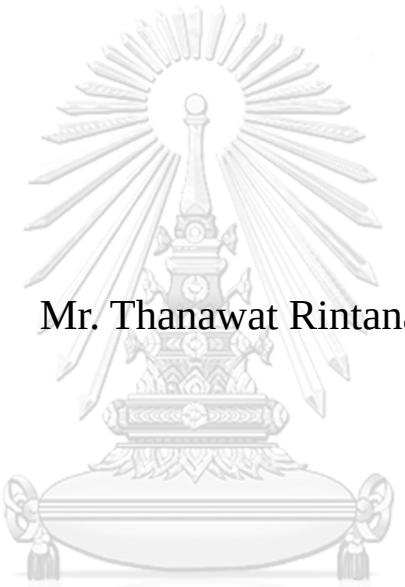
INFORMATION SECURITY AWARENESS LESSON USING GAMIFICATION

Mr. Thanawat Rintanalert



A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Science in Computer Science and
Information Technology
Department of Mathematics and Computer Science
Faculty Of Science
Chulalongkorn University
Academic Year 2023

บทเรียนความตระหนักรู้ด้านความมั่นคงปลอดภัยสารสนเทศผ่านการใช้วิธีการแบบเกม

นายธนวัต รินธนาเลิศ

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
สาขาวิชาวิทยาการคอมพิวเตอร์และเทคโนโลยีสารสนเทศ ภาควิชาคณิตศาสตร์และวิทยาการคอมพิวเตอร์
คณะวิทยาศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2566

Thesis Title	INFORMATION SECURITY AWARENESS LESSON USING GAMIFICATION
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Field of Study	Computer Science and Information Technology
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ธนวัต รินธนาเลิศ : บทเรียนความตระหนักรู้ด้านความมั่นคงปลอดภัยสารสนเทศผ่านการใช้วิธีการแบบเกม. (INFORMATION SECURITY AWARENESS LESSON USING GAMIFICATION) อ.ที่ปรึกษาหลัก : ผศ. ดร.อาธร เหลืองสดใส

ในมุมมองด้านการศึกษา ที่ความตั้งใจและความสม่ำเสมอของผู้เรียนเป็นปัจจัยสำคัญสู่การเรียนรู้อย่างยั่งยืน แนวคิดเกมมิฟิเคชั่น หรือการใช้วิธีแบบเกม ได้ถูกนำมาใช้เป็นกลยุทธ์หนึ่งในการช่วยนำไปสู่เป้าหมาย การวิจัยนี้ศึกษาเกี่ยวกับกลไกของเกมมิฟิเคชั่น ในการนำสเน่ห์ที่น่าดึงดูดใจของวิดีโอเกมที่ทำให้ผู้เล่นสามารถดำดิ่งกับความสนุกเป็นระยะเวลานานมาปรับใช้กับระบบการศึกษา โดยเราจะแบ่งกลุ่มการทำการทดสอบเปรียบเทียบระหว่างนิสิตระดับปริญญาตรีสองกลุ่ม กลุ่มแรก (กลุ่มเกม) ศึกษาผ่านการเล่นเกม และกลุ่มที่สอง (กลุ่มดั้งเดิม) ผ่านคลิปวิดีโอ อ้างอิงการเรียนหน้ากระดานในห้องเรียน

กลุ่มเล่นเกมได้ดำดิ่งสู่ความสนุกของวิดีโอเกม และได้เรียนรู้เนื้อหาการตระหนักถึงความปลอดภัยของข้อมูล ที่สอดแทรกอยู่ภายในตัวเกมไปในตัว ในระหว่างนั้นกลุ่มดั้งเดิมเรียนรู้เนื้อหาเดียวกันผ่านสื่อวิดีทัศน์ หลังจากนั้นทั้งสองกลุ่มจะนำสิ่งที่ได้เรียนรู้มาทดสอบความเข้าใจผ่านแบบทดสอบ ผลลัพธ์ที่ได้เป็นที่ประจักษ์ว่ากลุ่มเกมนั้นนอกจากจะแสดงความกระตือรือร้นอย่างมากระหว่างการเล่นเกม ยังได้คะแนนโดยเฉลี่ยจากการทำแบบทดสอบสูงกว่ากลุ่มดั้งเดิม แสดงให้เห็นว่าการศึกษาไม่จำเป็นต้องน่าเบื่อ แต่สามารถทำให้สนุก และผู้เรียนเพลิดเพลินไปพร้อมกันได้

การสัมภาษณ์หลังการทำแบบทดสอบของนิสิตที่เข้าร่วมวิจัยในครั้งนี้ทำให้เราได้ทราบถึงข้อมูลเชิงลึกหลายประการ ดังเช่นศักยภาพของวิดีโอเกมในการเป็นสื่อการสอนทางการศึกษา นอกเหนือจากการเป็นสื่อเพื่อความบันเทิง และความเป็นไปได้ของการนำวิดีโอเกม และลักษณะการสอนแบบดั้งเดิมมาใช้ควบคู่กันในห้องเรียน สรรสร้างเป็นแนวทางการศึกษาแบบใหม่ที่เน้นการมีส่วนร่วมของผู้เรียน ช่วยให้จดจำเนื้อหาการเรียนได้ดียิ่งขึ้น

การวิจัยในครั้งนี้ยังได้ขยายออกจากขอบเขตการทดลองเดิม ส่องสว่างแนวทางวิวัฒนาการของวิดีโอเกมเพื่อการศึกษา การแสดงศักยภาพในการหลอมรวมเป้าหมายการเล่นเกม กับเป้าหมายทางการศึกษา นำไปสู่การศึกษารูปแบบใหม่ ที่เข้าถึงง่าย และสร้างความมีส่วนร่วม จากการสำรวจครั้งนี้ จึงเป็นการนำหลักการด้านเกมมิฟิเคชั่น และความเป็นไปได้ที่หลากหลายมาใช้ให้เกิดผลประโยชน์ ยกระดับภูมิทัศน์ด้านการสอนอย่างแท้จริง

สาขาวิชา	วิทยาการคอมพิวเตอร์และเทคโนโลยีสารสนเทศ	ลายมือชื่อนิสิต .....
ปีการศึกษา	2566	ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

6172624223 : MAJOR COMPUTER SCIENCE AND INFORMATION TECHNOLOGY
KEYWORD: gamification, videogame, information security awareness

Thanawat Rintanalert : INFORMATION SECURITY AWARENESS LESSON USING GAMIFICATION. Advisor: Asst. Prof. ARTHORN LUANGSODSAI, Ph.D.

In the landscape of education, where engagement and retention are pivotal, gamification emerges as a dynamic strategy. This research delves into the realm of gamification, a process that infuses the captivating allure of videogame mechanics into educational contexts. Embarking on an experimental journey, this study orchestrates an intricate interplay between two distinct groups of undergraduate students – Group A, the "Gamified Group," and Group B, the "Traditional Group."

Within this dynamic framework, Group A immerses itself in the immersive realm of educational videogames to grasp the nuances of information security awareness. In parallel, Group B embraces a more traditional approach, delving into the same subject matter through video presentations. Both groups subsequently engage in rigorous quizzes to evaluate their comprehension. The results unfold a compelling narrative: the Gamified Group exhibits heightened enthusiasm and active participation, unveiling a landscape where learning transcends the boundaries of monotony.

As the data crystallizes, the test scores echo a resounding resonance – the Gamified Group's average score eclipses that of the Traditional Group. Deeper insights gleaned from student interviews validate the potential of videogames as potent tools of education. A harmonious convergence of traditional pedagogies and gamified dynamics emerges, fostering heightened class participation and enhancing memorization capacities.

This research transcends its experimental confines, illuminating a pathway towards the evolution of education videogames. By unraveling the potential synergies between gaming mechanics and educational objectives, it paves the way for more efficacious, engaging, and accessible learning experiences. In the wake of this exploration, the horizon of education stands enriched, poised to embrace the multifaceted potential of gamification as a conduit to elevate pedagogical landscapes.

Field of Study:	Computer Science and Information Technology	Student's Signature .....
Academic Year:	2023	Advisor's Signature .....

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to my family, whose unwavering support and encouragement have been the foundation of my academic journey, and my friend, whose presence and camaraderie have made this academic pursuit a memorable and fulfilling experience. Their love, understanding, and constant belief in my abilities have been instrumental in pushing me forward during challenging times.

I extend my heartfelt appreciation to my esteemed professor advisor, Asst. Prof. Dr. Arthorn Luangsodsai, as well as Asst. Prof. Dr. Somjai Boonsiri and Assoc. Prof. Dr. Peraphon Sophatsathit, whose guidance, expertise, and invaluable insights have shaped the direction of this research. Your mentorship and encouragement have inspired me to strive for excellence and to continuously push the boundaries of my knowledge.

Lastly, I would like to extend my heartfelt gratitude to the students who participated in this research. Your willingness to be a part of this study and your active engagement in the experiment have been invaluable contributions to the success of this thesis. Your valuable feedback, insights, and perspectives provided crucial data that enriched the findings of this research. Your dedication and cooperation throughout the process have been instrumental in shaping the outcomes and conclusions of this study.

This thesis is a culmination of not just my efforts but the collective support and belief of those around me. I am sincerely thankful to each and every one of you for being an indispensable part of this rewarding academic pursuit.

Thanawat Rintanalert

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Chapter 1
Introduction

"Embracing technology's transformative potential, we usher in a new era of learning where interactive engagement blurs the lines between education and entertainment, shaping minds through the captivating power of gamification."

New Era of Learning

In the era of digitalization, information has assumed paramount importance and value. Consequently, individuals in the information technology and various business sectors find themselves compelled to acquire relevant knowledge. In this context, the burgeoning digital learning network has gained significant traction as a platform for enhancing security awareness, catering to both individual and corporate needs. However, the learning process can often devolve into monotony, particularly when the subject matter does not align with one's current knowledge, experience, or interests. Novice learners might spend extended periods grappling with basic concepts, necessitating a high level of motivation to maintain focus. Many individuals find themselves disheartened by this laborious process, resulting in diminishing returns over prolonged study periods and unsatisfactory average examination results. Gamification has emerged as a remedy to this dilemma, with its proven ability to bolster learners' motivation and willingness to actively engage in educational activities.

1.1 Statement of the Problems

1. The prevalence of online threats, including scams, fraud, and malicious attacks, often arises from individuals' lack of Information Security Awareness.

2. The complexity of Information Security as a learning topic contributes to difficulties in understanding and applying it in real-world scenarios.

3. The potential of video games as an educational platform and the underutilization of gamification techniques are areas under study and are currently underused in the Thai education curriculum.

1.2 Objective of the Study

This research aims to explore the application of gamification in the context of information security awareness lessons through the design and development of a gamified educational videogame. The specific objectives of the study are as follows:

1. To design and develop a gamified educational videogame, named "Croissant's Adventure," specifically tailored for teaching information security awareness lessons. This involves incorporating game elements, mechanics, and interactive features that enhance engagement and motivation in the process.

2. To conduct an experiment to compare the effectiveness of the gamified educational videogame with traditional classroom learning methods in teaching information security awareness concepts. The study will measure and analyze the learning outcomes, retention of knowledge, and overall understanding of the subject matter between the two groups.

3. To evaluate the impact of the gamified educational videogame on students' learning experiences and attitudes towards information security awareness. The study will gather feedback and insights from the participants to understand their perceptions, satisfaction, and motivation in using the gamified platform for learning.

4. To identify the strengths and weaknesses of the gamified educational videogame as a learning tool for information security awareness. Through participant feedback, observations, and data analysis, the study aims to pinpoint areas of improvement and potential enhancements to the game's design and content.

5. To explore the potential of gamification as an innovative and engaging approach to enhance information security awareness and knowledge retention among students. The research aims to contribute valuable insights into the effectiveness of gamified learning platforms in the field of information security awareness education.

The hypothesis underlying this study postulates that the gamified learning approach will heighten participant motivation, subsequently resulting in improved test scores for security awareness assessments in contrast to those who undergo traditional learning methods. By achieving these objectives, this study seeks to contribute to the growing body of knowledge on gamification in educational contexts and provide practical implications for the design and implementation of gamified learning platforms in the field of information security awareness education.

1.3 Terminology

In the following, important terms, used throughout this research are explained:

Gamification A strategic approach to enhance activity and create a similar experience to playing a videogame, with the objective of motivating and engaging users in a non-game context.

Gamified learning platform Refers to "Croissant's Adventure," a videogame developed for this research, which serves as the primary study tool.

Information Security Awareness refers to the understanding and consciousness of individuals, employees, or users within an organization regarding potential risks, threats, and best practices associated with safeguarding sensitive and confidential information. It involves educating individuals about data protection, identifying security threats, and adhering to security policies and procedures.

This research aims to integrate the content of Information Security Awareness into the Gamified learning platform and conduct an experiment to measure its effectiveness as a learning tool compared to traditional learning methods.

Traditional Learning The conventional method of education conducted in physical classrooms with face-to-face interactions between students and teachers. This approach involves attending classes at a designated location and receiving instruction through lectures, discussions, and presentations. Additionally, online classes have gained popularity during the COVID-19 pandemic, providing students with the flexibility to study in a safe and comfortable environment.

Gamification/Gamified group A group of students participating in this research, learning information security awareness through playing "Croissant's Adventure."

Traditional group A group of students participating in this research, learning information security awareness through traditional learning methods.

Videogame An interactive electronic entertainment medium involving player engagement and interaction with a virtual world through a user interface displayed on a screen. Video games offer a wide variety of genres, platforms, and styles, providing diverse experiences and challenges to players.

Educational Videogame A type of video game that is specifically designed with the primary purpose of teaching or imparting knowledge and skills to the players. Unlike traditional video games, which are primarily meant for entertainment, educational video games are created to promote learning in a fun and interactive way. The game "Croissant’s Adventure," developed as a Gamified learning platform for this research, falls into the category of educational video games.

Croissant’s Adventure A videogame developed using Unity Game Engine, designed in the classic "Super Mario Bros." platforming genre.

Minigames Games within a game. "Croissant's Adventure" features various minigames in each stage.

Quiz A Multiple-Choice Exam where test-takers must choose the correct answer from a list of options provided for each question. Multiple-choice exams are widely used in educational settings, assessments, and standardized tests due to their efficiency in grading and structured format for evaluating knowledge and skills.

1.4 Contributions

This research is determined to provide several significant contributions to the field of cyber security education and gamification, as follow:

1. The primary aim is to enhance Information Security Awareness lessons by transforming them into fun-filled engagements through the incorporation of gamification elements. By infusing game design and principles into the learning process, the study seeks to make the subject matter more appealing and interactive.

2. Additionally, the implementation of gamified learning using the videogame "Croissant's Adventure" aims to increase student motivation in learning Information Security Awareness. The engaging and interactive nature of the game is expected to encourage active participation, leading to improved examination performance and a deeper understanding of the subject.

3. Moreover, this research endeavors to broaden the study of gamification in educational game development. By focusing on gamification in a higher education environment, specifically in the context of Information Security Awareness, the research aims to expand the understanding of how gamification principles can be effectively applied to enhance learning experiences. This exploration may open new avenues for incorporating gamification in other educational domains.

4. Additionally, the study seeks to promote Information Security Awareness among individuals, not only within the tech industry but also among the general population. By educating individuals about potential risks, threats, and best practices, the research aims to empower them to safeguard sensitive information and protect themselves from cyber threats.

