



Designing and Developing a Serious Game to Teach Digital Wellbeing

J Esterhuizen

 **orcid.org 0000-0003-2721-8459**


Dissertation accepted in fulfilment of the requirements for the degree *Master of Science in Computer Science* at the North-West University

Supervisor: Dr DP Snyman

Co-supervisor: Prof GR Drevin

Co-supervisor: Prof L Drevin

Graduation: July 2024

The bottom half of the cover features a blue-to-white gradient background with abstract, flowing white lines, mirroring the design of the top half.

Acknowledgements

This dissertation would not have been possible without the aid, guidance, advice and encouragement from many people.

I could not have undertaken this journey without my supervisors Dr Dirk Snyman, Prof Günther Drevin and Prof Lynette Drevin, whose guidance, expertise and feedback have been pivotal throughout this process and helped shape and refine my work. I am greatly appreciative of the opportunities provided to me by them be it aiding in their classes or given the opportunity to travel abroad.

In addition, I am also thankful to Prof Klimis Ntalianis of the University of West Attica whose external perspective and brief yet insightful guidance brought forth many ideas, some of which that could not form a part of this study and I aspire to one day explore them in personal projects.

I would like to thank my friends and fellow students who provided support and engaged in discussions on aspects of my research. I am grateful to my tabletop gaming group who provided, at times, needed respite and inspiration throughout this process.

I am also grateful to the experts that participated in the study and provided feedback on the serious game. I am also thankful to the NWU who provided financial support through the postgraduate bursary scheme without which this would not have been possible. Thank you, Dr Isabel Swart for taking the time for the language editing of this dissertation. Lastly, I would like to thank the many individuals who were a part of the process for the publication of aspects of this research.

Preface

This dissertation is a culmination of research into the fields of ludology, gamification, pedagogy and human-computer interaction. A sizeable portion of the research into these fields as a part of this study resulted in two seminal articles that have been published:

- Esterhuizen, J., Drevin, G.R., Snyman, D.P., Drevin, L.: Linking gamification, ludology and pedagogy: Principles to design a serious game. In: Sampson, D.G., Ifenthaler, D., Isaías, P. (eds.) 19th International Conference on Cognition and Exploratory Learning in Digital Age (CELDA 2022), pp. 57-65. IADIS Press, Lisboa, Portugal (2022)
- Esterhuizen, J., Drevin, L., Drevin, G.R., Snyman, D.P.: Design choices among recent security related serious games. In: Chova, L.G., Martínez, C.G., Lees, J. (eds.) 16th annual International Conference of Education, Research and Innovation (ICERI2023), pp. 8807-8816. IATED Academy, Seville, Spain (2023)

These articles were written during the course of, and for the purposes of this dissertation. Additionally, they are included as Appendices C and D respectively and are a key part of the research process where this dissertation informed the publications, and the publications the dissertation. As such, some sections of this document make reference to these articles and reiterate the information.

Abstract

The use of technology in a person's everyday life has become a norm, as most people interact with smartphones, personal computers and the Internet. While the use of these technologies is undoubtedly helpful, if not crucial, to our everyday activities, when interacted with incorrectly it can have detrimental effects. For this reason, research into and campaigns regarding the concept of digital wellbeing have been initiated. This concept deals with ensuring people are engaging with technology in a healthy manner.

This study is focused on designing and developing a serious game to educate people on the topic of digital wellbeing. In order to achieve this, a literature study is conducted into the fields of ludology, gamification, pedagogy and human computer interaction as each contributes vitally to ensuring that the serious game is fit for its purpose. Additionally, several other serious games are studied to determine what common design principles are being used, and alongside the other research, a set of design principles is set for the development of this serious game.

Furthermore, this study resulted in a serious game which is a digital computer game with education as the aim in this case. The serious game was developed using the Godot game engine and GDscript as the main development tools. The serious game takes the player through three distinct scenarios related to digital wellbeing in which the player collects information and answers a quiz, based on that information.

Additionally, an expert review to judge the effectiveness of the serious game was conducted. Experts were instructed to play the game and then answer a questionnaire which included questions distilled from heuristic evaluation models. The feedback from this is mostly positive and overall, the serious game is deemed sufficiently successful; however, there are some issues that can be addressed.

Keywords: Digital wellbeing, game design and development, gamification, human-computer interaction, ludology, pedagogy, serious games

Contents

Acknowledgements	i
Preface	ii
Abstract	iii
1 Introduction	1
1.1 Background	1
1.2 Problem Statement	3
1.3 Research Aim, Objectives and Questions	3
1.3.1 Research aim	3
1.3.2 Research Objectives	3
1.3.3 Research Questions	4
1.3.4 Scope, Limitations and Risk Analysis	4
1.4 Research Methodology	5
1.5 Ethical Consideration	6
1.6 Dissertation Overview	7
1.7 Summary	7
2 Literature Review	8
2.1 Introduction	8
2.2 Digital Wellbeing	9
2.2.1 Defining Digital Wellbeing	9
2.2.2 Current Digital Wellbeing Interventions	10
2.2.3 User response to Digital Wellbeing Interventions	12
2.2.4 Issues Relating to Aspects of Digital Wellbeing	14
Physical Health	14
Mental Health	18
Digital Security	22

2.3	Ludology	26
2.3.1	Serious Games	26
2.3.2	Approaches to Game Design and Analysis	27
2.3.3	Analysis of Serious Game Implementations	32
2.3.4	Game Design	35
2.4	Gamification	39
2.4.1	Digital Gamified Environments and the Differences to Serious Games	40
2.4.2	Components of Gamification	40
2.5	Pedagogy	43
2.5.1	Merrill’s First Principles of Instruction	43
2.5.2	Experiential Learning Theory	44
2.6	Human-Computer Interaction	45
2.6.1	Information Visualisation	46
2.6.2	Interaction Design Principles	49
2.7	Summary	51
3	Development of the Serious Game	52
3.1	Terminology Relating to Games Development	52
3.2	Design Phases	53
3.2.1	Research	53
3.2.2	Design Document	54
3.3	Design Principles	54
3.3.1	Reflection	54
3.3.2	Feedback	54
3.3.3	Story	55
3.3.4	Structuring	56
3.3.5	Tailoring	57
3.3.6	Features from Interaction Design	57
3.4	Specification	58
3.5	Gameplay and Game Setting	58
3.5.1	Story	58
3.5.2	World/Environment	59
3.5.3	Characters in the Game	60
3.5.4	Main Objective and Core Mechanics	60
3.5.5	Controls	61

3.6	Front End	61
3.6.1	Start Screen	62
3.6.2	Menus	62
3.6.3	Credits Screen	63
3.7	Technology	64
3.7.1	Target Systems	64
3.7.2	Hardware	64
3.7.3	Development Systems and Tools	64
3.8	Development Phases	64
3.8.1	Learning the Godot Engine	65
3.8.2	Basic Prototype	65
3.8.3	Scenes	65
3.8.4	Dialogue	66
3.8.5	User Interface	68
3.8.6	Playable levels	69
3.8.7	Mini games	71
3.8.8	Exporting and Hosting	73
3.9	Navigating the Game from Launch to Completion	73
3.10	Summary	79
4	Evaluation	80
4.1	Expert Review Setup	80
4.2	Feedback on the Serious Game	82
4.2.1	Current Limitations of the Game	91
4.3	Summary	92
5	Reflection	93
5.1	Articles	93
5.1.1	CELDA 2022	94
5.1.2	ICERI 2023	94
5.2	Serious Game Artefact	94
5.3	Recommendations based on Expert Review Feedback	94
5.4	Summary	96
6	Conclusion	97
6.1	Study Overview	97
6.2	Research Aim, Objectives, and Questions	98

6.2.1	Research Objectives	98
6.2.2	Research Questions	99
	1. What are the digital threats that users face that can be mitigated by increased knowledge and understanding of digital wellbeing?	99
	2. What type of serious game would be most beneficial for the teaching of digital wellbeing?	100
	2a. What type of game can reach the most users?	100
	2b. What platforms allow for the full scope of the serious game? .	100
	2c. Where is the intended venue of play?	101
	2d. When is the intended time of play?	101
	3. What qualities are needed within a serious game to educate a user on the topic of digital wellbeing?	101
6.3	Future Work	101
6.4	Summary	102
	Reference List	103
	Appendices	111

