6. Conclusion

Cybersecurity training program using serious game is an active area of research and development. a novel serious game designed to serve as an effective learning platform for individuals, such as students and employees, with the aim of enhancing their technical skills in the field of cybersecurity named Security Power Lab (SPL). The game offers a diverse range of educational content tailored to users' preferences, taking into consideration their existing knowledge, skills, and abilities (KSAs). This personalized approach ensures that users receive customized and relevant learning materials, enabling them to effectively enhance their cybersecurity competencies. The implementation of SPL has been achieved using Godot engine because it provides the necessary tools and features for serious games to make the SPL a unique and captivating game experience.

The results indicate that the proposed game serves as a crucial training tool for increasing cybersecurity knowledge and abilities. Furthermore, the game has strong system usability, with a good score of 74.09%. Finally, SPL distinguishes itself from other serious games through its inclusive range of educational content, tailored to the individual user's knowledge, skills, and abilities (KSAs) as well as their personal preferences.

Finally, it is suggested to expand the SPL game to take the form of big online lab center for national security adoption. This would involve integrating the game with other online resources and tools related to national security, creating a comprehensive online learning platform.

References

[1] Mishra, Alok, et al. "Cybersecurity enterprises policies: a Comparative study." Sensors 22.2 (2022): 538.

[2] Triplett, William J. "Addressing human factors in cybersecurity leadership." Journal of Cybersecurity and Privacy 2.3 (2022): 573-586.

[3] Ahmed G, Ragsdell G, Olphert W (2014) Knowledge sharing and information security: a paradox? In: 15th european conference on knowledge management (ECKM 2014), Polytechnic Institute of Santarém Portugal. pp. 1083–1090

[4] singh, h., singh, b.p.: e-training: an assessment tool to measure business effectiveness in a business organization. in: 2015 2nd international conference on computing for sustainable global development (indiacom), new delhi, pp. 1229–1231 (2015).

[5] Amin, Gulala Ali Hama, and Karzan Hussein Sharif. "Kurdish Language Learning Tool in Serious Game." Kurdistan Journal of Applied Research (2020): 13-23.

[6] Sharif, Karzan H., and Siddeeq Y. Ameen. "A review of security awareness approaches with special emphasis on gamification." 2020 International Conference on Advanced Science and Engineering (ICOASE). IEEE, 2020.

[7] Beckers, Kristian, and Sebastian Pape. "A serious game for eliciting social engineering security requirements." 2016 IEEE 24th International Requirements Engineering Conference (RE). IEEE, 2016.

[8] Sheng, Steve, et al. "Anti-phishing phil: the design and evaluation of a game that teaches people not to fall for phish." Proceedings of the 3rd symposium on Usable privacy and security. 2007.

[9] Weanquoi, Patrickson, Jaris Johnson, and Jinghua Zhang. "Using a game to improve phishing awareness." Journal of Cybersecurity Education, Research and Practice 2018.2 (2018): 2.

[10] Cone, Benjamin D., et al. "A video game for cyber security training and awareness." computers & security 26.1 (2007): 63-72.

[11] Baldassarre, Maria Teresa, et al. "Teaching Cyber Security: The HACK-SPACE Integrated Model." ITASEC. 2019.

[12] Jian, Ng Jia, and Intan Farahana Binti Kamsin. "Cybersecurity Awareness Among the Youngs in Malaysia by Gamification." 3rd International Conference on Integrated Intelligent Computing Communication & Security (ICIIC 2021). Atlantis Press, 2021.

[13] NOVA Labs. (2020). Cybersecurity lab. https://www.pbs.org/wgbh/nova/labs/lab/cyber

[14] Giannakas, Filippos, et al. "A comprehensive cybersecurity learning platform for elementary

education." Information Security Journal: A Global Perspective 28.3 (2019): 81-106.

[15] Wen, Zikai Alex, et al. "What. hack: engaging anti-phishing training through a role-playing phishing simulation game." Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems. 2019.

[16] Visoottiviseth, Vasaka, et al. "POMEGA: Security game for building security awareness." 2018 Seventh ICT International Student Project Conference (ICT-ISPC). IEEE, 2018.

[17] Olsen, Tanner, Katelyn Procci, and Clint Bowers. "Serious games usability testing: How to ensure proper usability, playability, and effectiveness." Design, User Experience, and Usability. Theory, Methods, Tools and Practice: First International Conference, DUXU 2011, Held as Part of HCI International 2011, Orlando, FL, USA, July 9-14, 2011, Proceedings, Part II 1. Springer Berlin Heidelberg, 2011.

[18] A. Bangor, P. T. Kortum and J. T. Miller. An empirical evaluation of the System Usability Scale. Int. J. Hum. Comput. Interact, 2008, 24 (6), pp. 574-594.

[19] Kaya, Aycan, Reha Ozturk, and Cigdem Altin Gumussoy. "Usability measurement of mobile applications with system usability scale (SUS)." Industrial Engineering in the Big Data Era: Selected Papers from the Global Joint Conference on Industrial Engineering and Its Application Areas, GJCIE 2018, June 21–22, 2018, Nevsehir, Turkey. Springer International Publishing, 2019.

[20] J. Brooke. SUS - A quick and dirty usability scale. Usability Eval. Ind., 1996, 189 (194), pp. 4-7.

[21] Brooke, J. "SUS: a retrospective. J Usability Stud. 2013; 8 (2): 29–40." (2021).

[22] J. R. Lewis and J. Sauro. The Factor Structure of the System Usability Scale. Human Centered Design, Human Centered Design. Springer Berlin Heidelberg, 2009, pp. 94-103.

[23] Binyamin, Sami, Malcolm Rutter, and Sally Smith. "The utilization of system usability scale in learning management systems: a case study of Jeddah Community College." (2016).

[24] Lewis, James R., and Jeff Sauro. "Item benchmarks for the system usability scale." Journal of Usability Studies 13.3 (2018).

[25] Yalamanchili, A. ., Venkatasekhar, D. ., & Kumar, G. V. . (2023). Iot Based Alzheimer's Disease Diagnosis Model for Providing Security Using Light Weight Hybrid Cryptography. International Journal on Recent and Innovation Trends in Computing and Communication, 11(4), 148–159. https://doi.org/10.17762/ijritcc.v11i4.6398

[26] Mwangi, J., Cohen, D., Costa, R., Min-ji, K., & Suzuki, H. Optimizing Neural Network Architecture for Time Series Forecasting. Kuwait Journal of Machine Learning, 1(3). Retrieved from http://kuwaitjournals.com/index.php/kjml/article/view/132