5. Furthermore, this study endeavors to explore the potential of gamification in higher education in Thailand, a country known for its avid consumption of entertainment. While existing video games in academic settings are primarily focused on children's education or confined to private organizational use, this research aims to shed light on how gamification can be effectively utilized in a higher education environment, specifically in cyber security education.

In conclusion, the contributions of this research are aimed at making a significant impact on Information Security Awareness and gamification. Through the creation of an engaging and interactive educational videogame and the exploration of gamification in higher education, the study aspires to improve learning outcomes, increase student motivation, and promote awareness of information security. These contributions may also lead to valuable insights and innovations in educational game development, contributing to the broader understanding of gamified learning approaches.

1.5 Thesis Outline

The research is structured as follows:

Chapter 2 delves into defining gamification, cybersecurity, and their interrelation with information security awareness. The chapter also encompasses a comprehensive literature review of gamification and video game-related research. It highlights the process of selecting target audiences for the study and lays the groundwork for the preparation of the gamified lesson.

Chapter 3 provides a breakdown of the game development stages for "Croissant's Adventure," spanning from prototype creation to the final product, along with a post-release strategy.

Chapter 4 outlines the experimental setup, encompassing preparation, execution, and the ensuing results, offering valuable insights gained from the process.

Chapter 5 synthesizes the study's findings, culminating in a concise conclusion, followed by future recommendations and insights to guide subsequent endeavors.

Chapter 2
Background and Methodology

"Gamification is the process of using game thinking and game dynamics to engage audiences and solve problems."
Gabe Zichermann

"I think games are going to dwarf all other forms of entertainment in the future."
Gabe Newell

In this chapter, this research delves into the fundamental underpinnings that shape the trajectory of the research. By illuminating the multifaceted worlds of gamification and cybersecurity, delving into their definitions, intricacies, and their relevance to modern educational paradigms. As two distinct fields, gamification and cybersecurity interlace in a study to explore the potential of gamified learning in enhancing the understanding of cybersecurity concepts.

The canvas of this exploration is adorned with past research and experiments that have ventured into the realm of gamification. By surveying the landscape of existing studies, this research gathers valuable insights into the efficacy, challenges, and prospects of integrating gamified elements into educational practices. These findings not only illuminate the path ahead but also set the context for this research's endeavor.

As this research embarks on the journey to illuminate the symbiotic relationship between gamification and cybersecurity education, it is pivotal to establish the precise target audience that this research seeks to impact. The process of selecting the target audience is intricately interwoven with the objectives, as it shapes the dynamics of the experiment and the subsequent interpretations of the results.

2.1. The definition of Gamification

The concept of Gamification is not exactly novel in Western countries, as it exists for a decade only to gain increasing interest in Asian countries recently. In this research,

various experiments of Gamification done by researchers around the world were studied to find inspiration on how to integrate information security learning platforms with Gamification.

Gamification constitutes a deliberate strategy aimed at amplifying engagement by crafting an experience akin to playing a video game. Its objectives are to motivate and captivate users, achieved through the infusion of game design and principles into non-game contexts. Sociologist Erving Goffman [1] emphasizes the essence of fun in gaming, stating in his essay "Fun in Game" that the impetus behind engagement and motivation lies in the intrinsic enjoyment games offer. In line with this perspective, a truly engaging video game thrives on the allure of fun, transcending mere adherence to rules and design strategies.

Further research has contributed to a refined understanding of Gamification. For instance, studies by M. Morales-Trujillo and G. García-Mireles[2] define gamification as integrating game elements into non-gaming environments. Adnan Ahmad et al.[3] characterize it as using game design elements like points, badges, leaderboards, and rewards in non-game contexts, such as education, to motivate learners and enhance learning outcomes. Additionally, Eyvind Garder B Gjertsen [4] defines gamification as applying game design elements in non-game contexts. These definitions emphasize the utilization of game design techniques and mechanics to influence behavior, skill development, or innovation within specific target audiences, such as employees or customers.

In Thailand, during the technological boom in the 2000s, personal computers, later known as PCs, were commercialized, and the internet became an affordable commodity. During this period, one notable development was the emergence of the very first iteration of Thai-made educational videogames.

Figure 1: The Little Boss, a kid educational game release during 2000s

"Little Boss," also known as "Thao-Gae Noi" (see Figure 1) in Thailand, is a collection of educational videogames specifically designed for children under the age of 15. These games feature various scenarios in which players assume the role of "Little Boss," managing different businesses such as restaurants, pizzerias, and convenience stores. Additionally, there is a version called "Adventure Little Boss" where players become adventurers, facing challenges that involve mathematical, language, and scientific quizzes while fighting against monsters.

Since then, videogames have continued to evolve from mere forms of entertainment to full-fledged subjects of study. Alongside this evolution, the concept of gamification has also emerged and gained prominence.

2.2.The definition of Cybersecurity

The term "cybersecurity" has become commonplace and somewhat diluted in its significance. To attain a comprehensive understanding, it is imperative to dissect two distinct aspects: Information Security and Cyber Resilience, each bearing distinct perceived objectives[5]. Information security pertains to thwarting unauthorized access and manipulation of data during various stages of transmission and storage. This concept revolves around safeguarding the triad of confidentiality, integrity, and availability, commonly referred to as the CIA triad, which encapsulates both physical and digital data, encompassing personal as well as organizational information.

Cybersecurity is the act of defending computers, servers, mobile devices, electronic systems, networks, and data inside cyberspace from malicious attacks that range from personal devices to business organizations. It is handled by professionals and usually deals with cybercrime, cyber fraud, and law enforcement. Cyber resilience is the ability to mitigate damage and compromise done by malicious attacks and remain operational in a critical situation.

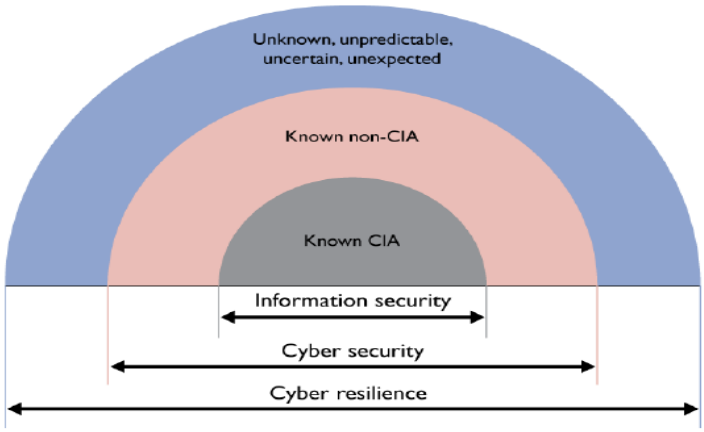


Figure 2: Cyber Security Model

To sum up, information security, as illustrated in Figure 2, constitutes the minutest components of the trio; nonetheless, it holds paramount importance due to its direct relevance to daily technological usage and an individual's ability to avert becoming a target of malicious assaults. Should such an attack occur, cyber security functions as a protective barrier to halt the proliferation of further damage. However, in instances of utter failure, cyber resilience serves as the ultimate contingency strategy to endure the assault and restore operations as closely as possible to their pre-attack state. The optimal strategy remains prevention, obviating attacks from transpiring in the first instance. Thus, by amplifying awareness among individuals will undoubtedly curtail the frequency of cyber breaches.

2.3.Past research and experiments involving Gamification.

The literature review section presents a comprehensive examination of previous research and studies related to gamification and its application in education. One of the significant influences in this research is Erwin Goffman's essay[6], "Fun in Game," which emphasizes the motivational and engaging aspects of videogames. This

notion is further supported by Yu-Kai Chou's "Octalysis Framework for Gamification and Behavioral Design," which highlights the integration of fun and engaging elements from games into real-world activities[1].

In Adnan Ahmad et al.'s "The Impact of Gamification on Learning Outcomes of Computer Science Majors," [7]the study explores how gamification, which integrates game elements like points and leaderboards into learning, affects computer science education. The research assesses student satisfaction and performance across various contexts, acknowledging challenges like resistance and resource constraints. It also highlights the potential of computer games and serious games in education and references "Total Engagement: Using Games and Virtual Worlds to Change the Way People Work and Businesses Compete" for insights into enhancing engagement in business through gamification. The paper suggests that while gamification offers promise, more research is needed to determine optimal conditions and best practices in education.

Meanwhile, in "Gamification and SQL: An Empirical Study on Student Performance in a Database Course"[3] by M. Morales-Trujillo and G. García-Mireles, the study focuses on the impact of gamification, including elements like challenges, points, and leaderboards, on student performance, motivation, and user experience in SQL instruction using Query Competition. The research demonstrates a significant performance improvement and higher motivation levels among students with access to gamified content. It emphasizes the need for further research and recommends integrating gamification as a complementary tool alongside traditional teaching method.

Eyvind Garder B Gjertsen's paper “Use of Gamification in Security Awareness and Training Programs”[2] explores the integration of gamification into security awareness and training programs. Gamification entails the incorporation of game design elements into non-gaming contexts, a strategy aimed at enhancing user engagement and motivation. Elements like storytelling and real-life simulations are identified as effective tools for this purpose. While research on gamification's impact

in cybersecurity remains limited, the paper highlights its potential to significantly improve learning outcomes, countering the often-tedious nature of traditional training programs. Effective gamification should include attributes like relevance, scalability, adaptability, and immediate feedback.

In summary, this paper defines gamification to leverage game elements for increased user engagement and improved learning outcomes. It advocates for the integration of gamified software applications into training programs, fostering a security-focused culture that may lead to behavior change in daily work activities.

Various research papers and journals delve into the relationship between gamification and educational outcomes. R.K. Dixit et al.[4] explore the integration of gamification with traditional teaching methods, leading to problem solving among students. Conversely, Ulrike Hammerschall's study[8] examines gamification's effects on motivation, emphasizing the importance of autonomy and engagement during the action and maintenance stages.

Additionally, Maciej Laskowski's experiment[9] explores the use of gamification in the academic field and its impact on students' involvement and participation. Chee-Ken Wong and Chien-Sing Lee's research[10] focuses on the effect of gamification in STEM learning, employing surveys to gather users' opinions and experiences. Yevgeniya Daineko et al.[11] develop an educational software based on Unity 3D, highlighting the potential of new technologies in enhancing knowledge transfer.

In the context of videogame genres, Laura Alejandra Martinez-Tejada et al.[12] investigate the influence of gameplay, difficulty, graphics, and sound on player interest and engagement. Furthermore, data from Steam[13] and Gameindustry.biz[14] reveal a significant increase in videogame purchases during the COVID-19 pandemic, demonstrating the growing popularity and relevance of gaming in the current climate.

Moreover, TechSauce[15] reports a surge in gaming-related conversations on Twitter during the pandemic, highlighting the socialization, leisure, and stress relief aspects of gaming. Zhu Lin's journal[16] explores relativity of human behavior and the popularity of "Animal Crossing: New Horizon" and "Doom Eternal" during the pandemic, showcasing how videogames provided an escape and stress relief for players.

Overall, the literature review indicates that gamification, when applied strategically, can positively impact various educational contexts, making tasks more enjoyable and fostering engagement. With insights from these studies, this research aim to design and implement the gamified platform for enhancing information security awareness education and further contribute to the growing field of gamification research.

2.4.Target Audience

In scientific research, consistency in the target audience is crucial. Therefore, in the context of this study, the primary target audience should be an undergraduate student from the Chulalongkorn university's computer science department. Further details will be provided in the following chapters.

Chapter 3
Game Design and Development

"I think what's really important is to always be working on new ideas and new ways of doing things, and not just be recycling old ideas."

Shigeru Miyamoto

The development of a videogame involves a series of well-defined stages that enable game developers to bring their creative vision to life. Referred to as the "Stages of game development," these processes vary from developer to developer, as game development is often seen as an art form rather than a rigid science. In the context of this research, the development of this research's own educational videogame platform for teaching information security leads to identification of five key stages: Discovery, Production, Testing, Releasing, and Post-release (see Figure 3). Each stage plays a crucial role in ensuring the success and quality of the final product, navigating the intricate journey of transforming an idea into a fully functional and engaging videogame.

Figure 3: 5 Stages of videogame development

3.1.Stage 1: Discovery

The Discovery phase includes the design process with game assets, targeted player base, initial game design elements (prototyping), and many more. Drawing insights

from Laura Alejandra Martinez-Tejada et al.'s experiment (2020), it becomes evident that the complexity of a videogame is not a determining factor in achieving the intended objective of gamification. Instead, simplicity can often yield more accurate results when assessing the effectiveness of gamification. Considering this, this research made the strategic choice of using Unity as game engine for developing the gamified platform. Unity stands as one of the most renowned game engines in the current market, offering a vast library of resources and an established online community to support the development process. The final product of gamified platform comprises a compilation of engaging and interactive minigames, all merged into a unified gaming experience.

Furthermore, this research acknowledges the role of auxiliary applications in the game development process. While not necessarily categorized as game engines, tools like Torque, Blender, and Adobe prove invaluable for creating models, artwork, and other essential elements needed in the finished game.

A distinctive advantage of gamification over traditional learning methods lies in its ability to provide students with an interactive and immersive educational experience, akin to that of a videogame. For instance, one of minigames features the student (player) assuming the role of "Mario" from the iconic platforming game "Super Mario Bros." (see Figure 4). Through skillfully combining the storyline of Mario's quest to rescue Princess Peach from the evil Bowser with the lesson aims educate the player about the common delivery methods of computer viruses. This gamified approach captivates learners, leveraging storytelling and gameplay elements to drive engagement and enhance knowledge retention.

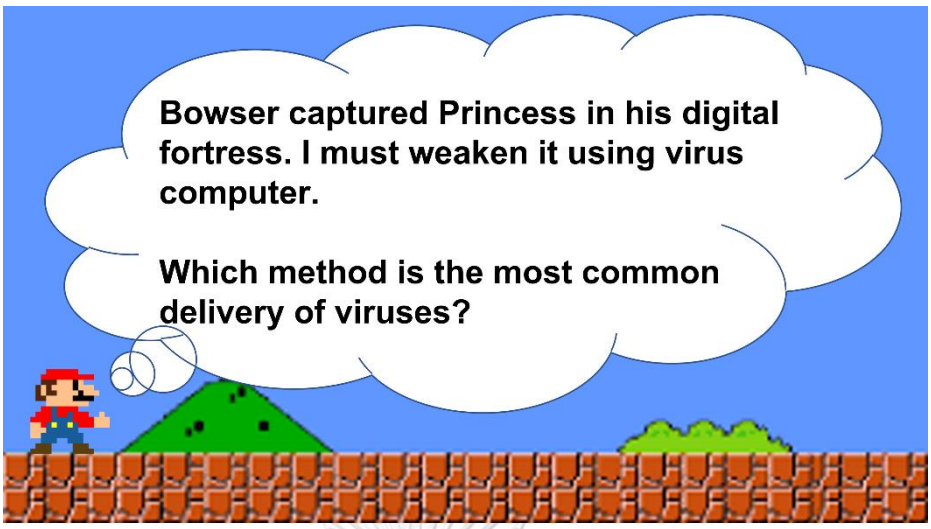


Figure 4: A screen from the prototype resembled Super Mario Bros.