List of Figures

1.1	Research Methodology Process	6
2.1	Research Methodology Process - Artefact Development Stage (Research)	8
2.2	Examples of smartphone implementations of digital wellbeing with Android on the top, Apple on the bottom (Self-Sourced).	11
2.3	Example of a video game's (Monster Hunter Generations Ultimate) reminder to take breaks (Capcom, 2017).	12
2.4	Example of a phishing e-mail (Self-acquired)	24
2.5	Example of a phishing SMS (Self-acquired)	25
2.6	Example of a badge/achievement from a video game ("Cassette Beasts" through Steam)	41
2.7	Summary of Merrill's First Principles (Own Creation)	43
2.8	Rule of Thirds (Adapted from Benoît, 2019)	47
2.9	Common Poster Layouts (Adapted from Benoît, 2019)	47
3.1	Research Methodology Process - Artefact Development Stage (Design and Development)	52
3.2	Art example of a character	58
3.3	Partial Section of Digibot's Sprite Sheet	59
3.4	Starting Environment per Level	60
3.5	Title Screen Wireframe	62
3.6	Character Selection Screen Wireframe	62
3.7	Level Selection Screen Wireframe	63
3.8	Resources Used Screen Wireframe	63
3.9	Initial Prototype	65
3.10	Basic Setup of a Level Scene	66
3.11	Navigating to the appropriate question in the dialogue manager	67
3.12	Testing Dialogue	68
3.13	Final Main Menu	68
3.14	Player and Level Select Scenes	69

3.15 Credits and Achievements Scenes	69
3.16 Level Start Example (Level 2: Mental Health)	70
3.17 Roaming Level Example (Level 1: Physical Health)	70
3.18 Reading Information Example (Level 1: Physical Health)	71
3.19 Minigame for Level 1: Physical Health	71
3.20 Minigame for Level 2: Mental Health	72
3.21 Minigame for Level 3: Security	72
3.22 Main Menu of the Game	74
3.23 Menu Screens 1	74
3.24 Menu Screens 2	75
3.25 Menu Screens 3	75
3.26 Introducing the Narrative	76
3.27 Gathering the Information	76
3.28 Playing a Minigame	77
3.29 Taking the Quiz	77
3.30 Getting End-of-Level Feedback	78
3.31 Level Select Changing to Match Player Performance	78
3.32 Pausing the game	79
4.1 Research Methodology Process - Evaluation Stage	80
5.1 Research Methodology Process - Communication Stage	93
6.1 Research Methodology Process - Communication Stage	97

List of Tables

2.1	Likes and Dislikes for Digital Wellbeing Applications	14
2.2	Benefits of a digital detox (Compiled from Nguyen, 2021)	22
2.3	A summary of the issues for the aspects of digital wellbeing	26
2.4	Game Components and the Design Counterparts under MDA (Hunicke et al., 2004)	28
2.5	List of Games (Esterhuizen et al., 2023)	33
2.6	Design Principles Listed by Usage (Esterhuizen et al., 2023)	35
2.7	Player types and associated characteristics (Van Gaalen et al., 2022)	42
2.8	Visual Elements (Benoît, 2019)	48
4.1	Reviewer Information	82
4.2	Expert Review Scores	83
4.3	Controls Comments	85
4.4	User Interface Comments	86
4.5	Simplicity Comments	86
4.6	Narrative Comments	87
4.7	Customisation Comments	87
4.8	Achievements Comments	88
4.9	Quiz Comments	88
4.10	Fun Comments	88
4.11	Gameplay Structure Comments	89
4.12	Potential Improvements Comments	89
4.13	Introductory Viability Comments	90
6.1	Objective completion	99

List of Abbreviations

HCI	Human-Computer Interaction
DES	Digital Eye Strain
CVS	Compute, Vision Syndrome
DSM-V	Diagnostic and Statistical Manual of Mental Disorders (Fifth Ed.)
MDA	Mechanics, Dynamics and Aesthetics
DDA	Dynamic, Difficulty and Adjustment

1 Introduction

In this chapter, a brief overview of what this study will entail is given. Details on the background of the issue, main and secondary objectives, and scope and methodologies of the study are given. Additionally, the main problem statement and chapter overview are provided.

1.1 Background

Technology integration into a person's everyday life has become a reality with modern communication technologies, such as smartphones (Nguyen, 2021; Roffarello & De Russis, 2019). Children as young as twelve months can use touchscreen devices and meaningfully interact with them at two years of age, with the majority of said interaction being via photo and video-based applications (Ahearne et al., 2015). This shows that the adoption of technology can begin at an early age. One may argue that early exposure can be beneficial and provide an advantage in the contemporary technological landscape.

However, there are growing concerns about the potential adverse effects of constantly using smart devices and being exposed to the digital content they provide (Cecchinato et al., 2019; Giraldo-Luque et al., 2020; Roffarello & De Russis, 2019). Examples of these adverse effects include smartphones causing user mental health distress, acting as a source of distraction, and causing issues with social interaction (Roffarello & De Russis, 2019). Certain mechanisms of social media are also found to be causing issues, such as notifications leading to anxiety (Giraldo-Luque et al., 2020). Additionally, users face more tangible threats when using any device connected to the internet. Examples include cyber-stalking, cyber terrorism, cyber theft, and financial fraud through digital avenues (Arfi & Agarwal, 2013).

To combat the ill effects of technology use, the drive for digital wellbeing, or digital wellness, was started by Google with the belief that "technology should improve life, not distract from it" ("Digital Wellbeing through technology | Google." n.d.). Digital

wellbeing is a new concept and lacks a singular concrete definition. However, a simple description based on digital capabilities is the “capacity to look after personal health, safety, relationships and work-life balance in digital settings” (Jisc, 2019). Furthermore, Feerrar (2020) discusses various definitions and lists a framework that provides four main elements for digital safety and competence: protecting devices, personal information and privacy, physical wellbeing, and the environment.

Attempts to achieve digital wellbeing have mostly been through the placing of tools that monitor and limit users’ device usage. Examples of these types of tools include do not disturb modes and time limits, both of which could lead to lengthy periods away from technology (Nguyen, 2021; Widdicks, 2020). There is, however, an issue with these types of tool: they do not encompass the entirety of digital wellbeing and may not represent a long-term solution in environments (such as employment) where users are required to be constantly connected (Feerrar, 2020; Nguyen, 2021). Current approaches to digital wellbeing seem to focus on controlling users instead of educating them on how to manage their own digital wellbeing which may distance users from taking responsibility for their digital wellbeing. There are several potential means to educate a user on digital wellbeing, such as standard educational content, utilising instructional pamphlets or videos, as well as a more engaging medium, using gamification or serious games. Gamification is the use of game mechanics, such as reward systems or a narrative, to improve the learning process (Almeida & Simoes, 2019). Serious games, which have seen success in similar endeavours relating to education (Dincelli & Chengalur-Smith, 2020; Sheng et al., 2007), are games that are designed for training by using a goal-oriented digital environment dealing with specific scenarios (Almeida & Simoes, 2019).

Serious games also fall under the academic study field of ludology which is concerned with the study of games (Frasca, 2002). The main difference between these two approaches is that gamification makes use of specific game elements, such as achievements and badges, to make training more fun, whereas serious games are tailored to the specifications of a training topic in the form of a game or simulation (Almeida & Simoes, 2019). While these are two distinct approaches, using gamification in a serious game’s design phase is helpful. Of note is the applicability of gamification or digital serious game systems toward specific demographics, i.e., using a serious game may not be optimal for the elderly and dense reading material would not be advised for pre-school children.

Due to the aforementioned integral part that technology plays in everyday life, an ideal means to teach people about their digital wellbeing may be best presented as a digital serious game, simulation, or other type of technological application. As such, this study will focus on the design and development of one such serious game that focuses on the concept of digital wellbeing with the research question being *how a serious game can teach users about digital wellbeing*.

1.2 Problem Statement

The use of technology is an integral part of everyday life and as such, there are considerations that must be in place regarding how to use technology in a meaningful and healthy manner. A recent drive for the concept of digital wellbeing has been started which encompass a user's ability to protect their devices, privacy, as well as their own health and wellbeing. While there are currently several mechanisms in place to assist users in ensuring their own digital wellbeing, there is a lack of focus on educating users on the underlying premises of digital wellbeing and how to facilitate it for themselves.

1.3 Research Aim, Objectives and Questions

1.3.1 Research aim

The main aim of this study is to *design and develop a serious game to teach users about certain aspects of digital wellbeing*. In support of this aim, several objectives and research questions must be addressed and answered.

1.3.2 Research Objectives

To aid in reaching the above aim, certain objectives are to be met during the research process:

1. Various case studies and literature centred on designing or developing a serious game and accompanying fields on education and digital wellbeing will be **studied**,
2. **Development** of the serious game,

3. **Evaluation** of the serious game through expert review, and
4. **Critical reflection** on the results of the evaluation.