Another rationale behind the decision to craft a minigame within the framework of Super Mario Bros. is the game's widespread recognition. Even those unacquainted with video games are familiar with the iconic figure of Mario. By adopting the role of Mario, this research establishes a clear objective for players: to rescue the princess by selecting the accurate response. This paves the way for the gameplay phase of the minigame. As Mario, the player navigates and engages with the environment, striking the coin blocks to unearth the correct answer, as depicted in Figure 5. Should the player-guide Mario select an incorrect answer, the corresponding coin block deactivates, prompting the player to attempt another coin block. This cycle persists until the player ultimately selects the correct answer.

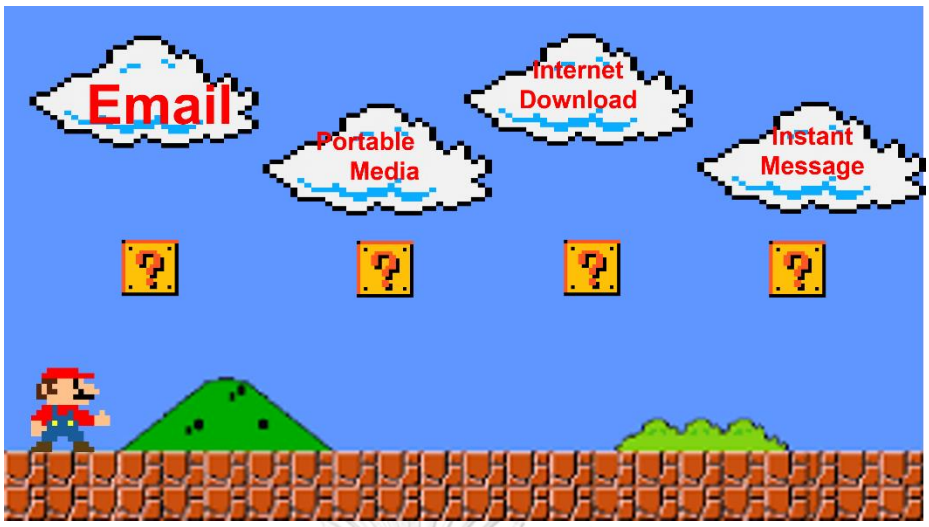


Figure 5: Prototype of "Mario-like" minigames

Nonetheless, it's crucial to note that the Mario character and its associated assets are the intellectual property of Nintendo and are safeguarded by copyright law. An alternative consideration is to employ an "asset flip" strategy or employ copyright-free assets instead of Mario. This adjustment would solely impact the visual aspect while leaving the core gameplay untouched.

In another example of a minigame, a basic matching challenge is introduced, casting the player in the role of an electrician tasked with accurately connecting electrical wires, as illustrated in Figure 6. Although this gameplay concept bears resemblance to the coin block selection in the Mario minigame, it differs in its visual representation. This variety is intentionally integrated to stave off repetitive gameplay experiences and furnish the player with novel encounters, a tactic frequently employed by video game developers to sustain a dynamic gameplay loop. Selecting an incorrect wire prompts the wire to revert to its original position, signifying to the player that their choice was incorrect and prompting them to select a different wire.

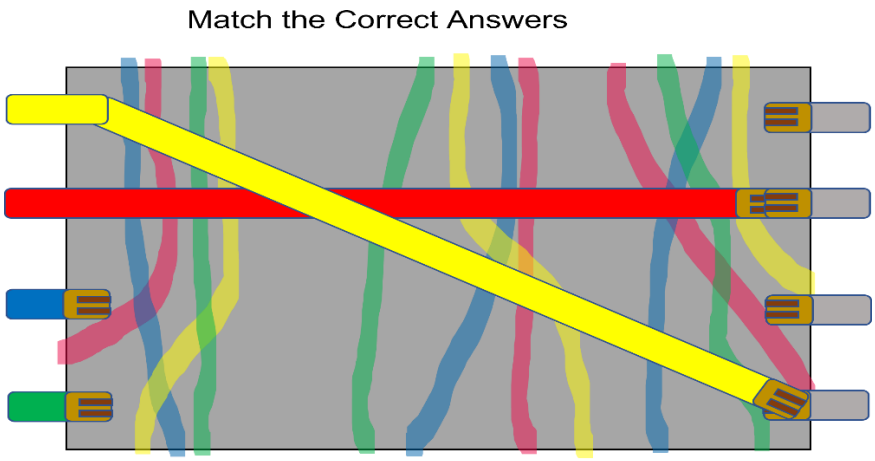


Figure 6: A prototype of an electric wiring minigame

As previously mentioned, undergraduate students from the computer science department at Chulalongkorn University are the chosen target audience for this research. The plan involves dividing the students on the day of the experiment into two distinct groups: the Gamified group (Group A) and the Traditional group (Group B). These groups will receive different learning platforms to explore information security topics. Group A will engage with the game 'Croissant's Adventure', while Group B will learn through video presentations. It's important to note that both platforms contain content from the same source.

Given that students from both Group A and Group B are allotted the same amount of time to learn about information security, it becomes imperative to design the video game with this consideration in mind. Unlike learning content from video presentation, video game playtime can significantly vary, and without appropriate constraints, certain students might struggle to complete the game within the stipulated timeframe. Once both groups have concluded studying their respective lessons, the research progresses to the subsequent phase: the quiz-taking stage.

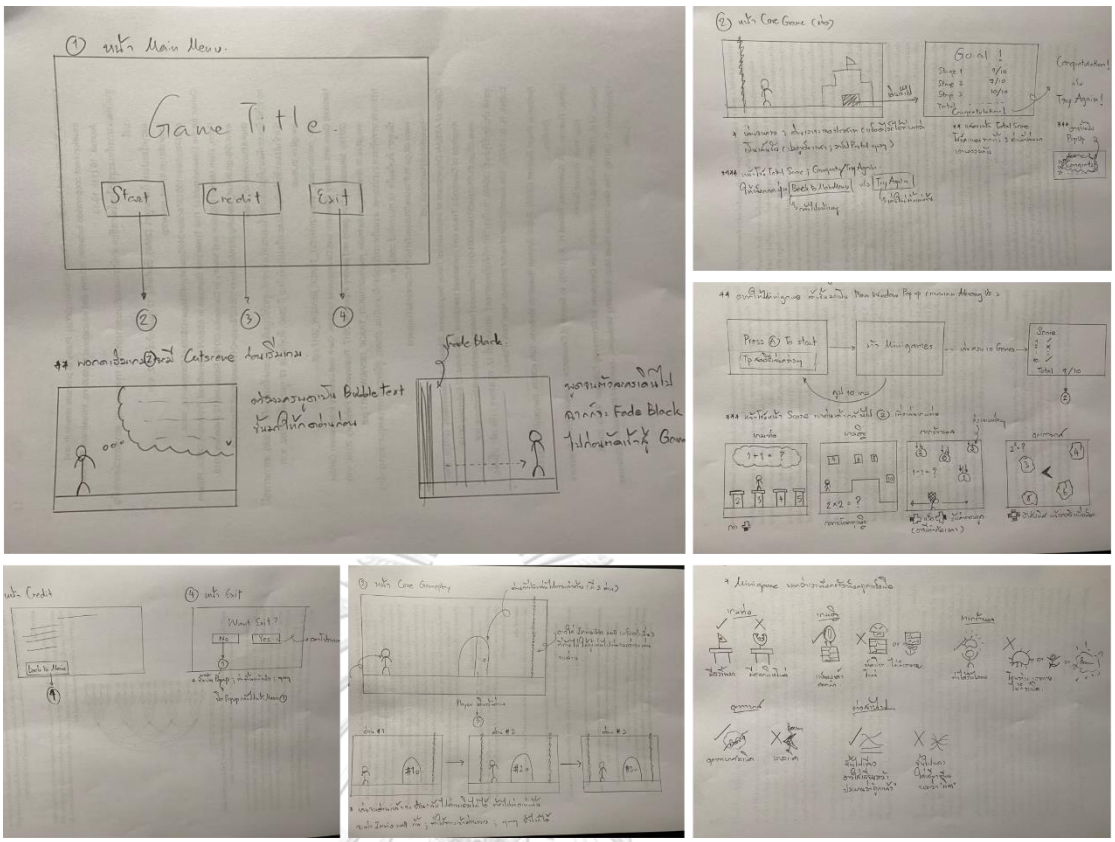


Figure 7:Paper Prototyping

With the concept solidified, the initial phase of the development process involved creating a prototype, which commenced with penning down ideas on sheets of paper (see Figure 7). Analogous to blueprints in construction, these sketches served as a guiding framework for subsequent developmental stages. Every facet intended for the game, including UX/UI designs, scene transitions, world architecture, character portrayal, gameplay components, minigame integration, and more.

Figure 8:Creation of game assets

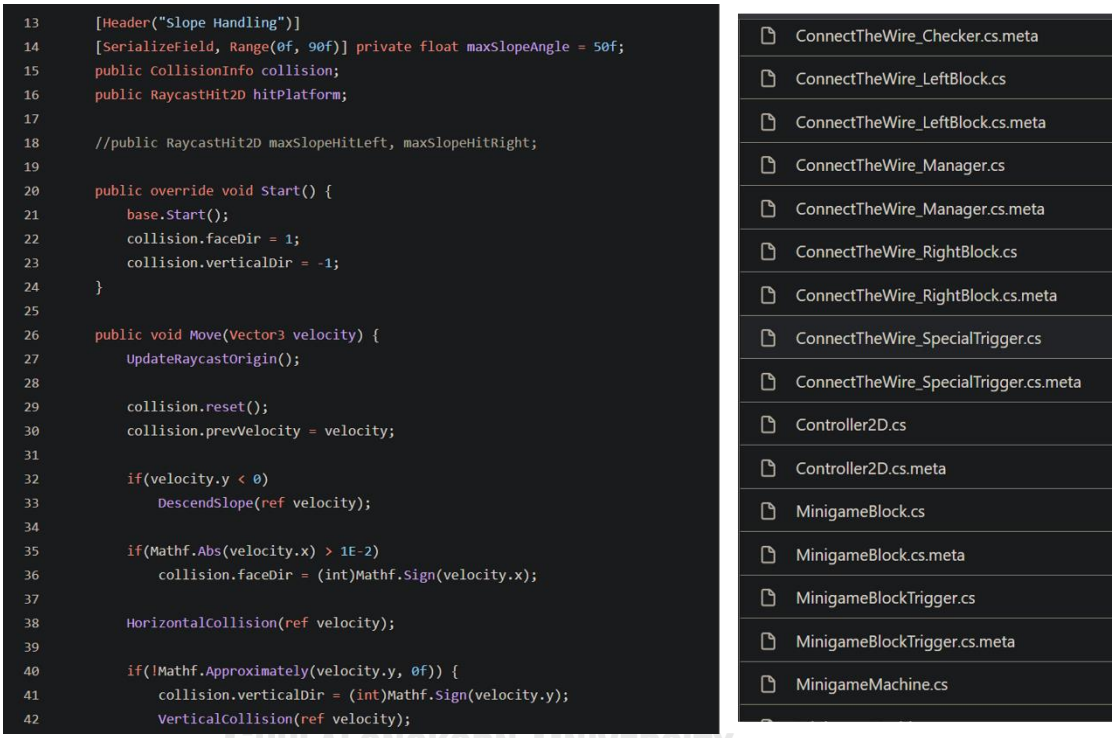
As previously mentioned, the utilization of Mario's aesthetics and character design was precluded due to copyright considerations and the aspiration for a game to possess its distinct identity. Consequently, the choice was made to fashion an entirely novel protagonist along with reimagining various in-game elements, such as blocks, doors, and adversaries (see Figure 8). The outcome materialized in the form of an endearing central playable character affectionately named "Croissant," after the famous French delicacy, set against the backdrop of the vibrant universe that is "Croissant's Adventure."

Like how contemporary classrooms utilize PowerPoint presentations as a tool for lesson delivery, Croissant's Adventure serves as a videogame-based tool for delivering Information Security lessons.

3.2.Stage 2: Production

The Unity game engine employs the C# programming language as its default for the development of "Croissant's Adventure." Leveraging a game engine proved highly advantageous, as it provided a foundational coding structure, enabling a dedicate efforts entirely to the creative process of game development while being relieved of non-game-related coding concerns (see Figure 9).

In the vein of coding conventions, a mathematical aspect emerged, manifesting in the determination of object values, parameters, and formulas. This encompassed factors such as character movement speed, slope traversal speed, jump height, collision detection, and a host of other considerations. The developmental journey entailed extensive testing and refinement within this sphere. This research will provide a detailed explanation of how each coding script impacts various aspects of the game, with a particular focus on the mini-games section.



```
13      [Header("Slope Handling")]
14      [SerializeField, Range(0f, 90f)] private float maxSlopeAngle = 50f;
15      public CollisionInfo collision;
16      public RaycastHit2D hitPlatform;
17
18      //public RaycastHit2D maxSlopeHitLeft, maxSlopeHitRight;
19
20      public override void Start() {
21          base.Start();
22          collision.faceDir = 1;
23          collision.verticalDir = -1;
24      }
25
26      public void Move(Vector3 velocity) {
27          UpdateRaycastOrigin();
28
29          collision.reset();
30          collision.prevVelocity = velocity;
31
32          if(velocity.y < 0)
33              DescendSlope(ref velocity);
34
35          if(Mathf.Abs(velocity.x) > 1E-2)
36              collision.faceDir = (int)Mathf.Sign(velocity.x);
37
38          HorizontalCollision(ref velocity);
39
40          if(!Mathf.Approximately(velocity.y, 0f)) {
41              collision.verticalDir = (int)Mathf.Sign(velocity.y);
42              VerticalCollision(ref velocity);
```

ConnectTheWire_Checker.cs.meta
ConnectTheWire_LeftBlock.cs
ConnectTheWire_LeftBlock.cs.meta
ConnectTheWire_Manager.cs
ConnectTheWire_Manager.cs.meta
ConnectTheWire_RightBlock.cs
ConnectTheWire_RightBlock.cs.meta
ConnectTheWire_SpecialTrigger.cs
ConnectTheWire_SpecialTrigger.cs.meta
Controller2D.cs
Controller2D.cs.meta
MinigameBlock.cs
MinigameBlock.cs.meta
MinigameBlockTrigger.cs
MinigameBlockTrigger.cs.meta
MinigameMachine.cs

Figure 9:Coding scripts of Croissant's Adventure

The inaugural script crafted for the game centered on Croissant's movement mechanics and her interactions with the various minigames. For the sake of simplicity, the game fashioned a level with a flat surface and a prototype of the block game. This served as a preliminary test to ascertain whether the outcomes aligned within expectations (see Figure 10).