1.3.3 Research Questions

In line with the aim, the overarching research question of *how a serious game can teach users about digital wellbeing* needs to be answered and has the following sub-questions to aid in its answer:

1. What are the digital threats that users face that can be mitigated by increased knowledge and understanding of digital wellbeing?
2. What type of serious game would be most beneficial for the teaching of digital wellbeing?
 - (a) What type of game can reach the most users?
 - (b) What platforms allow for the full scope of the serious game?
 - (c) Where is the intended venue of play?
 - (d) When is the intended time of play?
3. What qualities are needed within a serious game to educate a user on the topic of digital wellbeing?

1.3.4 Scope, Limitations and Risk Analysis

This study will focus on themes pertaining to ludology, pedagogy, human-computer interaction, and gamification which will be of use when designing the artefact. Further themes may be added as research progresses. Additionally, the theme of digital wellbeing will be included, as it forms the focus of the serious game and study.

In terms of the artefact, a single serious game will be developed. The contents and type of game will be decided upon after further research. The aspect of art (i.e., assets and music) will be acquired from various public domain sources while the remaining aspects (i.e., scripting, game editor mechanisms, writing, level design, etc.) will be entirely created for this study. The Godot game engine will be used to develop the serious game. This is due to the fact that it allows the development of both 2D and 3D digital games along with the use of multiple scripting languages, viz. GDScript, C#,

VisualScript, and C++ and C. This particular engine is open-source; therefore various third-party versions and modules exist that enables the use of additional scripting languages, namely Rust, Python and Java.

1.4 Research Methodology

The study will be guided by the design science research methodology. Design science research involves the development, design, and evaluation of the design choices of an artefact needed to solve the problems in a specific environment, whilst allowing for the generation of new knowledge (Dresch et al., 2015). This research methodology comprises the following major steps (Dresch et al., 2015) and how this study will correlate to each step:

1. Identify the Problem: During this step the issue of lack of education on digital wellbeing was noted,
2. Suggest a possible solution: A serious game to educate users is suggested with specific details on what the serious game will entail being researched as part of a literature review,
3. Develop an artefact: The serious game is designed as per the results of the literature review and developed accordingly,
4. Evaluate the artefact: The serious game will undergo an expert review from which the feedback will determine whether the serious game is adequate and what aspects need further refinement, and
5. Conclude and communicate: A discussion of the outcome of the study with reflection on the choices made and what potential future work could be conducted.

Figure 1.1 illustrates further how this dissertation will follow along with the design science methodology and will be presented at the onset of each chapter to highlight where in the process it sits.

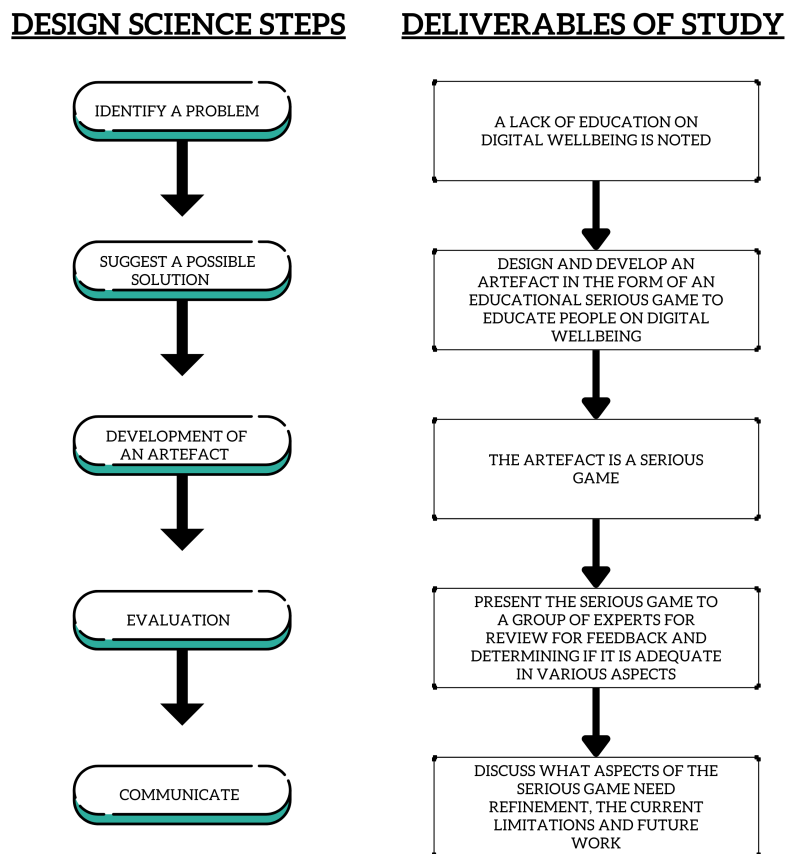


FIGURE 1.1: Research Methodology Process

1.5 Ethical Consideration

An expert review will be used to evaluate the serious game. The expert reviewers' identities will be kept anonymous. Furthermore, impressions of and feedback on the serious game will be kept confidential outside of this study, save for summaries and aggregations that will form part of any published results. Additionally, full disclosure regarding the purpose, the expected timeline, and enquiries will be extended to the experts participating in the review. The reviewers will be free to decline participation and withdraw from the study without consequence. There will be no compensation for participating in this study. The informed consent form to be used for this study is included under Appendix E.

Ethical clearance was granted for this study, under ethics number NWU-01363-22-A9, and the clearance certificate is displayed under Appendix E.

1.6 Dissertation Overview

This dissertation has the following structure:

- **Chapter 1: Introduction** – This section will provide an overview of the study as a whole with details on the scope and approach to project management,
- **Chapter 2: Literature Study** - This section will provide further information on digital wellbeing and the current state of tools used. A literature study will be conducted on ludology, gamification, pedagogy, and HCI to gain more insight into the knowledge needed to complete the study,
- **Chapter 3: Artefact Development Process** – The development of the artefact will be discussed detailing the stages and steps taken in the design and development of the serious game for this study,
- **Chapter 4: Evaluation** – The results of an expert review of the artefact will be discussed,
- **Chapter 5: Reflection** – A discussion on all outcomes of this study is provided. This will include the serious game artefact that will be developed, and any articles written throughout the study, and
- **Chapter 6: Conclusion** – A summary of what the study has accomplished alongside a reflection of the choices made and potential future work.

1.7 Summary

The use of technology is an integral part of everyday life and as such there are considerations that must be in place on how to use technology in a meaningful and healthy manner. Thus, a recent drive for the concept of digital wellbeing has been started and while there are currently several tools in place to facilitate users in ensuring their own digital wellbeing, there is a lack of focus on educating users on how to facilitate digital wellbeing themselves or to understand digital wellbeing. As such, the main aim of this study is to design and develop a serious game to teach users about certain aspects of digital wellbeing which will be aided with research into ludology, pedagogy, gamification and human-computer interaction. Additionally, upon the completion of the serious game, an expert review will take place for feedback on the design of the serious game.

2 Literature Review

The content of this chapter includes the literature review of the fields of ludology, gamification, pedagogy and HCI. Also included is an analysis of previous implementations of serious games.

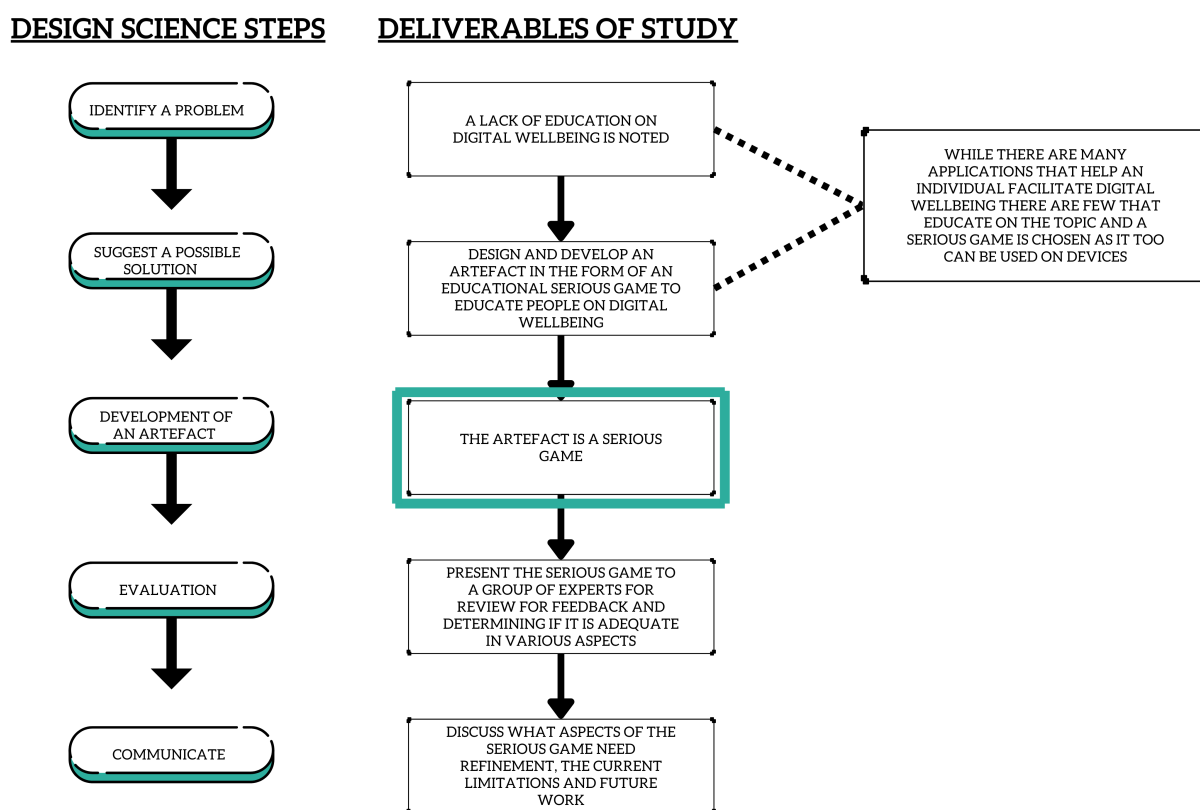


FIGURE 2.1: Research Methodology Process - Artefact Development Stage (Research)

2.1 Introduction

In order to design and develop a serious game with a focus on digital wellbeing, the proposed research questions (in Section 1.3.3) must be addressed. This will be done through a literature review of the fields of digital wellbeing, ludology, gamification,

pedagogy, human-computer interaction (HCI) and previous implementations of both serious games and gamified environments. Digital wellbeing is used, as it is the core concept on which the focus is, ludology, as it provides the fundamentals on the study of games, gamification, as it provides insight into gamifying topics, pedagogy, as it relates to instructional theory and education, and human-computer interaction (HCI) because it provides information on how users would interact with technology and previous implementations to better understand the design process.

2.2 Digital Wellbeing

2.2.1 Defining Digital Wellbeing

The terminology of digital wellbeing is relatively new and lacks a singular concrete definition. However, there are some connections with other terms, such as e-health or digital wellness. The definition to be presented arises mostly from discussion of the digital wellbeing term.

Most tend to juxtapose digital wellbeing against undesirable habits or in terms of digital ill-being; few define it on its own (Vanden Abeele, 2020). However, there are definitions that hold similar notions, with a simple description being the “*capacity to look after personal health, safety, relationships and work-life balance in digital settings*” (Jisc, 2019, p.8). Feerrar (2020) lists a framework that provides four main elements for digital safety and competence: protecting devices, personal information and privacy, physical wellbeing, and the environment.

There are also previous notions that aim to achieve the same outcome of digital wellbeing, such as digital wellness. Therefore, one way to define digital wellbeing is to describe it in terms of concepts, such as digital wellness. As such, one definition could be that digital wellbeing is how healthy a person’s physical and mental health is when dealing with technology (McMahon & Aiken, 2015). McMahon and Aiken (2015) continue and list various aspects, such as “...their online security and privacy cognitions, attitudes and behaviours, their use of and level of attachment to their devices, their impulsivity in responding to device notifications, their multitasking patterns, cross-platform and device behaviours, their screen time duration [and] their posture.” (p. 1419).

McMahon and Aiken (2015) also discuss the physiological, behavioural, and psychological elements of digital wellness with sub-points to each. Under the physiological element, they mention that extended usage of devices is detrimental to a user's health and that the constant availability of an immense amount of information leads to stress. For the behavioural element, the focus is on the points of problematic usage of the Internet, referring to internet addiction, and media multitasking, which refers to how certain users will be using multiple devices and constantly switching focus while others do not (McMahon & Aiken, 2015). The psychological points mentioned are that of online privacy and online disinhibition, meaning a lack of restraint whilst a user is interacting online (McMahon & Aiken, 2015).

The above definition is centred around the various elements of a person's wellbeing that should be kept healthy whilst using technology instead of what digital wellbeing is as a concept. Vanden Abeele (2020) attempts to define digital wellbeing as a dynamic construct while making considerations that technology is both abundant and has both positive and negative impacts on people. The definition is as follows: "Digital wellbeing is a subjective individual experience of optimal balance between the benefits and drawbacks obtained from mobile connectivity" (Vanden Abeele, 2020, p. 938). Digital wellbeing is described here as being different for each person which means each person will have different means of achieving digital wellbeing.

As such, this study will make use of the following definition of digital wellbeing: *Digital wellbeing encompasses an individual's ability to foster healthy usage of technological devices and includes being able to secure said devices, privacy, as well as their own physical and mental health.* As this definition refers to an individual's ability, it then refers to the subjectivity of how achieving digital wellbeing would be different for each person.

2.2.2 Current Digital Wellbeing Interventions

There are currently many types of application and device that employ some form of digital wellbeing. This comes in a variety of applications, settings and data that is available to users of certain devices.

Smartphones are integral to everyday life (Roffarello & De Russis, 2019) and as such are therefore the first interaction most will have when discussing digital wellbeing.

Smartphones are perceived as a source of distraction in addition to causing issues with a person's mental health and social interaction (Roffarello & De Russis, 2019). These devices allow users to access a multitude of other applications each of which may cause other problems such as addiction. One example of feedback presented to most people is the daily breakdown of smartphone usage. As a result, most technology and software-based interventions focus on or are presented through a smartphone.

Roffarello and De Russis (2019) conducted a study to identify the features present within stand-alone digital wellbeing applications. From this study, it appears that a majority of these applications focuses on presenting information to the user through charts (around 60%) in addition to providing summaries and times of both phone usage and all application usage which are all around 50% (Roffarello & De Russis, 2019). Figure 2.2 provides an example of this which is provided by the device itself in place of a specific stand-alone application.

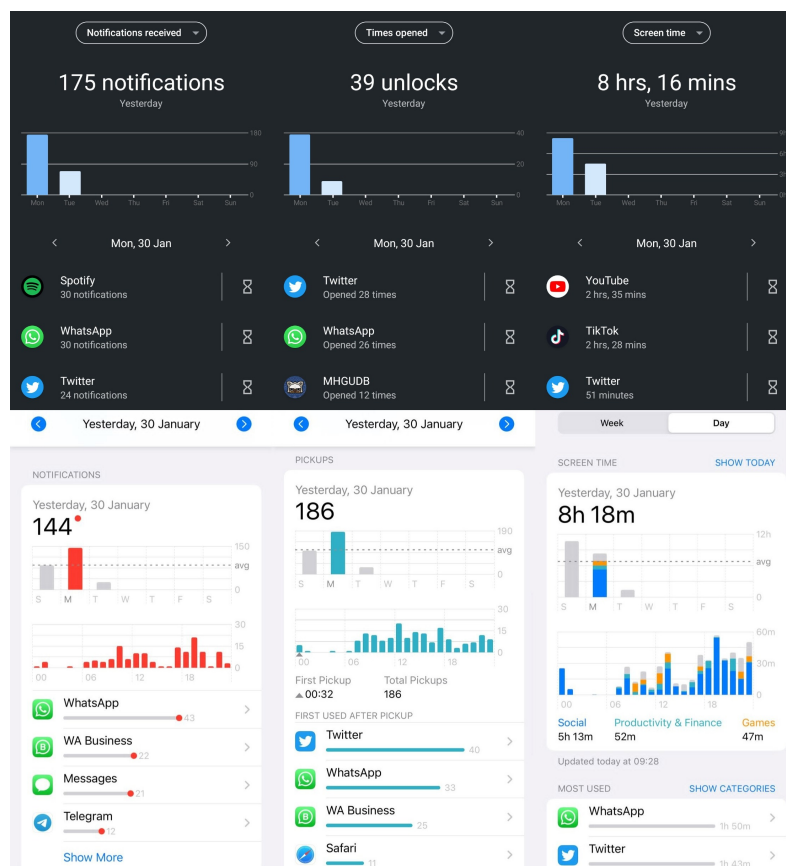


FIGURE 2.2: Examples of smartphone implementations of digital wellbeing with Android on the top, Apple on the bottom (Self-Sourced).

While presenting information to a user seems to be the most common feature of such applications, the next common set of features is blockers and timers (Roffarello & De Russis, 2019). The previous features are classed as “Self-Monitoring” while these blocking and timing features are classed as “Interventions”. These features then take a more active role in facilitating the digital wellbeing of a user instead of providing the information that they can use to self-monitor and make adjustments.

Digital wellbeing applications have a focus on monitoring a user through tracking behaviour and providing the feedback on it, which is vital to behavioural change, where once said, monitoring stops and a user’s behaviour can revert, as this alone allows for the breaking of habits, but not the creation of new ones (Roffarello & De Russis, 2019).