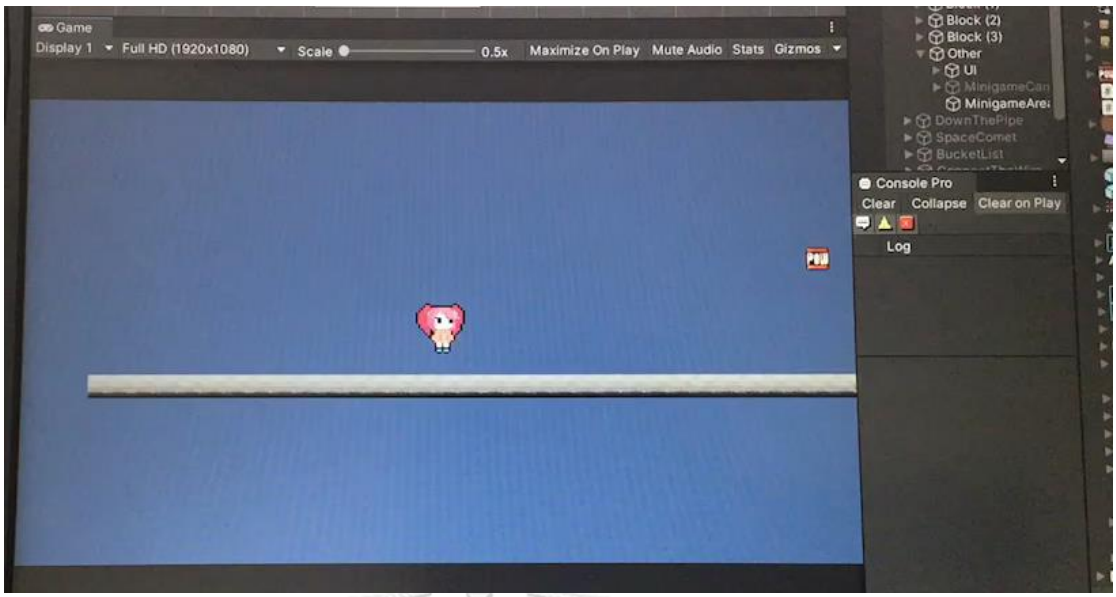


Figure 10:First testing

Having addressed the game's programming scripts, the project began to metamorphose into a more game-like entity. The protagonist of the game, "Croissant," abbreviated as PC for simplicity, continues in embodying a role akin to the renowned "Mario" in the game Super Mario Bros.

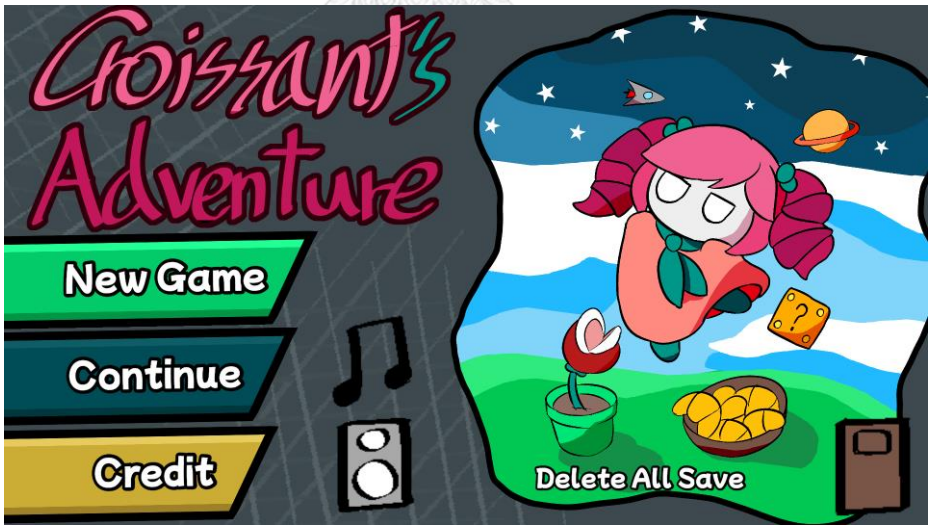


Figure 11: Main menu of Croissant's Adventure

The videogame combines educational value with videogame entertainment and cute art design. Croissant, The PC, is created in a pixel art resemble 8-bits retro game, various assets and obstacles that appear in game also created using the same technique. The game features a WSAD movement, an input that used to control the

PC by pressing W, S, A, and D buttons on keyboard, and jumping resembling Super Mario Bros (see Figure 12).

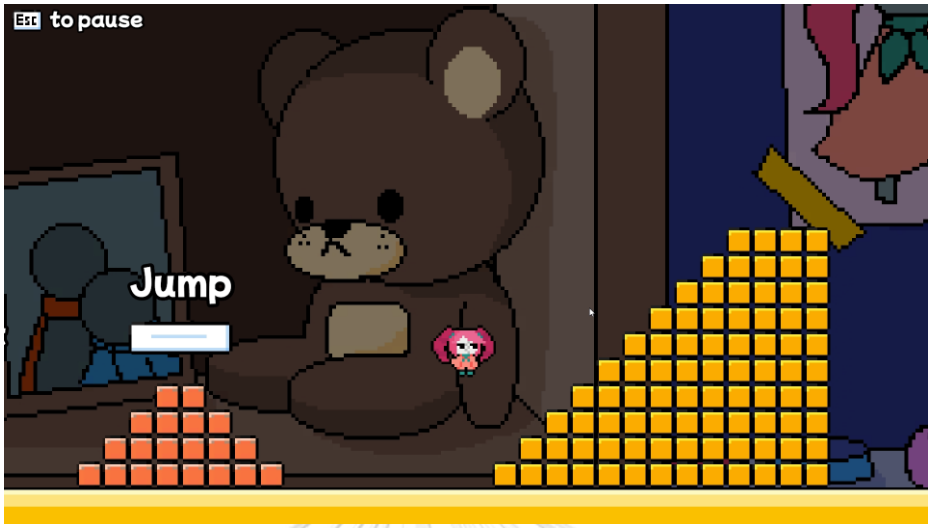


Figure 12: In game's gameplay of Croissant's Adventure

The Unity game engine's tools enable a seamless integration of game assets into visually appealing animations. This phase begins with animating the PC's movements on flat surface, including jumping, walking, and idling (see Figure 13).

```
private void Update()
      {
            base.transform.localScale = new
Vector3(_controller.collision.faceDir, 1f, 1f);
            if (GetState() != PlayerState.Emotion)
            {
                  if (GetState() == PlayerState.Jump)
                  {
                        _animator.Play("Jump");
                  }
                  else if (GetState() == PlayerState.Idle)
                  {
                        _animator.Play("Idle");
                  }
                  else if (GetState() == PlayerState.Walk)
                  {
                        _animator.Play("Walk");
                  }
            }
      }
```

Figure 13: Player Animation

To fully utilize the PC's ability to run, jump, and leap, the playground area was designed with increased verticality, featuring slopes, high ground, and underground

sections. This decision aimed to introduce more challenge and fun commonly found in platforming games like “Mario”. The following script methods (see Figure 14) exemplify how the code affects the PC's control, its movement speed on flat surfaces, ascension or descent on slopes, and collisions with various in-game obstacles and objects.

```
public void Move(Vector3 velocity)
	{
		UpdateRaycastOrigin();
		collision.reset();
		collision.prevVelocity = velocity;
		if (velocity.y < 0f)
		{
			DescendSlope(ref velocity);
		}
		if ((double)Mathf.Abs(velocity.x) > 0.01)
		{
			collision.faceDir = (int)Mathf.Sign(velocity.x);
		}
		HorizontalCollision(ref velocity);
		if (!Mathf.Approximately(velocity.y, 0f))
		{
			collision.verticalDir =
(int)Mathf.Sign(velocity.y);
			VerticalCollision(ref velocity);
		}
		base.transform.Translate(velocity);
	}

private void AscendSlope(ref Vector3 velocity, float slopeAngle,
Vector2 slopeNormal)
	{
		float num = Mathf.Abs(velocity.x);
		float num2 = Mathf.Sin(slopeAngle * ((float)Math.PI /
180f)) * num;
		if (velocity.y <= num2)
		{
			velocity.y = num2;
			velocity.x = Mathf.Cos(slopeAngle *
((float)Math.PI / 180f)) * num * Mathf.Sign(velocity.x);
			collision.below = true;
			collision.ascendingSlope = true;
			collision.slopeAngle = slopeAngle;
			collision.slopeNormal = slopeNormal;
		}
	}
```

Figure 14: Controller2D

3.2.1. Scenes Transition

Upon starting the game, players will be presented with the Main Menu (see Figure 11), featuring the character Croissant on a PC screen. The menu offers several options

to choose from: New Game, Continue, and Credits. Selecting “New Game” allows players to embark on a fresh journey, while “Continue” allows them to pick up where they left off in the game. The Credits option provides information about the development, art, creative team, and individuals involved in completing the game.

For players experiencing "Croissant Adventure" for the first time and selecting the New Game option, the scene transition will follow this sequence (see Figure 15):

Main Menu > Overworld Map > Stage 1 > Overworld Map > Stage 2 > Overworld Map > Stage 3 > End Game.

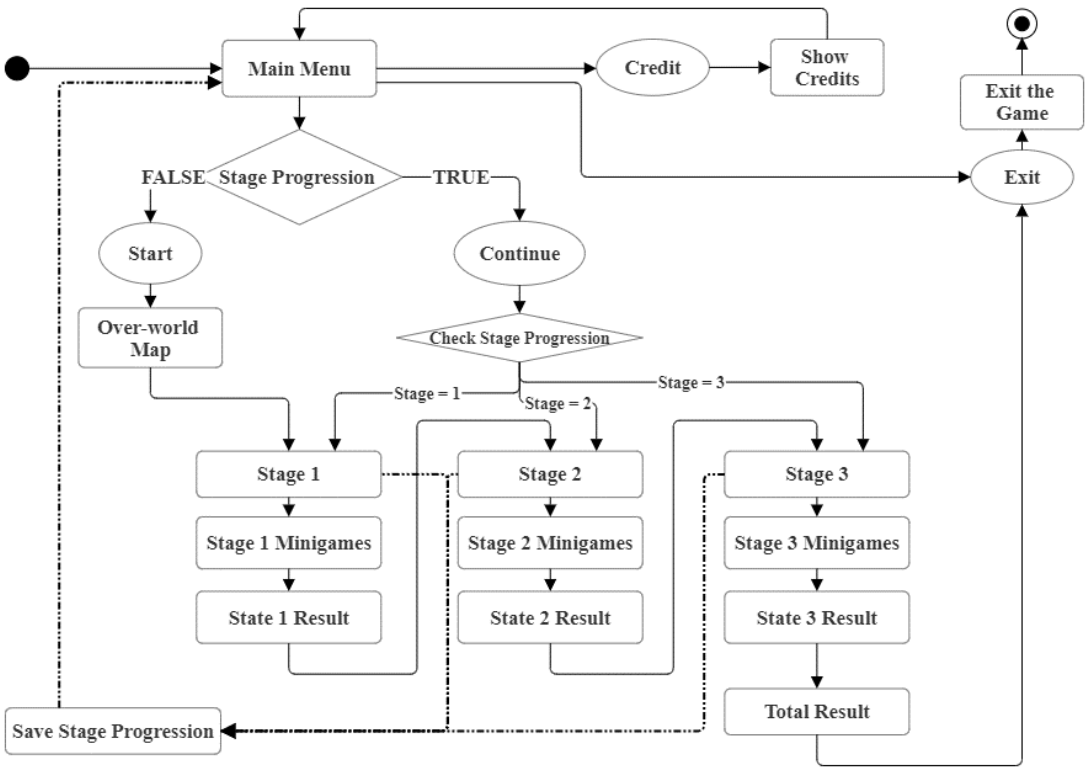


Figure 15: Game Stage Progression

Returning players who have already played the game and choose the “Continue” option will resume their journey from the point where they previously left off.

3.2.2. Game’s progression

After selecting "New Game" from the Main Menu, players will be taken to the "Overworld Map" (see Figure 16) where they will encounter doors leading to the three main stages of the game. The progression of the game follows a linear format,

reminiscent of games like Mario. As players control the PC character, they must move forward, with previously completed stages becoming locked. This progression continues until the end of the game, ensuring a sequential and immersive gaming experience.

Figure 16: Overworld in-game

The next step in this research is the design of the game stages. Since the quiz consists of three parts, each containing ten questions that progressively increase in difficulty structured within the game stages accordingly. Each stage comprises a designated "play area" filled with ten questions. To make the gameplay more engaging, five different mini games were integrated: the pipe, the meteorites, the wiring, the blocks, and the basket. The minigames themselves are intended to be educational so they are more lenient than typical videogames, there are no games over, no hazardous enemies that require players to replay if failed. Each minigames intention is to reinforce PC that answer correctly to keep remembering the correct answers and tell them the correct answers in case they are wrong.

The Information Security content is organized into three difficulty tiers: Easy, Normal, and Hard. The minigames within each stage contain different sets of questions. To provide a clearer example, the initial question in PART I of the quiz, "A good name for a password?" exclusively appears in the first stage. Conversely, the question "Who has the greatest influence over access security in a password authentication environment?" from PART II is confined to the second stage. Similarly,

the contents of PART III, representing the most difficult tier, do not appear in the first and second stages, exclusively featuring in the third and final stage. For detailed information about the specific questions included in each stage, refer to the appendix.

Through testing and experimentation, this research discovered that certain mini games were better suited for specific types of questions and answers. For instance, questions with lengthier wording proved to be more suitable for pipe or block mini games, as players could take their time to analyze and strategize. On the other hand, the meteorites and basket mini-games offered faster-paced gameplay with fewer text-based elements. In the following section will provide a detailed description of each mini-game and its unique features.

In "Croissant's Adventure," a series of mini games offer players engaging challenges. For instance, in one mini game involving pipes, players are rewarded with a celebratory sound and on-screen confirmation when they make the correct choice (see Figure 17). However, selecting the wrong pipe triggers a 'game over' sound, accompanied by an animated encounter with a menacing pipe monster resembling a red Venus fly trap. Regardless of the outcome, the game proceeds by displaying both the correct and incorrect pipe choices for players to observe.

Similarly, another mini game featuring croissants follows a similar pattern. Choosing the correct croissant results in a celebratory sound and on-screen validation, while an incorrect choice prompts a 'game over' sound and reveals the selected croissant as rotten. In both cases, the mini game concludes by displaying a delicious golden croissant alongside the rotten croissants, representing the correct and incorrect answers.

The mini game involving meteorites operates similarly. Correct selections elicit celebratory sounds and affirming visuals, whereas incorrect choices trigger a 'game over' sound and depict the player's spaceship exploding. The game then transitions back to the main game, displaying both the correct and incorrect meteorite choices.

Lastly, if players manage to align all nodes correctly, the mini game concludes with a celebratory sound and on-screen validation. Incorrect alignments produce an 'incorrect' sound and reset the node wiring. Players must complete the wiring before the countdown expires, or the mini-game ends with a 'game over' sound. Regardless of the outcome, the game returns to the main game screen, displaying the correctly aligned nodes.