There are also reminders with which certain applications will prompt the user, and Figure 2.3 shows such an example from a digital video game.



FIGURE 2.3: Example of a video game’s (Monster Hunter Generations Ultimate) reminder to take breaks (Capcom, 2017).

2.2.3 User response to Digital Wellbeing Interventions

When developing a digital wellbeing application, as it falls under e-health, it is important to note that one type of feature may be liked by some people while being disliked by others and as such, runs the risk of wasting resources on the development (McMahon & Aiken, 2015). One example of this is the concept of a digital detox where a user avoids using technology. This may work for certain people, but may lead to

more stress in others, as they may be under the expectation to be constantly available for work (McMahon & Aiken, 2015) which is now common, as daily use of digital devices is normal for employment purposes (Sheppard & Wolffsohn, 2018). The general use of technology is also increasing for all (Coles-Brennan et al., 2019; Sheppard & Wolffsohn, 2018).

The study conducted by Roffarello and De Russis (2019) also includes what users liked and disliked about digital wellbeing applications. From this study, it is seen that users are fascinated by the idea of having a digital assistant, as it was found useful for breaking their phone addiction and has the potential to make them “feel better”. Users also like the fact that one application can be used for multiple purposes, with the examples given being studying, working, sleeping and parental control (Roffarello & De Russis, 2019). Out of all the features these types of application offer, the most appreciated are those of statistics and blockers and timers, as the former is helpful for a user to identify their usage patterns and the latter to control unhealthy behaviour which is useful to increase productivity (Roffarello & De Russis, 2019). It should also be noted that users prefer the restrictive nature of blockers over the use of times, as more use the latter feature.

In terms of what users’ dislike regarding these applications, a large portion of users dislike when there are bugs or design flaws present in the application, an example being if the application tracked the background processes of an application against the user’s active usage (Roffarello & De Russis, 2019). With flaws that affect the accuracy of the data presented, users find these applications “useless” (Roffarello & De Russis, 2019). Some users also take issue with how the digital wellbeing application can affect their devices, for example by reducing battery time. In line with users liking the restrictive nature of some applications, they also dislike if the restrictions of the application are easily bypassed as it then defeats the purpose of restricting access. A small section of users is concerned that these types of application are invasive and intrusive (Roffarello & De Russis, 2019).

Another study, conducted by Almourad et al. (2021), likewise focused on the acceptance and rejection factors of a digital wellbeing application. The acceptance factors include functionality in the form of progress tracking, visualisation, constant feedback, sensory stimulus, and power of choice (Almourad et al., 2021). As for the user experience side, factors included ease of use, appealing layout, personalisation,

and customisation (Almourad et al., 2021). The rejection factors additionally include functionality in the form of lack of customisation, inconsistency, autonomy disruption and inaccuracy (Almourad et al., 2021). With regard to usefulness, lack of personalisation, practical unacceptability and repetitive reminders are mentioned (Almourad et al., 2021).

TABLE 2.1: Likes and Dislikes for Digital Wellbeing Applications

Likes	Dislikes
The idea of having one	Bugs and design flaws
Multiple use cases	Effect(s) on device
Various features	Intrusion on privacy
Ability to control unhealthy behaviours	Lack of personalisation
Progress tracking	Lack of customisation
Feedback	Inconsistency
Power of choice	-

2.2.4 Issues Relating to Aspects of Digital Wellbeing

As per the definition of digital wellbeing presented above, the aspects which are to be discussed below pertain to a user's physical and mental health, as well as digital security in terms of technology. With each aspect, there are various issues that a user will experience due to the use of technology.

Physical Health

As a part of the definition of digital wellbeing, physical health in this context relates to issues that arise when the use of technology directly affects a user's physical body.

One such example is digital eye strain (DES), also known as computer vision syndrome (CVS), in addition to visual fatigue (Sheppard & Wolffsohn, 2018). The multiple naming conventions of this condition result from the multitude of devices from which it can arise and as such be easier explained to a patient and the public where confusion could arise when referring to a smartphone as a computer (Sheppard & Wolffsohn, 2018). DES is a condition which is characterised by some form of visual disturbance or ocular discomfort with accompanying symptoms listed below (Coles-Brennan et al., 2019). This condition also affects all users of digital devices but

people who make use of such devices in a professional capacity are at a greater risk. The most common symptoms of this condition are tired eyes, dry eyes, eye discomfort, eye strain, tearing, burning eyes, general fatigue, sensitivity to bright lights, blurred vision, double vision, headaches, pain in the neck and shoulders and difficulty refocusing when viewing at different distances (Coles-Brennan et al., 2019; Sheppard & Wolffsohn, 2018). While these symptoms typically last a short while, users who use devices professionally may experience long-term issues, as an increased use of devices increases the symptoms (Coles-Brennan et al., 2019).

There are a few proposed ways to manage DES which include the management of dry eye. One way of reducing this is through the use of eye drops which can reduce the symptoms of tiredness, dryness and the issue of focusing; however, it may not completely remove this condition (Sheppard & Wolffsohn, 2018). 70% of a group of users who used a computer for more than three hours a day found a beneficial dissipation of all symptoms after taking dietary supplements (omega-3 fatty acids) for three months (Sheppard & Wolffsohn, 2018). Applying some form of blink training may also be beneficial, as it was found that when staring at a screen, users reduce the number of blinks, as well as have more incomplete blinks per minute and training to reduce these incomplete blinks may prove beneficial (Coles-Brennan et al., 2019; Sheppard & Wolffsohn, 2018). Users also tend to squint when viewing a screen which may contribute to symptoms of tired eyes and eye-related pain (Coles-Brennan et al., 2019).

There are also certain sets of people who are more likely to experience symptoms of DES due to pre-existing conditions. This includes contact lens users, as it was found that this group have a higher percentage by about 15% of listing symptoms than those who do not use contact lenses (Coles-Brennan et al., 2019). It was found that dryness symptoms were relieved once the lenses were removed (Coles-Brennan et al., 2019); however, this would then have users dealing with any vision impairment for which they require the lenses. Similarly, people with astigmatism are also typically affected more and can help mitigate the symptoms with corrective glasses (Coles-Brennan et al., 2019; Sheppard & Wolffsohn, 2018).

While the above management strategies focused on specific causes, there are more general ergonomic means. Some ergonomic practices include ensuring there is appropriate lighting in the room, adjustment of various parameters, such as screen

resolution or font size, and regular breaks (Coles-Brennan et al., 2019). Furthermore, while taking breaks, it is also recommended to follow the “20/20/20” strategy which includes looking at an object at least 20ft away for 20 seconds after every 20 minutes of device usage (Coles-Brennan et al., 2019). The use of an anti-reflection screen has seen an increase in blink rate and reduction in DES symptoms (Coles-Brennan et al., 2019).

Another aspect of physical wellbeing that technology seems to have an effect on is sleep. Some people have reported that when not using their devices for social media before bed allowed them to fall asleep faster (Nguyen, 2021). In another study, the use of social media before sleep did not present a notable reduction in the quality of sleep, as participants reported only marginally worse quality (Combertaldi et al., 2021). However, this study was conducted to focus on active social media use, with applications such as WhatsApp and Snapchat, instead of more passive ones, such as Instagram or Facebook (Combertaldi et al., 2021). The effects of blue light were, however, not a part of this study and exposure to it was reduced.

While exposure to blue light can be harmful to the eyes, in addition to long-term exposure to less intense light, the levels emitted by screens are low and are not too much of a concern and there are applications and blue-light filtering glasses to further mitigate what harm could arise (Coles-Brennan et al., 2019; Sheppard & Wolffsohn, 2018). However, while damage to the eye may be minimal, blue light is still something that needs to be minimised. One aspect where this is more of a concern is with regard to a person’s sleeping patterns, as the exposure to the light emitted from device screens is enough to disrupt sleeping patterns (Sheppard & Wolffsohn, 2018). Blue light is also a cause of DES and while studies have not shown that blue-light filtering is impactful in reducing the symptoms of DES, it has been found that people with dry eyes did have some reduction of complaints and high-level blocking did reduce feelings of itchy eyes; however, there are questions about it being a result of placebo (Sheppard & Wolffsohn, 2018). While there is not much evidence that it does work for all, it may still prove effective for some users of digital screens.

Using technology for extended periods of time without breaks can also lead to various posture issues and could lead to pain (Meates, 2021). Meates (2021) analysed multiple studies looking into the physical impacts on adolescents arising from problematic technology use which covered smartphone use and sitting at a desk

using devices. The first effect is that of strain on the neck and back. Due to the posture taken while using a smartphone, back, neck and shoulder pain can arise as reported in several studies that Meates (2021) included. The main issues presented were pain or discomfort in the neck and back. Sore eyes, or general eye discomfort was also mentioned which has discussed above. This pain of the neck is often diagnosed as tension neck syndrome and is characterised by pain and muscle tenderness (Wærsted et al., 2010). Using a smartphone in one hand can cause increased tenderness in the neck as opposed to two-handed use, as found in a study amongst young adults (Meates, 2021). The same issues of neck and back pain were described by students who used a computer as part of their curriculum and often assumed a hunched position while using it (Meates, 2021). Sitting at a desk while working with a device also comes with other issues, such as the aforementioned eye issues, but also mid and lower back pain.

A study conducted in Nigeria with 1041 user responses found that neck, lower back, and wrist pain were the most prevalent from computer use (Adedoyin et al., 2003). The likely sources resulting in discomfort or pain were also discussed with back pain stemming from incorrect posture while sitting, neck pain from incorrect placement of screens and wrist pain arising from prolonged keyboard and mouse use and could lead to carpal tunnel syndrome (Adedoyin et al., 2003).

One way to mitigate the ill effects posed on the body, is to take a break every 30 minutes while working at a computer and to not exceed 60 minutes if possible. This break should also include some form of physical activity, such as stretching (Adedoyin et al., 2003; Meates, 2021). Additionally, correctly placing monitors at the right level on a desk in such a way that you are not looking down or up at it can prevent neck strain (Adedoyin et al., 2003).

The use of a chair armrest while using a keyboard or mouse may help reduce the chance of tension neck syndrome while a forearm support board could also help with both neck and shoulder issues (Wærsted et al., 2010). Keeping the inner elbow angled above 121° and the shoulder angled below 35° may decrease the risk of pain or discomfort, as well as ensure the keyboard is not placed too much higher than elbow level (Wærsted et al., 2010). Keeping the hand using the mouse less than 20° outwards from the body is advised to reduce the risk of pain arising in the wrist (Wærsted et al., 2010).

The above-mentioned mitigation strategies may have an effect on reducing the risk of pain or discomfort, but Wærsted et al. (2010) mention that the measures taken had a tangible effect in one study with a specific group of participants while in another study with a different class of participants, it showed no effect. There are also other potential detriments that improper technology use can cause, such as hearing issues, that can be discussed, but the ones above cover the most common issues.

Mental Health

The use of technology can affect a person's mental wellbeing in a variety of ways due to the ubiquitous access to information, as well as overuse which can arise from everyday use to addiction.

The first threat and impact stemming from overuse is that of internet addiction. While the only condition recognised by the *Diagnostic and Statistical Manual for Mental Disorders* (DSM-V) is Internet Gaming Disorder (American Psychiatric Association, 2022), it is agreed upon by most experts that people are struggling to manage their use of the internet which leads to consequences in the personal, familial, and social spheres (Scott et al., 2017). A point of contention in internet addiction becoming a formal diagnosis stems from its difficulty in distinguishing between the overuse and reliance on technology and the need to use it for business or personal usage in a legitimate and purposeful manner (Scott et al., 2017). Regardless of the apprehension of formal classification, some countries, such as China and South Korea have facilities and policies in place to treat internet addiction (Scott et al., 2017). Technology overuse can impact a person through stress, lowered self-esteem, issues with attention, a need for instant gratification and various other mental health issues (Scott et al., 2017).

As internet gaming disorder is the only recognised disorder in the DSM-V and general internet use can also be problematic, the criteria for internet gaming disorder may also apply to general internet addiction. As such, the criteria for a diagnosis are (American Psychiatric Association, 2022):

1. Preoccupation with Internet games,
2. Withdrawal symptoms when internet gaming is removed,
3. The need to spend an increasing amount of time engaged in Internet games,
4. Unsuccessful attempts to control participation in Internet games,

5. Loss of interest in previous hobbies and entertainment,
6. Continued excessive use of Internet games despite knowledge of psychosocial problems,
7. Deception of family members, therapists, or others regarding the amount of internet gaming,
8. Use of Internet games to escape or relieve a negative mood, and
9. Jeopardising or losing a significant relationship, job, or educational or career opportunity because of participation in Internet games.

The severity of internet addiction can also range from only displaying some of the criteria and reliance to severe when all criteria are met. With regard to internet addiction, the use of therapy and counselling can help and is most effective if implemented before the overuse of the internet develops into an addiction (Cho, 2015). There are centres in some countries, such as Schwerin Helios medical centres in Germany or the National Centre for Youth Internet Addiction Treatment in South Korea, which help with such technology overuse or dependency (Cho, 2015; Dau et al., 2015). Another means often discussed is abstinence from technology which may only prove helpful in specific cases (Dau et al., 2015) and may prove detrimental to a person if their occupation is reliant on using the internet or devices.

South Korea has a national policy to help mitigate internet addiction which includes infrastructure, such as the aforementioned treatment centre (Koh, 2015). The policy also restricts internet or gaming access to certain groups and if a person is not within South Korea, following a similar self-imposed restriction may be effective. One such policy, the “Shut-down System”, restricts people under 16 years old from playing games between midnight and 06:00 (Koh, 2015). From this concept, one could impose such a restriction on oneself in order to remove oneself from the internet, games or technology in general, provided doing so does not impose other risks.

Overall, the two main approaches to dealing with internet addiction, or internet gaming disorder, are prevention and treatment. With regards to prevention, South Korea puts effort into annual “training” which includes informing people about internet addiction (Koh, 2015). An example of this is the promotion of self-control among the adolescents. As for as treatment is concerned, this entails the

aforementioned counselling or therapy and help centres and while there is a lack of evidence-based treatments specifically designed for internet addiction, it has been found that standard cognitive and behavioural treatments are most often effective (Scott et al., 2017).

Another impact technology can have is that of stress which leads to many of its own impacts. Stress can stem from a myriad of sources relating to technology use, the first of which is that of work-life balance. Due to the constant access to devices and the immediate communication they offer, it is often difficult for some to fully separate from work after hours, in addition to personal issues causing stress while at work (Scott et al., 2017). The disconnect between these spheres can lead to increased stress for some which has negative impacts on creativity, decision making, relationships and physical and mental health (Scott et al., 2017). The lack of clear boundaries between work and life in this context leads to issues both personally and professionally in terms of work performance and personal relationships respectively. As the cause for stress in this particular situation is the lack of a clear separation between work and personal life, setting one such clear boundary could help mitigate the stress caused.

Another important facet to take note of when always connected to information is that of doom-scrolling. Doom-scrolling is the cycle of seeking negative information on social media or news feeds (Satici et al., 2023). This is likely to happen when a person is presented with uncertainty, such as with the COVID-19 pandemic, and has the urge to gather as much information as possible which results in scrolling through social media for hours which generally provides negative news or information (Satici et al., 2023). Doom-scrolling may also lead to higher levels of depression, anxiety, stress, distress and generally lower levels of wellbeing (Satici et al., 2023).

Specific to doom-scrolling in terms of the above-mentioned issues, is that of news avoidance. News avoidance is when people will intentionally and significantly limit their social media use to avoid seeing current event news (Mannell & Meese, 2022). Avoidance is mostly practised on occasion during points that could lead to an information overload (Mannell & Meese, 2022). News avoidance is helpful to some as it can mitigate a wide array of wellbeing-related issues as it helps people set boundaries around technology use, manage emotional resources and better engage with others (Mannell & Meese, 2022).

Following this, and previous mentions of abstinence from technology, it is vital to a person's mental wellbeing with respect to digital wellbeing as a whole that managing their usage in terms of time spent is important. As with news avoidance, this requires balancing the need to mitigate the negative impacts while still using technology in such a way that one does not create other issues for oneself (Mannell & Meese, 2022). Nguyen (2021) echoes this point, stating that explicit and complete non-use of technology is not always desirable and that a more nuanced approach is needed. Examples, such as disconnecting from social media entirely, may cause a negative impact on one's communication skills and relationships or issues relating to employment as certain occupations require the use of technology (Nguyen, 2021). In fact, temporary breaks from social media sites, such as Facebook, may allow a person to return to using it in a more healthy and mindful manner (Nguyen, 2021). Each individual will deal with social media differently; some individuals may view instant messaging applications as social media, while others view it as a replacement for phone calls or SMSs.

This act of abstaining from technology use is also referred to as a "digital detox" and can have a varied length, as well as only abstaining from one application or feature to total abstinence of all technology (Nguyen, 2021). This practice is also mentioned under a campaign stemming from South Korea's internet addiction response policies where the hazards of spending too much time on smartphones are highlighted (Koh, 2015). There are three main strategies which include disconnecting from devices, specific applications or platforms and certain platform content, features, or communication (Nguyen, 2021). Participants in Nguyen's (2021) study also state similar effects that were shown by Mannell and Meese (2022) where it positively impacted their overall wellbeing.