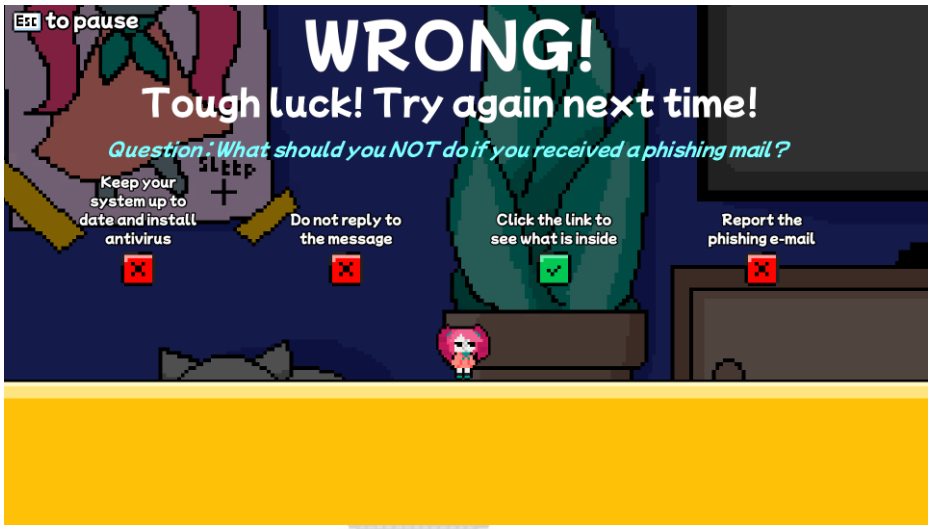


Figure 17: Result screen of every minigame, example of Whack a blocks

3.2.3. Whack-A-Blocks mini-game

Reminiscing the famously known gameplay in “Mario”, players are presented with a question on the upper part of the screen. The PC must choose the correct answer from four choices of blocks. By positioning themselves under the chosen block and pressing the 'spacebar,' the PC jumps and hits the block, destroying it in the process (see Figure 18 Top left image). In essence, this is a gamified version of 'multiple choices question' featured prominently in a contemporary exam.

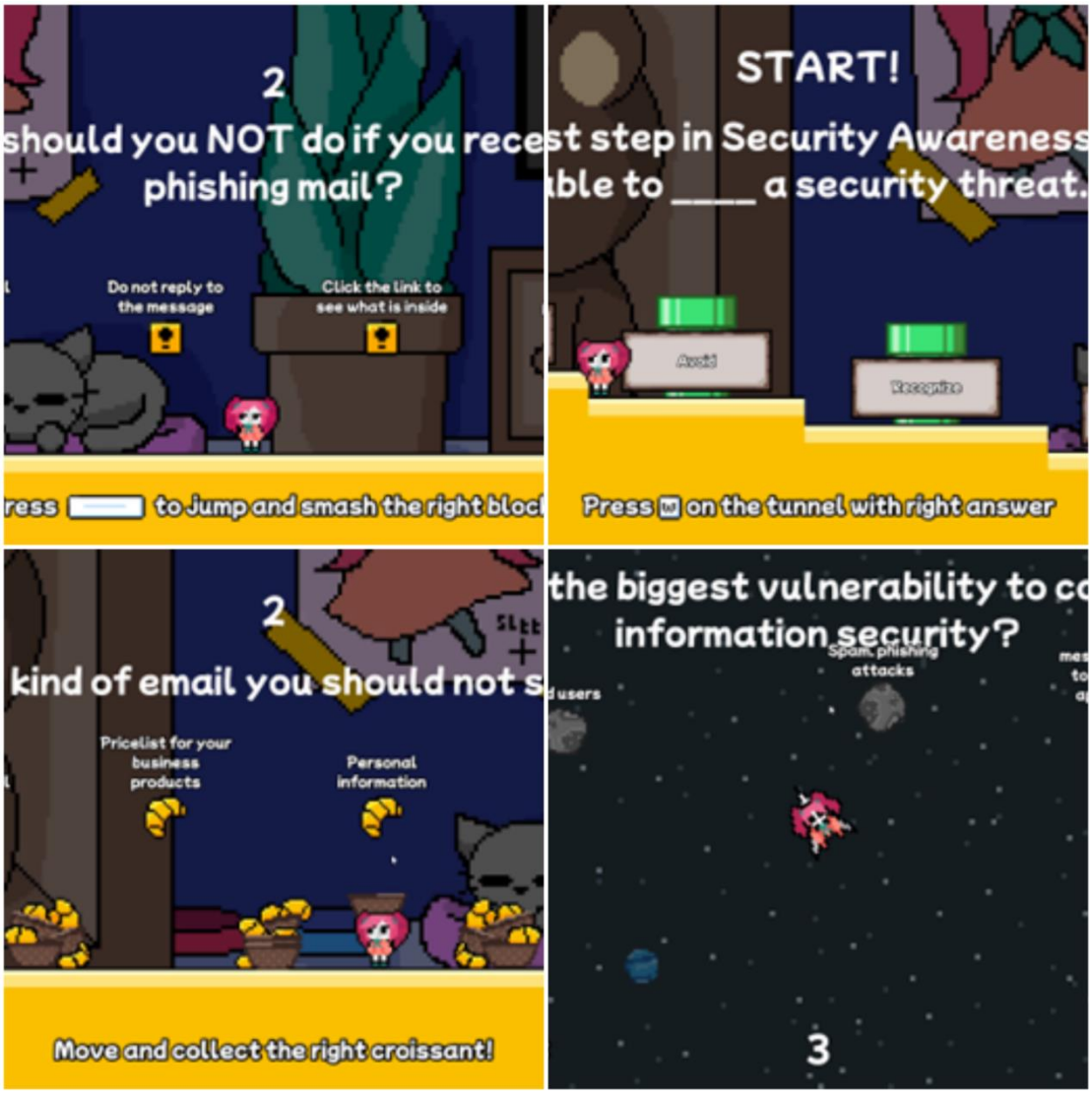


Figure 18: A Whack-A-Block minigame (Top left); A Pipe minigame (Top right); A Basket minigame (Bottom left); and Meteorite minigame (Bottom right)

In the case of coding for the Whack-A-Block mini-game (see Figure 19) demonstrates how the script controls the mini-game's reactions to the player's inputs. More precisely, the PlayAnimation() method assesses the player's response and initiates the appropriate animation, either _animator.Play(animation_right); for a correct answer or _animator.Play(animation_wrong); for an incorrect one. The DestroyAfterEnd() method resets the minigame state to its default state before player interaction.

```
using UnityEngine;
public class MinigameBlockAnimation : MonoBehaviour
{
	private Animator _animator;
	private MinigameBlock _block;
	[SerializeField]
	private string animation_right;
	[SerializeField]
	private string animation_wrong;
	private void Start()
	{
		_animator = GetComponent<Animator>();
		if (_animator == null)
		{
			_animator = GetComponentInChildren<Animator>();
		}
		_block = GetComponent<MinigameBlock>();
	}
	public void PlayAnimation()
	{
		if (_block.isRightAnswer)
		{
			_animator.Play(animation_right);
		}
		else
		{
			_animator.Play(animation_wrong);
		}
	}
	public void DestroyAfterEnd()
	{
		base.transform.gameObject.SetActive(value: false);
	}
}
```

Figure 19: Minigame Block Animation

3.2.4. Pipe mini-game

Another minigame that features a similar gameplay to ‘Mario’. This one is almost the same as the Whack-a-blocks game before but instead of jumping, the PC will have to choose the correct pipe to go down. By pressing ‘spacebar’ to realign themselves on top of the chosen pipe and pressing ‘W’ (see Figure 18 Top right image).

3.2.5. Basket mini-game

In this mini game, the PC will hold an empty basket on top of their head while the game shows the question on the upper part of the screen. The game will countdown starting from three. Once the countdown reaches zero four croissants will slowly drop

from the sky. The PC will have to position themselves so that the basket on their head catch the chosen croissant (see Figure 18 Bottom left image).

3.2.6. Meteorite mini-game

This is one of the few minigame that features a drastic change from ‘Mario’ gameplay and control. Inspired by the classic ‘Asteroid’ videogame, The meteorite minigame (see Figure 18 Bottom right image). transform the PC into a spaceship traveling deep space with many meteorites floating around. The PC can move using WSAD to accelerate, reverse thrust, and turn left or right. Pressing a ‘left mouse button’ will prompt the spaceship to shoot a beam of laser, that if hit any meteorites will destroy it.

The Meteorite game, recognized for its distinctive gameplay, stands out as one of the two minigames, alongside the Wiring minigame, involving intricate scripting beyond the scope of other minigames. The example code (see Figure 20) elaborates on the programming approach.

The GetLookDirection() method constantly monitors the mouse cursor's position on the screen, adjusting the ship's orientation accordingly. The rotation speed of the ship towards the mouse cursor is controlled by the RotateSpaceCraft(float targetAngle) method. SetVelocity(), OnAccelerate(InputValue value), and OnStrafe(InputValue value) govern various aspects of the ship's movement, encompassing its standard drifting speed in a designated direction, speed modulation during boosting (triggered by the W key), and strafing (initiated by A and D key presses), respectively.

```
	private Vector2 GetLookDirection()
	{
		Vector2 vector =
Camera.main.ScreenToWorldPoint(mousePosition);
		Vector2 vector2 = base.transform.position;
		return (vector - vector2).normalized;
	}

	private void RotateSpaceCraft(float targetAngle)
	{
		currentAngle = Mathf.SmoothDampAngle(currentAngle,
targetAngle, ref AngleVec, rotationSmoothTime);
		base.transform.rotation = Quaternion.Euler(0f, 0f,
currentAngle);
	}

	private void SetVelocity()
	{
		float num = ((movementDirection.y == -1f) ?
decelerationDamp : 1f);
		Vector2 target = base.transform.up *
movementDirection.y * num * accelerateSpeed + base.transform.right
* movementDirection.x * strafeSpeed;
		currentVelocity = Vector2.SmoothDamp(currentVelocity,
target, ref MovementVec, movementSmoothTime);
	}

	private void OnAccelerate(InputValue value)
	{
		movementDirection.y = value.Get<float>();
	}

	private void OnStrafe(InputValue value)
	{
		movementDirection.x = value.Get<float>();
	}

	private void OnMousePosition(InputValue value)
	{
		mousePosition = value.Get<Vector2>();
	}

	public void SetMoveState(bool state)
	{
		ableToMove = state;
	}
}
```

Figure 20: Meteorite Minigame Ship Control

3.2.7. Connecting Wires mini-game

Wiring mini-game has been one of the very first idea this research decided to include minigames into ‘Croissant Adventure’, and it has improve considerably from prototype draft. This minigame, like the meteorites minigame, features a shift from

normal gameplay with its own unique control. The PC will operate the wiring controller and try to match the question node from the left side with the correct answer nodes from right side. Once all wiring nodes are wired up, the PC can check their validity by clicking on the red ‘CHECK’ button located on the bottom left of the screen (see Figure 21).

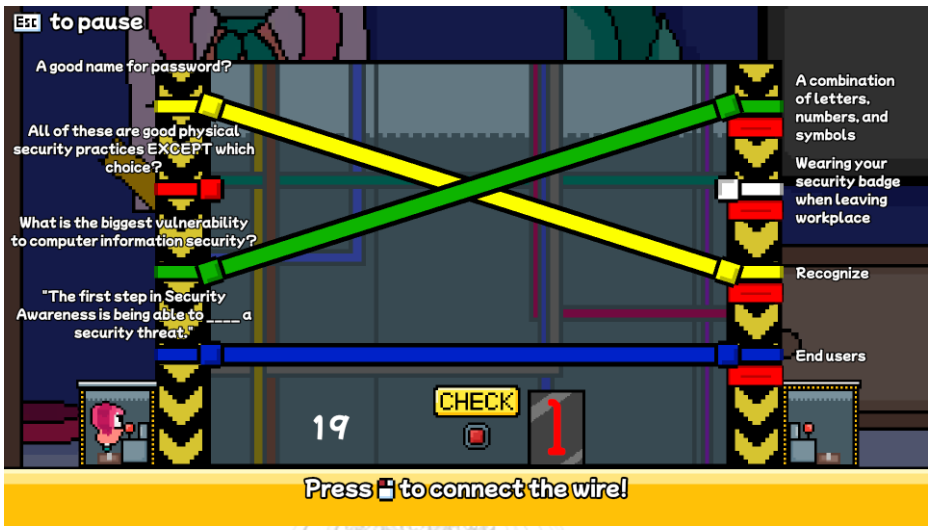


Figure 21: The released version of Connecting the Wire minigame

The wiring minigame is unique from the rest of the minigames in that, by design, it is the only minigame that can have multiple questions in one playthrough. Other minigames can only have one question at a time. This design choice allows game to be flexible with how to include all the required information for each stages without filling the stages with too many minigames, effectively cutting the number of minigames per stages from ten to seven.

Just like the Meteorite minigame, the Wiring minigame involves extensive scripting, particularly for managing the overall game flow, left-side nodes, right-side nodes, and validation of connecting nodes. On the left side, the mechanics of the wires in the minigame are illustrated through the Update() and OverrideWireSelection(Transform rightBlock) methods (see Figure 22). These methods update the current wire position based on the mouse cursor, wire length, and angle from the left node to the current cursor position. The right side also employs similar methods that complement those on the left side.

```
private void Update()
      {
            if (state == WireState.Selected)
            {
                  Vector2 vector =
Camera.main.ScreenToWorldPoint(Mouse.current.position.ReadValue())
;
                  Vector2 vector2 = new
Vector2(_wireStretch.position.x, _wireStretch.position.y);
                  float num = Vector2.SignedAngle(vector -
vector2, Vector2.right);
                  _wireStretch.parent.rotation =
Quaternion.Euler(new Vector3(0f, 0f, 0f - num));
                  _wireStretchSprite.size = new Vector2((vector -
vector2).magnitude, 1f);
            }
      }

public void OverrideWireSelection(Transform rightBlock)
      {
            _wireStretch.gameObject.SetActive(value: true);
            Vector2 vector = new
Vector2(rightBlock.GetChild(0).position.x,
rightBlock.GetChild(0).position.y);
            Vector2 vector2 = new Vector2(_wireStretch.position.x,
_wireStretch.position.y);
            float num = Vector2.SignedAngle(vector - vector2,
Vector2.right);
            _wireStretch.parent.rotation = Quaternion.Euler(new
Vector3(0f, 0f, 0f - num));
            _wireStretchSprite.size = new Vector2((vector -
vector2).magnitude, 1f);
            state = WireState.Connected;
            _manager.setState(WireGameState.Free);
      }
```


Figure 22: Connect the Wire - Left blocks

The ConnectTheWire_Checker script (see Figure 23) is responsible for checking the correctness of the connections made. This method retrieves components, including answers and questions, from both the left and right nodes linked by the wire. It then verifies whether these connections are correct or not and displays the result accordingly.

```
public bool CheckAnswer()
	{
		bool result = true;
		for (int i = 0; i < rightBlockParent.childCount; i++)
		{
			ConnectTheWire_RightBlock component =
rightBlockParent.GetChild(i).GetComponent<ConnectTheWire_RightBloc
k>();
			bool connectionComparison =
component.getConnectionComparison();

		component.transform.GetChild(2).GetComponent<SpriteRenderer>
().color = (connectionComparison ? rightColor : wrongColor);
			if (!connectionComparison)
			{
				result = false;
			}
		}
		return result;
	}
```

Figure 23: Connect the Wire - Checker

Each stage has a total of ten questions and once the PC reaches the end of the stage, the game will show the result of all questions, correct or wrong, that the PC has answered. By pressing 'Enter' the game will teleport the PC back to the overworld map.

Figure 24: End stage result screen

After the PC has cleared all minigames on stage and find an exit the game will show how many scores they have gained so far depending on whether they answer the questions in minigames correctly or not. The game will unlock the previously locked

stages for the PC to proceed, this will repeat until the PC complete all 3 stages in which the game will calculate and show total scores before ending the game as illustrate in Figure 24. The following script method illustrates how the game displays the end-of-stage score (see Figure 25).

```
private void Update()
      {
            if (!inputAction.triggered || !isAvailable ||
GameStateManager.isPausing || GameStateManager.isLeaving)
            {
                  return;
            }
            if (!haveShowScore)
            {
                  haveShowScore = true;
      GetComponent<MinigameUIManager>().UISwitch(activeStatus:
true, doneStatus: false);
                  PlayerPrefs.SetInt("Level" +
(SceneManager.GetActiveScene().buildIndex - 1) + "Score",
_levelManager.GetResultNow());
                  PlayerPrefs.SetInt("Progress",
SceneManager.GetActiveScene().buildIndex);
                  _resultUI.parent.gameObject.SetActive(value:
true);
                  for (int i = 0; i < _resultUI.childCount - 1;
i++)
                  {
                        TextMeshProUGUI component =
_resultUI.GetChild(i).GetComponent<TextMeshProUGUI>();
                        if (_levelManager.GetResultAt(i))
                        {
                              component.text = i + 1 + " - <sprite
index=1>";
                        }
                        else
                        {
                              component.text = i + 1 + " - <sprite
index=0>";
                        }
                  }
                  _director.playableAsset = _resultScreenClip;
                  _director.Play();
                  StartCoroutine(ShrinkSequence());
            }
            else if (!isLoading && !isShowingScore)
            {
                  isLoading = true;
                  isAvailable = false;
                  _director.playableAsset = _transitionOutClip;
                  _director.Play();
            }
      }
```

Figure 25: Level Ender

3.3.Stage 3: Testing

The testing was done in parallel during the development period. As the gameplay loop consists of PC playing multiple minigames in one stage the minigames took priority. Many gameplay elements were adjusted for smoother gameplay and improved "Quality of Life" that make the game experience more enjoyable and reduce frustrations.

The very first testing is the PC itself. Movement speed, jump height and interaction with various objects in-game were tested to make sure they work properly. The movement speed and jump height are substantial than expected as the time went by. Realized that the PC with unbalanced speed and jumping height was extremely hard to control the PC movement speed and jumping height has been adjusted to match the flow of gameplay.

The second test is the minigames scattered throughout each stage of the game. Different minigames require different testing but the "Asteroid" minigame as in this minigame the PC does not make an appearance but the spaceship which has different control scheme from the rest of the game.

The third test focuses on sound and visual ques for example the "Electrical wiring" minigame has flashing lights indicating the correct or wrong answers. Numerous tests were conducted with different use cases to determine any bugs and fixed them accordingly.

The final test involved a testing run. Playing the game from start to finish while trying to "find as many bugs as possible (i.e., a coding errors that cause an unexpected problem with software)". Such bugs that were found include skipping stages, skipping minigames, and movements glitches which were fixed accordingly.

Testing the game allowed for a better understanding of how the game would be perceived to the player; by replaying, adjusting, and then played again to improve both the gameplay and fixing any problems that encountered along the way.

At the end of development phase, the last testing was conducted after the final patch of the game then the game is ready for its first maiden release.

3.4.Stage 4: Release

The research has reached a critical stage - the first maiden release of the game to be played by participants. However, several preparations need to be made to ensure the successful execution of this stage.

The first concern is to effectively inform and advertise the research to potential participants, specifically the student body. To generate interest, the decision was made to leverage the allure of playing a video game and adopted a "friend to friend" approach, encouraging students to invite their friends to participate. This approach yielded positive results, as many students expressed interest and agreed to take part in the research photo'd in Figure 26.

Figure 26: The day of the experiment

The second concern revolves around arranging a suitable meeting for the experiment to take place. After careful consideration, the university's computer laboratory was selected as the ideal location, equipped with all the necessary resources shown in Figure 27. However, the timing proved to be challenging due to the final examination period, with each student having different availability. The meeting had to be

meticulously planned at a time when many students were free, recognizing the risk of a low participant count. Fortunately, a satisfactory number of students were able to attend the meeting.

Figure 27: Students from Gamified group playing "Croissant's Adventure".

The third concern involved organizing the experiment itself. Despite an effort to minimize uncertainties, some minor setbacks were encountered. The lab's PCs lacked sound, some students arrived late and missed the initial orientation, and the weak internet connection prevented the downloading of the video game stored on the Cloud service.

To address these issues, improvised arrangements were made. Students from the traditional group either watched the presentation on their own smart devices or gathered in study groups utilizing a PC with sound. Latecomers were provided with a clear understanding of the research's purpose and instructions on what they should do. Finally, a USB drive containing a copy of the game was used to directly install it on the lab's PCs.

Once all the problems were addressed, the experiment proceeded smoothly until its completion.

3.5. Stage 5: Postproduction

The purpose of this research is twofold: firstly, to apply gamification to the field of cybersecurity education through the development of a video game, and secondly, to determine whether this gamified approach enhances students' understanding of the subject compared to traditional classroom learning. Additionally, game development itself presents an additional objective.

While the development and patching phase of most video games in the market may mark the end of their life cycle, this is not the case for the game, "Croissant's Adventure". The purpose of a video game is to provide entertainment to the players, and obtaining reviews from those who have played the game is crucial. As the developers of the game are oftentimes the initial players, and their review comes in the form of making additions and patches to enhance the overall enjoyment. Elements of the game that were found tedious or excessively difficult from a player's perspective were adjusted. The opportunity to have a diverse group of people play the game provides valuable insights for further improvements.

Chapter 4
Result and Discussion

"The results and discussion sections are the heart of the manuscript. These sections tell what you found and why you think it's important. They relate your findings to the prior research discussed in your introduction and provide a bridge to your conclusion."

Ronald A. Berk

"Discussing results is like unwrapping a mystery gift – each layer reveals insights, surprises, and the joy of discovery."

The Internet

In this chapter, this research presents the findings and insights obtained from the extensive experimentation and analysis conducted throughout this research. The focus of Chapter 4 is to discuss the outcomes of the gamified learning platform, "Croissant's Adventure," in comparison to traditional learning methods for teaching information security awareness. As this research delve into the results and engage in thoughtful discussions aims to shed light on the effectiveness of gamification in the educational context, offering valuable insights into its potential as a powerful tool for promoting active learning and knowledge retention.

Throughout the previous chapters, this research laid the groundwork for the study, setting clear objectives and defining the scope of the research. Elaborated on the development of the educational videogame, its unique features, and its incorporation of information security awareness content. Additionally, details of the experimental design and the selection of a target audience, which consisted of Chulalongkorn university undergraduate students.

Now, as this research embarks on the discussion of the results, the impact of the gamified platform on the learning experience of the participants will be unraveled. By analyzing data collected from both the gamified group, who engaged with "Croissant's

Adventure," and the traditional group, who experienced the educational video lectures, this research seek to draw meaningful conclusions that will contribute to the fields of gamification and educational game development.

In this chapter, key aspects, such as the effectiveness of "Croissant's Adventure" in enhancing students' knowledge retention, motivation, and performance in the cybersecurity domain were addressed. Furthermore, exploring the participants' feedback and perceptions, providing invaluable insights into the strengths and areas for improvement of the gamified learning approach.

The results and discussions presented in this chapter will guide towards a deeper understanding of the potential of gamification in higher education. Moreover, it will pave the way for future studies in the realm of gamified learning and its broader impact on education, as this research strive to foster innovative and engaging methods for imparting knowledge and nurturing the minds of learners.

4.1.Selecting a Target Audience

In this study, the primary focus is on developing a videogame tailored for teaching advanced topics in higher education. To achieve this, a specific target audience has been chosen: undergraduate students from Chulalongkorn university. This research anticipated at least 10 participants for the experiment to yield substantial results. The participants will be divided evenly into two distinct groups, namely Group A, referred to as the "Gamified Group," and Group B, known as the "Traditional Group." Each group will be exposed to different learning methods:

The Gamified Group (Group A) will engage with a gamified lesson delivered in the form of a videogame (Croissant’s Adventure). The content of the lesson in the game will be the same as educational video provided to Group B, but with appropriate adjustments to accommodate the gameplay experience.

The Traditional Group (Group B) will receive an educational video that contains all the lessons on Information Security Awareness, following the conventional means of studying through class lectures.

Both groups will be given approximately 30 minutes to play and study. After the learning phase is completed will proceed to the examination stage to evaluate the effectiveness of each learning approach. This research approximates the total time for each individual student to complete their assignments within 60 minutes.

4.2.Preparation for the gamified lesson

The preparation for the gamified lesson encompasses two main stages. The first stage involves the development of a videogame platform specifically designed for the gamified group. This platform will serve as the primary means of learning for Group A, providing them with an interactive and engaging experience.

The second stage of preparation revolves around creating the learning material for the traditional group (Group B). After careful consideration, the decision to utilize a video presentation as a teaching approach was chosen. The decision was influenced by the widespread use of PowerPoint-style presentations in contemporary educational settings. To ensure the effectiveness of this research, it was essential to design a video presentation that was concise, structured, and of high quality.

Drawing upon the understanding of gamification and educational game development, this research embarked on extensive research to identify the key components that make a compelling and impactful classroom experience. Additionally, various lectures conducted by different educators at Chulalongkorn university were observed to gain valuable insights into the dynamics of traditional teaching methods.

In addition to providing educational content through videogame and videos lecture, quizzes shall be incorporated for both groups. These quizzes will serve as a means of evaluating the students' understanding and knowledge retention, ensuring that both groups undergo a similar assessment process.

By carefully orchestrating these two stages of preparation, the aim to create a well-rounded and comprehensive learning experience for both groups, fostering a conducive environment for effective education and meaningful results.

To ensure the accuracy of the experiment, the content within Croissant's Adventure, Video Presentation, and Quiz originates from the same source, inspired, and derived from ISACA CISM's information security test. Further details regarding this will be discussed in the following section.

4.3.Preparing environments

Utilizing a video presentation format for students of Traditional group offered the advantages of easy sharing among participants and compatibility with various smart devices. This decision proved to be prudent, particularly considering the challenges encountered with the laboratory computers mentioned in Stage 4: Release.

Considering that the traditional group would spend half of their time watching the video presentation (with the other half dedicated to quizzes), the presentation is structured to be time efficient. It was designed to be approximately 20 minutes long, divided into three parts, mirroring the structure of the video game and quizzes. However, the video presentation differed from the game in that it had a storytelling element, with information interwoven throughout, as opposed to the game's sequential stage-by-stage approach. This deliberate approach aimed to simulate the experience of students in traditional classrooms, where they must actively listen to the teacher, absorb the information, analyze it, and arrive at conclusions.

4.4.A Quiz

A quiz was administered to participants from both Group A and Group B following the completion of their respective lessons. Each participant was instructed to complete the test within a 30-minute timeframe and was prohibited from using any form of assistance during this period. The exam was divided into three parts, each progressively increasing in difficulty. Part 1 encompassed foundational information security knowledge (easy), Part 2 covered intermediate concepts (normal), and Part 3

delved into advanced information security knowledge (hard). Each part consisted of 10 questions, resulting in a combined total of 30 questions. Participants were presented with traditional multiple-choice questions, requiring them to select the most accurate options from the provided choices. The question content for the exam was inspired from the ISACA CISM's information security tests (2020-2021).

The quiz will serve as an assessment tool to demonstrate that Croissant's Adventure is a superior tool for delivering Information Security topics compared to the video presentation, showcasing its effectiveness in both knowledge delivery and efficiency.

Once all participants from both groups had completed the test, a comprehensive analysis of the scores was conducted, enabling a comparative evaluation in the following aspects:

1. Academic Performance: A comparison of which group achieved higher scores by correctly answering the maximum number of questions out of 30.
2. Basic Knowledge: A comparison of how many students from each group passed the easy difficulty level.
3. Intermediate Proficiency: A comparison of how many students from each group passed both the easy and normal difficulty levels.
4. Advanced Mastery: A comparison of how many students from each group successfully completed all difficulty levels in the exam, obtaining a minimum total score of 18, with at least 6 scores achieved in each difficulty level.

Given the exam's linear progression, gradually increasing in difficulty after every 10 questions, this assessment provides insight into whether students in each group possess well-rounded knowledge or specialize in specific areas. For instance, while one student might exhibit strong competence in advanced information technology, their grasp of fundamental information security could be lacking. Another student might excel in basic and intermediate information technology while struggling with advanced information security knowledge. The passing threshold requires a

correctness rate exceeding 60% (6 out of 10) for each part of the exam, allowing for a comprehensive assessment of participant knowledge across the difficulty spectrum.

4.5.Result Analysis

Up to this point, this research has successfully developed Croissant's Adventure as a gamified platform and conducted an experiment. However, three objectives remain: to assess the impact of Croissant's Adventure on student motivation and as an educational tool, to identify its strengths and weaknesses, and to explore the potential of gamification as an innovative and engaging approach. These objectives lead to two hypotheses:

Hypothesis 1: Gamifying the learning process will enhance participant motivation, leading to improved test scores in security awareness exams compared to those who engage in traditional learning methods.

Hypothesis 2: The introduction of gamification, making the learning process more engaging and 'fun,' will result in increased participant attention and interest.

The test results from both Group A and Group B will be aggregated and subjected to a comprehensive comparison, aiming to validate the hypotheses intended to ascertain the validity of these hypotheses. Depending on the outcomes will undertake a thorough examination of the contributing factors that have influenced the experimental results. This examination will encompass identifying potential areas for improvement and further investigation. Ultimately, based on the alignment or divergence of the hypotheses with the experimental outcomes will draw meaningful conclusions from this research endeavor.

4.6.Result

The test was conducted on two separate occasions, both tests divided participants equally into two groups: A and B.

In the initial test, involving a student from the same coursework and academic years as a participant, observations of students from Group A ("Gamified") during the experiment revealed a positive response and overall interest in the gamification platform, with most of the group expressing interest in the incorporation of educational topics into video games.

During an experiment various data gatherings were conducted, things like students' behaviors and visual cues during their watching video sessions and playing videogame. This information is essential in determining the success of this research, in case of videogame is to captivate the player and keep them entertain, and in case of video presentation is to see if a design structure of presentation is of high quality that students never felt bored or confuse.

After analyzing the results from the quizzes conducted in the experiment, an interesting finding emerged. The group that was assigned to gamified learning scored an average of 24.5 out of 30, which was significantly higher compared to the traditional group's average score of 15.2. This indicates a notable difference of approximately 61.18 percentage points between the two groups (see Figure 28).