Taking part in a digital detox was found to have benefits for a person's psychological wellbeing, time management, and physical wellbeing (Nguyen, 2021). Table 2.2 shows the benefits for the former two as the only benefit for physical wellbeing is better sleep which is discussed above in the physical wellbeing subsection.

TABLE 2.2: Benefits of a digital detox (Compiled from Nguyen, 2021)

Psychological wellbeing	Time management
More peace of mind and no social pressure	More time for leisure activities
Feeling more rested	Increased productivity
Feeling less overwhelmed	Better distraction avoidance

As with the physical wellbeing mitigations, the ones described here for mental wellbeing are also subjective to each person. As such, the strategies discussed may work for some and might not help others. However, due to the range that a digital detox can stretch, from temporary to situational and from social media platforms to entire devices, it is likely that there is a combination that will work (Nguyen, 2021).

Digital Security

When discussing digital wellbeing and how to engage with technology in a healthy manner, it is also important to discuss the technology itself and how it can be affected and protected. As of November 2022, the most common cyberthreats were malware, account takeovers, phishing, and ransomware (Statista, 2023). These are therefore the aspects of digital security with regard to digital wellbeing which will be covered. These will be discussed as passwords, as strong passwords can protect against some account takeover methods, phishing, and malware, as ransomware is a type of malware.

The first aspect of digital security to be discussed is that of passwords. Virtually everyone who makes use of a device to connect to or has an account on the internet has a password. Passwords chosen are typically easy for a person to remember but that comes at the cost of it being easier for an attacker to guess or brute force it (Dell'Amico et al., 2010). Most proactive password-checking systems generally measure a password's strength, based on its length, inclusion of special characters and the use of both upper- and lower-case letters which is a good indicator to mitigate a brute force attack, but may fall short with other types of attacks (Dell'Amico et al., 2010). However, these proactive systems vary from platform to platform and may run on different rules where a password may be described as very weak by one may be described as strong by another, as some only follow the aforementioned criteria while others also include identifying commonly used words (de Carné de Carnavalet &

Mannan, 2014). For instance, taking the password “*password*” and making it “*7Password!*” will have it go from weak to strong on one system, but remain weak on another. This is likely due to the latter system including the chance of mangling being used in a dictionary attack by which existing passwords in the dictionary are changed according to certain rules set by the attacker (Dell’Amico et al., 2010). A dictionary attack primarily targets weaker passwords, as the dictionary or a list of many potential passwords used by an attacker holds common words typically used as passwords (Dell’Amico et al., 2010). These dictionaries can sometimes hold passwords from real-life data breaches and an attacker can utilise multiple dictionaries, resulting in roughly four million passwords to try (de Carné de Carnavalet & Mannan, 2014; Dell’Amico et al., 2010).

One way to develop a strong password is to turn a phrase or sentence into a password which allows for a strong password that is also easy to remember (Dell’Amico et al., 2010). This entails picking a sentence, for example “*Typically, hello world is the 1st program most write!*” which would become “*T,hwit1pmw!*”. However, when picking a phrase, it is important to make sure it is not a popular one, such as song lyrics, as some dictionaries can include these. Using personal information, such as a birthday, licence plate or pet name in a password is also not advised, as these can be easier to break than a password based on a common word (Dell’Amico et al., 2010). With regard to a brute force attack, a longer password will fare better than one that includes special characters and both upper and lower case, but a password should still include all, as it increases the number of characters that would need to be tested at each length (de Carné de Carnavalet & Mannan, 2014).

While having a strong password is important, a phishing attack bypasses this as a user directly gives the attacker their password (Dell’Amico et al., 2010). Phishing is a type of social engineering attack which acts as the beginning of another type of attack, be it stealing personal information or installing malware through some initial communication, such as e-mail, SMS or a web page mimicking a legitimate one (Khonji et al., 2013). Social engineering is an approach that focuses on gaining access to systems or information through people (Aldawood & Skinner, 2018).

The detection of phishing attacks falls into two main approaches, the first being user vigilance and the other being software detection (Khonji et al., 2013). The software detection typically makes use of blacklists and heuristics to identify and restrict these

attacks. This typically results in a message being sent to a spam folder. User vigilance is when a person is able to identify a phishing attempt, typically when software detection fails to, and responds accordingly (Khonji et al., 2013).

A person identifying a phishing attempt will need to be aware of the aspects that make a phishing link or message identifiable. Most phishing attempts will try to create a sense of urgency or importance, as it has a psychological effect on the victim as they are likely to act quickly and without much thought (Alkhalil et al., 2021). Another identifiable aspect is the embedded buttons or links within a message; the corresponding URL will not match with a site typically used for the presented function. The origin of the message, such as the sender's email, will likely also be questionable due to several factors, such as extra or substituted letters or an incorrect domain (Alkhalil et al., 2021). Figure 2.4 shows an example of a phishing e-mail that was not automatically sent to the spam folder. As detailed above, it attempts to create urgency within the recipient with the title being "Update Payment Now!!". Additionally, the "Update Now" button, instead of linking to a page under the Netflix domain, links to a page under the Wix domain. The sender's email is mimicking that of Netflix, but the domain is incorrect, as it is "wixemails", whilst "netflix" is being written as "netfl-x".

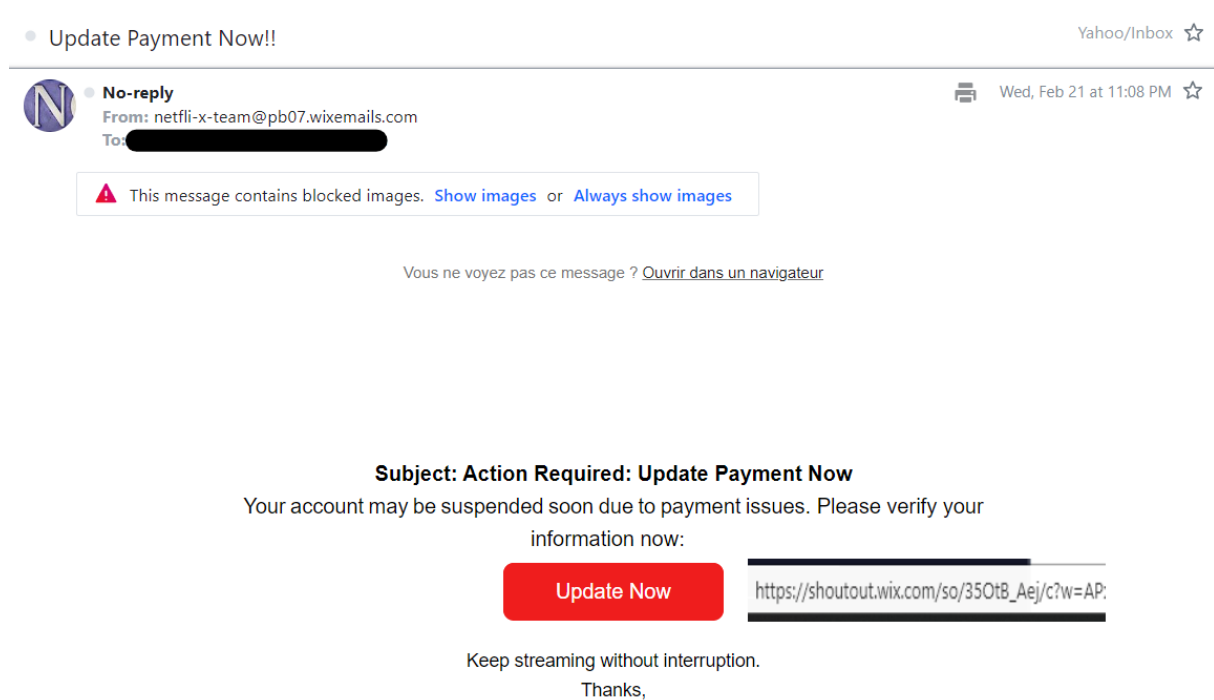


FIGURE 2.4: Example of a phishing e-mail (Self-acquired)

Figure 2.5 is an additional example of a phishing attempt through SMS. With this one, the only discernible issue is that of the link, as it ends with “login1”, whereas the legitimate web site likely would not. Creating a sense of urgency is achieved by mentioning a banking account suspension which most people would wish to resolve as soon as possible.