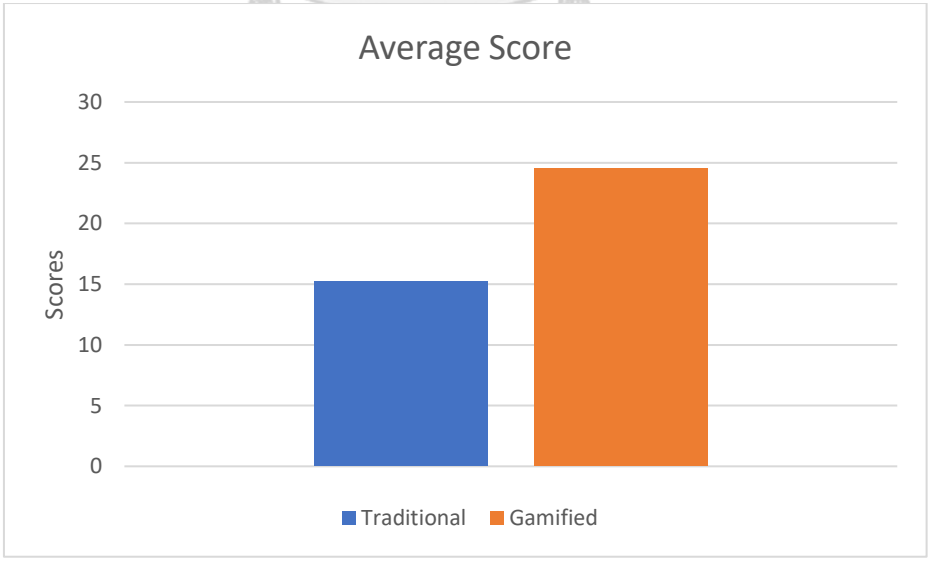


Figure 28: An average test score of both groups

Further analysis revealed the difference between the two groups. For the Gamified group cluster of scores (see Figure 29) shows several key findings. Firstly, the range

of scores indicates a difference of 13 points between the highest and lowest scores. Secondly, the mean score, calculated by summing all the scores and dividing by the total number of scores, is found to be 24.5. Additionally, the median score, representing the middle score when arranged in ascending order, is 26. Furthermore, the distribution of scores shows a concentration of high scores followed by a gradual decrease towards the lower end. It is worth noting that there is no mode in this cluster as no score appears more than once. The variation in scores is evident, with a range of 13 points and a greater concentration of higher scores compared to the lower scores, which are more spread out. In conclusion, this cluster showcases a mixture of high and low scores, with a relatively high mean score and some variability among the scores.

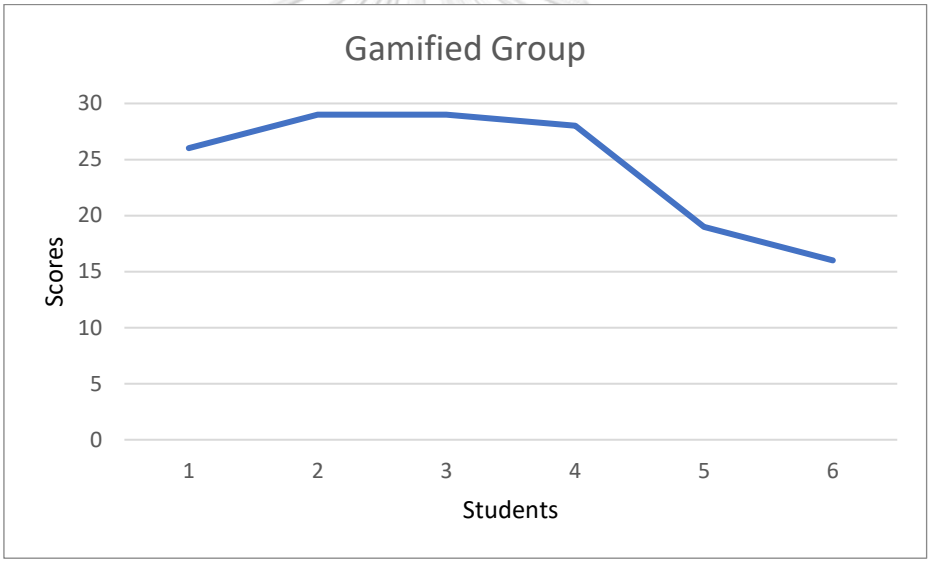


Figure 29: The score of Gamified group

As for the Traditional group (see Figure 30), the cluster of scores reveals another contrasting characteristics and distribution patterns within the data. Firstly, the range of scores indicates a difference of 15 points (22-7) between the highest and lowest scores. Secondly, the mean score is found to be 15.2 (76 divided by 5). Next, the median score represents the middle value is 15. No mode is identified within this cluster as no score appears more than once. The distribution of scores shows a variation among the values, ranging from 7 to 22. This indicates a spread across the possible score range. In conclusion, this cluster of scores exhibits a diverse range of performance levels, as reflected by the relatively low mean score of 15.2. The

distribution appears to be somewhat scattered, without a dominant mode. The variation among the scores suggests varying levels of achievement within this cluster.

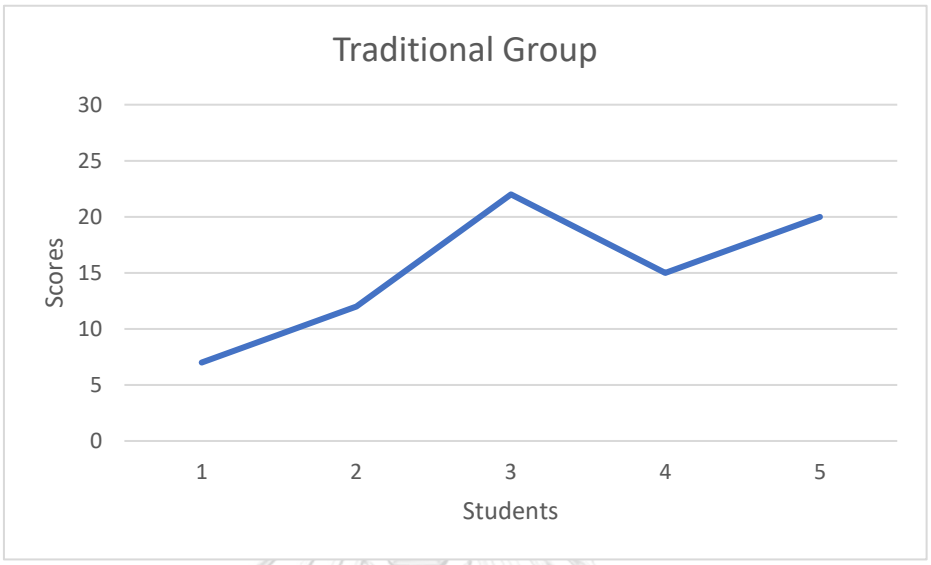


Figure 30: The score of Traditional group

Upon conducting a detailed analysis of individual students within each group, intriguing findings surfaced. Initially, as anticipated, both the Traditional and Gamified groups performed commendably in the initial set of questions (see question PART I at the appendix).

	TRADITIONAL						GAMIFIED						
	S1	S2	S3	S4	S5		S1	S2	S3	S4	S5	S6	
Q1	TRUE	TRUE	TRUE	TRUE	TRUE		TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	
Q2	TRUE	TRUE	TRUE	FALSE	FALSE		TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	
Q3	FALSE	FALSE	TRUE	TRUE	TRUE		TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	
Q4	FALSE	FALSE	TRUE	TRUE	TRUE		TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	
Q5	FALSE	TRUE	TRUE	TRUE	TRUE		TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	
Q6	TRUE	TRUE	TRUE	TRUE	TRUE		TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	
Q7	FALSE	TRUE	TRUE	TRUE	TRUE		FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	
Q8	FALSE	FALSE	TRUE	TRUE	TRUE		TRUE	TRUE	TRUE	TRUE	FALSE	FALSE	
Q9	FALSE	FALSE	TRUE	TRUE	FALSE		TRUE	TRUE	TRUE	TRUE	FALSE	FALSE	
Q10	FALSE	FALSE	TRUE	TRUE	TRUE		FALSE	TRUE	TRUE	TRUE	TRUE	FALSE	
Q11	TRUE	TRUE	FALSE	FALSE	TRUE		TRUE	TRUE	TRUE	FALSE	FALSE	TRUE	
Q12	FALSE	FALSE	FALSE	FALSE	FALSE		TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	
Q13	TRUE	TRUE	TRUE	TRUE	TRUE		TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	
Q14	FALSE	FALSE	TRUE	FALSE	TRUE		TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	
Q15	FALSE	TRUE	TRUE	FALSE	TRUE		TRUE	FALSE	TRUE	TRUE	FALSE	TRUE	
Q16	TRUE	TRUE	FALSE	TRUE	TRUE		TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	
Q17	FALSE	TRUE	TRUE	FALSE	TRUE		FALSE	TRUE	TRUE	FALSE	TRUE	FALSE	
Q18	FALSE	TRUE	TRUE	FALSE	TRUE		TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	
Q19	FALSE	FALSE	TRUE	TRUE	TRUE		TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	
Q20	FALSE	FALSE	TRUE	FALSE	TRUE		TRUE	TRUE	TRUE	TRUE	FALSE	FALSE	
Q21	FALSE	FALSE	TRUE	FALSE	FALSE		TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	
Q22	FALSE	FALSE	FALSE	FALSE	TRUE		TRUE	TRUE	TRUE	TRUE	FALSE	FALSE	
Q23	FALSE	FALSE	TRUE	TRUE	FALSE		TRUE	TRUE	FALSE	TRUE	TRUE	FALSE	
Q24	FALSE	FALSE	FALSE	FALSE	FALSE		TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	
Q25	TRUE	FALSE	TRUE	FALSE	TRUE		TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	
Q26	FALSE	FALSE	FALSE	TRUE	FALSE		TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	
Q27	FALSE	FALSE	FALSE	FALSE	FALSE		TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	
Q28	FALSE	FALSE	TRUE	TRUE	TRUE		TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	
Q29	FALSE	FALSE	TRUE	FALSE	FALSE		FALSE	TRUE	TRUE	TRUE	TRUE	FALSE	
Q30	FALSE	TRUE	FALSE	FALSE	FALSE		TRUE	TRUE	TRUE	TRUE	FALSE	FALSE	
TOTAL	7	12	22	15	20	15.2	26	29	29	28	19	16	24.5

Figure 31: Individual Test Scores of each group

However, when tackling the final set of questions (see question PART III at the appendix), the Traditional group encountered more challenges compared to their Gamified counterparts, grappling with a greater difficulty in comprehending the material. Furthermore, the test scores revealed the so-called 'hardest ones among the bunch,' signifying the most challenging questions within each quiz section. These specific questions garnered a higher number of incorrect responses from both the Traditional and Gamified groups compared to other questions within their respective tiers (see Figure 31).

4.6.1. Interview with Students

As part of the experiment conducted post-test interviews with students from both groups to gain deeper insights into their perceptions of the experiment. During this phase, several students expressed interest in experiencing the other group's learning method (playing the videogame or watching the lecture video), which provided an

intriguing additional perspective. The following section presents the detailed conversations and insights gathered from the interviews with the students.

4.6.1.1.The First Group Interview

In the first group interview with students from the Gamified group, their feedback primarily focused on aspects of the game that could be further improved. Firstly, they mentioned the issue of cut-off texts during gameplay, which occurs when longer texts go out of bounds. This signifies the plan to introduce a resolution setting in the game to accommodate different monitor resolutions and adjust the game layout to ensure that longer questions and answers fit properly on the screen.

Another area of concern raised by the group was related to the result screen, particularly the correct and wrong indicators that appear after each minigame. Students found it challenging to differentiate between them, more adjustment will be done to make these indicators more distinct to avoid confusion.

Furthermore, the meteorite minigame requires some adjustments, especially regarding its unique gameplay and control scheme. The instructions need to be clearer to ensure players understand the mechanics and objectives better.

Lastly, students commented on the time limits of certain minigames, suggesting that some of them should be lengthened. A shorter time limit was perceived to restrict players from making educated decisions, often leading them to rush and make hasty choices. By extending the time limits aims to provide players with more opportunities to make thoughtful decisions and enhance their overall gaming experience.

4.6.1.2.The Second Group Interview

During the second group interview, which included students from both the Gamified and Traditional groups, more valuable insights were gained from those who had experienced both learning methods. They praised the result screen in the videogame that displayed both correct and wrong answers after each minigame. This feature provided clarity to players about their understanding of the questions and the accuracy

of their responses. However, some students noted that the in-game controls, particularly jumping, were inconsistent and challenging. Specifically, in stage 2 of the game, set in a space-esque background, the floating jumping motion made sense, but it felt less immersive in other stages not related to space. This research aims to address this issue to ensure a more seamless and immersive gaming experience for all stages of the game.

Additionally, this group echoed the same recommendations for improvements related to the out-of-bound texts, time limits, and minigame instructions as mentioned by the first interviewed group.

When asked about the effectiveness of the gamified platform compared to traditional learning, the group highlighted its benefits for subjects that rely on straight memorization of "patterns." They found that the videogame facilitated review and improved memorization. On the other hand, they acknowledged that traditional learning through lectures required comprehension and the ability to identify "main and sub keywords" woven throughout the lecture. Processing the information and knowing where to focus their attention during lectures presented challenges for some students.

Overall, the second group interview provided valuable feedback on the strengths and areas of improvement for the gamified learning platform.

4.6.1.3.The Third Group Interview

The third group, composed of students from the traditional group, expressed their perspectives on the quiz and the challenges they faced. They found that the questions in the quiz itself were not particularly difficult, and most of them were within their expectations. However, they pointed out that the main difference between normal lectures and the video learning in the experiment was the inability to take notes and refer to them for information processing. In this experiment, students had to rely solely on their memorization of a large amount of information, making the quiz more challenging for them.

When asked about their views on using the gamified platform as a learning tool, the group agreed that it should be utilized. They believed that it could aid in brain development and analytical thinking. They also expressed that further improvements to the game could enhance its effectiveness as a learning tool.

Regarding the impact of more educational video games like this on student motivation and concentration in the classroom, the group believed that it would have a positive effect. They referred to an educational game called "Tao Gae Noi," which was discussed in Chapter 1, and highlighted its potential to enhance motivation and concentration among students.

The insights provided by the third group shed light on the different learning experiences between traditional lectures and the gamified platform. Their feedback and perspectives contribute to the ongoing efforts to improve the effectiveness of educational video games as a valuable tool for learning and cognitive development.

4.6.1.4.The Fourth Group Interview

The fourth group, comprising students from both the Gamified and Traditional groups, shared their experiences comparing the use of the educational video game, Croissant's Adventure, and traditional learning through video clips. They found that they learned more about the content of Information Security Awareness in the video game and enjoyed the overall experience. On the other hand, while the video clips contained more detailed information, students needed more time to process it, and taking the quiz immediately afterward made it more challenging.

The group echoed the problems mentioned by previous groups and provided additional insights. They found the meteorite minigame particularly challenging, as the fast-moving meteors made it difficult to read the answers hovering above them, in addition to the previously mentioned issue of out-of-bound texts.

When asked about their favorite and least favorite minigames, most students agreed that minigames with limited timeframes, like the basket minigame, were their least

favorite. Conversely, they favored brick and pipe games due to their absence of time limits and simpler gameplay. The wiring game received praise as the culminating minigame, testing players on what they had learned so far, but improvements were suggested for clearer instructions, smoother wiring of each node, and addressing out-of-bound text issues.

The interview revealed surprising findings as some students expressed their favorable views of the basket minigame, citing its challenge and fast-paced gameplay. Further inquiry showed that students' preferences were influenced by their familiarity with video games, ranging from those who were new to gaming to hardcore gamers seeking thrill and challenge. Thus, the difficulty level of the basket minigame could be perceived as either unbalanced and not enjoyable or challenging and exhilarating, depending on the individual.

When asked about their preference between traditional learning and the gamified platform, the consensus among the group was that playing the game allowed them to learn and immediately apply the knowledge. Seeing their answers, whether correct or wrong, in each minigame reinforced their understanding of the content. They suggested that combining learning through lectures beforehand and then using the game as a review could significantly improve memorization and understanding, providing a relaxed way of cramming before major examinations.

Regarding the possibility of using the gamified platform as the sole tool for learning, the group expressed reservations, favoring a combination of traditional learning and the gamified platform in a fifty-fifty ratio. However, they also highlighted that if teachers were to incorporate gamified platforms in their classes, it could greatly enhance student motivation and attention (see Figure 32).

Group	Feedback	Suggestions	Comments
1 Gamified	- Focused on improvement aspects, including cut-off texts, result screen indicators, and meteorite minigame. - Recommended extending time limits.	Address cut-off texts during gameplay, enhance clarity of correct/wrong indicators, refine meteorite minigame instructions, and consider time limit extensions.	Valuable insights for refining gameplay elements and ensuring player engagement.
2 Gamified & Traditional	- Praised result screen clarity, noted inconsistent in-game controls. - Highlighted issues with out-of-bound texts, time limits, and minigame instructions. - Shared positive views on gamified learning for memorization.	- Improve in-game controls, address issues with out-of-bound texts, time limits, and minigame instructions. - Enhance immersive experience across all game stages.	Provided dual perspectives on strengths and weaknesses of gamified learning, emphasizing benefits for memorization-oriented subjects.
3 Traditional	- Found quiz questions manageable but emphasized challenges due to lack of notetaking. - Believed gamified platform could aid brain development.	- Addressed quiz challenges related to memorization. - Acknowledged potential benefits of gamified learning for brain development.	Offered insights into differences between traditional lectures and gamified learning, emphasizing the importance of notetaking.
4 Gamified & Traditional	- Learned more about Information Security Awareness from the game, enjoyed the experience. - Encountered challenges with processing detailed information from video clips. - Shared concerns about meteorite minigame and provided feedback on favorite/least favorite minigames.	- Address challenges with processing detailed information in video clips. - Refine meteorite minigame for better readability. - Consider varying difficulty levels based on player familiarity with gaming.	Revealed diverse preferences based on gaming experience, suggested improvements for specific minigames, and advocated for a balanced approach combining traditional learning and gamified platforms.

Figure 32: Summary of the research study

The quiz results, along with the information gained from interviews with students, have confirmed our hypotheses. Gamifying the learning process has shown a positive effect in enhancing participant motivation, leading to improved test scores in security awareness exams compared to those engaging in traditional learning methods. The introduction of gamification makes the learning process more engaging and enjoyable, resulting in increased attention from students and a heightened interest in the topic.

Chapter 5
CONCLUSION AND FUTURE WORK

"Conclusions are like dessert – they should be sweet, concise, and leave your audience craving for more."

Anonymous

In conclusion, the results of the experiment have successfully met the objectives of this research, confirming that gamifying the learning process through a videogame is effective in improving cybersecurity lesson scores, thus validating the hypothesis. The success of the design of "Croissant's Adventure" as an enjoyable videogame has led to increased motivation among players to complete the game and learn essential information, resulting in higher test scores.

5.1. Conclusion

Insights gained from interviews with students who participated in the experiment revealed interesting findings. Students from the Traditional group, who initially learned the lesson through video presentations, found that playing "Croissant's Adventure" afterward reinforced their understanding of the topics. Similarly, students from the Gamified group, who watched video presentations after the game session, found that the knowledge gained from playing the videogame helped them better prepare for the presentation, making it easier for them to digest the information and identify key words previously encountered in the game, which were essential for their comprehension. In essence, the videogame either reinforced existing knowledge or prepared students with the prerequisites for deeper understanding.

Most students expressed support for integrating gamified platforms, like "Croissant's Adventure," as part of the class curriculum, citing the benefits of reinforcing traditional learning and improving classroom engagement. However, most students also voiced reservations about replacing traditional classes entirely with gamified platforms. They acknowledged that while educational videogames could be more enjoyable and enhance learning about Information Security, they cannot replace

traditional classes. Traditional classes excel in delivering large amounts of information necessary to cover entire topics essential for students' educational progress. Instead, gamified platforms like educational videogames should be used as a combination of a fifty-to-fifty ratio or as supplementary materials for review, providing students with a relaxed and engaging learning experience between traditional classes. By striking this balance, educators can leverage the benefits of both traditional and gamified learning approaches to enhance students' overall learning outcomes and engagement in the classroom.

5.2.Future Work

In the future, this research is committed to continuously improving "Croissant's Adventure" as a gamified educational platform for learning Information Security. Based on the valuable feedback gathered during the development phase, reviews, opinions, and insights from the participant students during the experiment, along with analysis, a comprehensive list of aspects that have contributed to the success of "Croissant's Adventure" in achieving the initial research objectives and validating the hypothesis. Additionally, areas that require improvement were identified, including bug fixes, glitch resolutions, recalibration of controls, and adjustments to certain gameplay elements. The aim is to create a refined and polished version of "Croissant's Adventure," maintaining its current quality and enjoyment while addressing the identified areas for enhancement.

Moreover, building on the foundation of "Croissant's Adventure," a plan has emerged to expand into the development of a new intellectual property (IP) that delves into a broader range of educational topics beyond Information Security. This new educational videogame will explore various gameplay aspects, potentially venturing into turn-based strategy or puzzle genres, in addition to the platforming genre showcased in "Croissant's Adventure."

As this research revolves around the development of a videogame, acknowledging the significance of frequent improvements through patching, a common practice in the gaming industry after a game's initial release. Utilizing feedback from players who

participated in the experiment, observations during the experimental phase, and the outcomes of this research, has proved fruitful to continually enhance the game. By considering the invaluable input from the audience and leveraging the findings of this research to create an evolving and ever-improving educational videogame experience that positively impacts the learning process and engages students in a fun and effective manner.

Looking forward, the potential of "Croissant's Adventure" and the possibilities it opens for creating innovative and engaging educational videogames that contribute to the enrichment of learning experiences for students of diverse subjects are exhilarating. With unwavering commitment to excellence and continuous improvement will lead to the development of educational videogames that inspire and empower learners worldwide. Whether as a full retail version available for purchase or an open-source platform accessible to all, the goal remains to promote knowledge acquisition and foster a love for learning through interactive and captivating videogame experiences.

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Appendix

Test

There are 3 parts of this test for a total of 30 questions. Each question has 4 choices: A, B, C, and D. Please choose only one that you think is the most correct answer. While doing the test, participants please refrain from using any means of assistance (Internet, Smart Devices, or consulting each other's). The time limit for this test is 45 minutes.

Participant of ___ Group A (Gamified) ___ Group B (Traditional)

Part I. 10 Questions

Each question has 4 choices: A, B, C and D. Please choose only one that you think is the most correct answer.

1. A good name for password?
   a. Your pet's.
   b. Numbers or symbols.
   c. A combination of letters, numbers, and symbols.
   d. Common names or words from dictionary.
2. Most common delivery method by viruses?
   a. Email
   b. Instant message
   c. Internet download
   d. Portable Media
3. What kind of email you should not send?
   a. Personal information.
   b. Pricelist for your business products.
   c. Humorous email.
   d. Location of a local diner.
4. What **IS NOT** the reasons that turn a trusted user into a malicious insider**?**
   a. Frustration with friend and co-workers.
   b. Stress
   c. Promotion
   d. Financial problem
5. "The first step in Security Awareness is being able to _____ a security threat."
   a. Avoid
   b. Recognize
   c. Challenge
   d. Log
6. What should you **NOT** do if you received a phishing mail?
   a. Do not reply to the message.
   b. Click the link to see what is inside.
   c. Keep your system up to date and install antivirus.
   d. Report the phishing email.
7. What is the biggest vulnerability to computer information security?
   a. Instant messaging, Peer-to-peer (P2P) applications.
   b. Malware-virus, worms, spyware

c. Spam, Phishing attacks
d. End users

8. Which is a measure for preventing a social engineering?
   a. Give out computer or network information.
   b. Doing company tasks in an unsecure setting.
   c. Secure sensitive document and medias.
   d. Give out personal identifiable information.
9. Which statement is allowed according to the limited personal use policy?
   a. Conducting business for personal gains
   b. Using company resource for political purpose(s)
   c. Sending personal email
   d. Downloading music and videoclips
10. All of these are good physical security practice **EXCEPT**:
   a. Wearing your security badge when leaving workplace.
   b. Close the door behind you when entering and exiting.
   c. Shielding your paperwork and screen.
   d. Store confidential item in a secure place.

End of Part I. Continue in Part II

Part II. 10 Questions

1. Who has the greatest influence over access security in a password authentication environment?
   a. System administrators.
   b. Business Executives
   c. Users
   d. Security Managers
2. Which of the following interpret requirement and apply them to specific situations?
   a. Policies
   b. Standards
   c. Guidelines
   d. Procedures
3. Business Continuity Plans (BCPs) should be developed primarily based on?
   a. Available resource
   b. Level of effort
   c. Projected Costs
   d. Business Needs
4. Which offer the strongest protection for wireless network traffic?
   a. WPA2
   b. WPA-AES
   c. WEP-128
   d. WPA-TKIP
5. Risk assessments should be performed ___?
   a. At the start of a program
   b. On a regular basis
   c. When an asset changes
   d. When a vulnerability is discovered

6. “A firewall that tracks open connection-oriented protocol sessions is said to be ____”
    a. State sponsored.
    b. Stateless
    c. Stateful
    d. Stated
7. During which phase of the system development life cycle (SDLC) should security first be considered?
    a. Planning
    b. Analysis
    c. Design
    d. Implementation
8. During which phase of the six-phase incident response model is the root cause determined?
    a. Recovery
    b. Identification
    c. Containment
    d. Eradication
9. Which two factors are used to calculate the likelihood of an event?
    a. Threat and vulnerability
    b. Vulnerability and asset value
    c. Asset count and asset value
    d. Threat and asset count
10. “A Business Continuity Plan (BCP) is not complete unless it includes ____”
    a. Dedicated resource
    b. Detailed Procedure
    c. Network Diagram
    d. Critical Process

End of Part II. Continue in Part III

Part III. 10 Questions

1. “A segmented network ____”
    a. Offer defense in-depth superior to a concentric-layers model.
    b. Consists of two or more security zones.
    c. Maximize the delay experienced by an attacker.
    d. Delivers superior performance for internal applications.
2. Outsourcing poses the greatest risk to an organization when it involves ___?
    a. Business Support Services
    b. Technology infrastructure
    c. Cybersecurity capabilities
    d. Core Business functions
3. A cybersecurity architecture designed around the concept of a perimeter is said to be ___?
    a. Data-Centric
    b. User-Centric
    c. Integrated

d. System-Centric

4. A passive network hub operates at which layer of the OSI Model?
    a. Data Link
    b. Physical
    c. Network
    d. Transport
5. Update in Cloud-computing environments can be rolled out quickly because the environment is ___?
    a. Homogeneous
    b. Distributed
    c. Diversified
    d. Secure
6. Where should an organization's network terminate virtual private network (VPN) tunnels?
    a. At an interior router.
    b. At a "honey pot" system in DMZ.
    c. At the destination system.
    d. At the perimeter.
7. "In practical applications ____"
    a. Symmetric key encryption is used to securely distributed asymmetric keys.
    b. Asymmetric key encryption is used to securely obtain symmetric keys.
    c. Symmetric key encryption is used only for short message, such as digital signatures.
    d. Asymmetric key encryption is used in cases where speed is important.
8. What kind of anti-malware program evaluates system process based on their observed behaviors?
    a. Heuristic
    b. Signature-based
    c. Stateful
    d. Polymorphic
9. Under the US-CERT model for incident categorization, a CAT-3 incident refers to which of the following?
    a. Improper use
    b. Investigation
    c. Denial of Services (DoS)
    d. Malicious code
10. Securing Supervisory Control and Data Acquisition (SCADA) system can be challenging because they ___?
    a. Operate in specialized and have non-standard design elements.
    b. Are subject to specialized requirements.
    c. Support critical infrastructure process.
    d. Cannot be replaced due to aging and complex infrastructure.

End of Part III

This is the End of the test

The following section shows the script as it appeared in the Information Security Video Presentation viewed by students of the Traditional group during the experimentation:

Part I: Basic Security
Imagine this scenario:
“You are working on your computer. Then received an email from an unknown person, claiming you won a big prize money.”
“What are you going to do?”
• Phishing Email is the most common method of computer virus delivery by Hackers.
• Disguised, Hackers lure us by false promises of prizes, promotions, or fake news.
• It’s up to us, Users, to recognize this subterfuge and avoid falling into traps.
• Having weak passwords or reusing them on multiple accounts is another method Hackers can use to attack you.
• Many use personal information (Name, Nickname, Birthdate, Pet’s name, etc.) or common words or simply easy-to-guess combinations as the basis for passwords.
• Always use strong passwords with combinations of letters, numbers, and symbols.
• Write down your passwords in a physical storage (e.g., Notebook) in case you forget.
• But keep it secure.
• Most workplaces have limited personal use policy in place to combat malicious or nefarious vulnerabilities caused by Hackers.

Part II: Intermediate Security
• A business continuity plan (BCP) is a set of detailed standards or procedures to ensure business continuity following any disruption caused due to cyberattacks, on-premise accidents, supply chain disruptions, natural disasters, and other operational failures.
Imagine yourself as a risk manager.
“Your company has recently come under cyberattacks and it’s time for you to find out how it happened.”
• A risk assessment is an important part of BCP.
• By identifying all the possible threats and vulnerabilities to your business and its processes, from wherever they might originate.
You assessed the risk and patched it out; the day is saved.
…now comes an important question.
“How do I prevent this from happening again?”
• A good life cycle of a system can contain many phases.
• But most importantly, and not shown, is “Planning” what you want to do with each phase.
• There exist types of Wireless Networks (Wi-Fi), For example, WEP, WPA, WPA2, and WPA3, each with different levels of security.
• WPA2 (Wi-Fi Protected Access 2) is the second generation of the Wi-Fi Protected Access wireless security protocol. It is designed to secure and ensure that data sent or received over your wireless network is encrypted, and only people with your network password have access to it.

• WPA3 (Wi-Fi Protected Access 3) is the newest wireless security protocol using a frequent and automatic encryption type called Perfect Forward Secrecy.
• Stateful firewalls are capable of monitoring and detecting states of all traffic on a network to track and defend based on traffic patterns and flows.
• Stateless firewalls, however, only focus on individual packets, using preset rules to filter traffic.
• Both have their strengths and weaknesses.

Part III: Advanced Security
You are appointed as a company's CISO
CAT-3 incident
Supervisory control and data acquisition (SCADA) is a system of software and hardware elements that allows industrial organizations to:
• Control industrial processes locally or at remote locations
• Monitor, gather, and process real-time data.
• Directly interact with devices such as sensors, valves, pumps, motors, and more through human-machine interface (HMI) software
• Record events into a log file
• Network segmentation is a network security technique that divides a network into smaller, distinct sub-networks that enable network teams to compartmentalize the sub-networks and deliver unique security controls and services to each sub-network.
• Network segmentation consists of two or more security zones.
• There are 3 main types of Cloud: Private, Public, and Hybrid.
• Homogenous cloud is one where everything is from the same vendor.
• Heterogeneous clouds, on the other hand, integrate public and private components from more than one vendor.
• Both Homogeneous and Heterogeneous have Pros and Cons.

End of Script

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