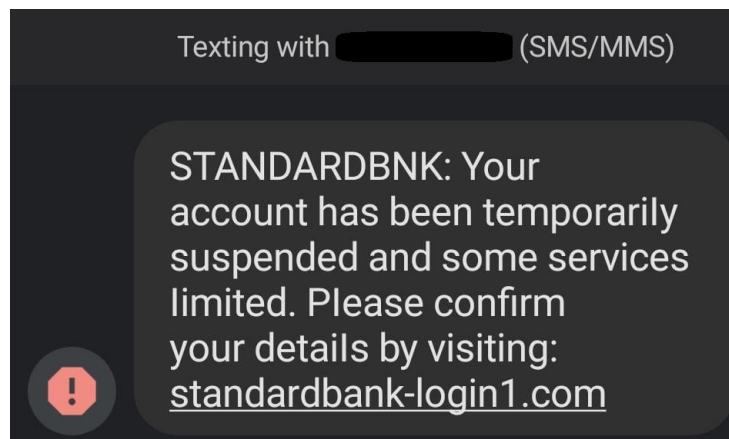


FIGURE 2.5: Example of a phishing SMS (Self-acquired)

In addition to being able to identify a phishing attempt, there are best practices to take when unsure if a communication is a phishing attempt. Firstly, never click on the links in a message unless the message was intended to be received, such as by clicking a password reset link after you requested it (Alkhalil et al., 2021). Having a unique password for each account is recommended; if the credentials are given to an attacker, only one account is compromised.

Phishing attempts, as discussed, will try to acquire personal information, but they can also be used to spread malicious software, or malware, to a user (Alkhalil et al., 2021; Khonji et al., 2013). Malware is designed to damage systems or specific files through various means (Hama Saeed, 2020). Malware can be used for many reasons, such as blackmailing a user for money through ransomware, stealing data with spyware, spamming advertisements with adware or turning a computer into a “zombie” for use by an attacker with a botnet (Hama Saeed, 2020).

While there are various types of malware, there are also many ways to counter them. The first is a malware removal tool that scans a system for malware and removes it. Anti-virus software is used to scan real-time activity on a system, such as newly downloaded files, and monitoring applications and can also remove malware

(Hama Saeed, 2020). Furthermore, as with phishing, having a user understand what to look out for to avoid malware is another countermeasure. Generally, the same identifiers apply, these being questionable file names, sender information and web pages mimicking legitimate ones.

From the above discussions and subsections, the three aspects of digital wellbeing as defined above additionally have key areas of focus for educating users. A summary of this section is presented in Table 2.3, highlighting the major points to be used as a part of the content to be used within the serious game being developed. There are more potential topics that could be covered, for example digital security could additionally go over other attacks, such as a man-in-the-middle attack; however, for the scope of the serious game, these are sufficient.

TABLE 2.3: A summary of the issues for the aspects of digital wellbeing

Physical Wellbeing	Mental Wellbeing	Digital Security
Digital Eye Strain	Internet Addiction	Passwords
Sleep	Stress	Phishing
Musculoskeletal pain	Doom-scrolling	Malware

2.3 Ludology

The field of ludology deals with the studying of games and has its' roots in the "*study of play*" through a social and cultural lens (Huizinga, 1949). However, the field also includes the study of digital computer-based games and is now defined as a discipline that studies games in general, and video games in particular (Frasca, 2013). There is also a focus on the individual elements of games, as well as developing models to explain the various mechanics and rules of games. This section will aid with defining what type of game is to be developed, as well as what design choices to make or include.

2.3.1 Serious Games

One major aspect of ludology is the topic of serious games. These types of game can be described as a video game that aims to both entertain the user, as well as achieve some sort of change in the user, be it behavioural or skills and knowledge with the

main focus not being on the entertainment, but rather on education (Pérez-Colado et al., 2021; Thompson, 2012). The main types are educational, training and health and behavioural change where the focus is on learning for the former two types and making a change in one's lifestyle in the latter two types. The subtype referred to as games for health are serious games that are specifically designed to change certain health behaviours of the user (Thompson, 2012). As this study relates to the digital wellbeing education of a user, as well as attempting to impart some form of behavioural change, it would fall under this classification.

The use of digital video games has gained interest amongst educators and scholars due to the ability to improve interest and retention among players by keeping them motivated (Pérez-Colado et al., 2021). The different genres these games can take on also have varying benefits. One example is games that focus on the inclusion of a narrative, offer an environment that is not difficult to create and can be immersive, flexible, and simplistic, while allowing players to take on roles and perform meaningful tasks (Pérez-Colado et al., 2021). The "point-and-click" type of game is a subgenre of a narrative game and typically makes use of interactive conversations in which the player can engage with different characters, each of which will have a specific role in the narrative (Pérez-Colado et al., 2021). This is often combined with the inclusion of objects and interactions to solve puzzles where the newfound knowledge a player has gained can be applied. Narrative games are used for many different reasons, from learning to awareness (Pérez-Colado et al., 2021).

2.3.2 Approaches to Game Design and Analysis

Within ludology there are many means and methods to categorise and classify games while they are being studied. These methods are to be looked at, as they provide a more concrete way to go about the design of the serious game.

The first of these methods to be looked at is the MDA approach which stands for Mechanics, Dynamics, and Aesthetics. This approach is centred on allowing easier study, design, and decomposition of games in general for various parties, such as researchers and game designers (Hunicke et al., 2004). This is accomplished by taking the components of a game and the respective design counterparts (Hunicke et al., 2004). Table 2.4 lists these components and counterparts.

TABLE 2.4: Game Components and the Design Counterparts under MDA
(Hunicke et al., 2004)

Game Component	Design Counterpart
Rules	Mechanics
Systems	Dynamics
“Fun”	Aesthetics

This approach focuses on the three design counterparts with the first one, Mechanics, dealing with the actions, behaviours, and control mechanisms a player is afforded (Hunicke et al., 2004). This component has a direct influence on the dynamics of a game, for example the mechanics of a shooter game being the weapons and spawn points which lead to the actions of camping (when a player remains in a singular area) (Hunicke et al., 2004).

Dynamics refers to the behaviour of the mechanics while the game is subject to player input (Hunicke et al., 2004). This component has an impact on aesthetics, as it functions to create experiences for the player. The example presented here is that of a sense of fellowship where players work together towards a common goal which is mostly present in multiplayer games (Hunicke et al., 2004).

Aesthetics refers to the emotional reactions a player has to the game while playing it (Hunicke et al., 2004). Under this approach there are several presented lists of aesthetics where each describes a game as something, namely:

1. Sensation - as sense-pleasure,
2. Fantasy - as make-believe,
3. Narrative - as drama,
4. Fellowship - as social framework,
5. Challenge - as obstacle course,
6. Expression - as self-discovery,
7. Submission - as pastime, and
8. Discovery - as uncharted territory.

The above taxonomy of the aesthetics of a game aids in deciding how to develop a game. An example of this is that for a game to be competitive, players will typically face off against one another and in order to keep the game interesting, there typically needs to be some sort of feedback on how they are doing (Hunicke et al., 2004).

The next discussion points on game design are rooted in behavioural science concepts. Thompson (2012) lists five main points to keep in mind when designing a serious game for health and behavioural change. These are:

- Knowledge and skill provide the foundation for behaviour change,
- Personal mastery is key; bring on the avatars!,
- Show me the way: observational learning facilitates behaviour change,
- Just for me: the importance of tailoring, and
- Fun trumps all.

The first of these deals with the concept that a user needs to acquire the knowledge relating to how they can manage their own behaviour, as well as providing them with skills to effectively make some behavioural change (Thompson, 2012). The user must be able to identify what aspects they should change and how they can go about enacting that change in their lives. Thompson (2012) continues listing several of said skills, such as the ability to set realistic goals, being able to monitor own progress and how to solve problems encountered. Thompson (2012) also mentions how previous serious games achieved their desired behavioural change, namely character dialogue and modelling, smaller games within the serious game and the inclusion of some story elements.

The second point, "Personal mastery is key", is rooted in the idea that an effective way to learn a new skill or behaviour is through being able to perform this skill or behaviour. This takes time and serious games allow for the trial and error associated with the mastery required to be carried out in a timelier manner through the goals set in the game which is accompanied by feedback on the user's performance (Thompson, 2012). The use of a serious game thus links real-world concepts with the activities in the game's virtual world. Thomson (2012) states that the use of avatars by the user, takes this link further, as it is a form of self-representation within the serious game.

The following point, “Show me the way”, deals with observational learning, also known as modelling, where it is said to be effective for a person to observe someone else properly perform a skill and learn from it, as well as understand the effects of certain choices in relation to those skills (Thompson, 2012). With relation to a serious game, the user’s avatar can be the stand-in for the “model” to be observed in addition to other characters.

The next point, “Just for me: the importance of tailoring’ is concerned with attracting and maintaining players’ attention, as it allows for the initiation of processing information and lengthens the exposure to the behavioural change knowledge and thus leads to a greater chance the change will happen in the player (Thompson, 2012). This is done through the use of personalised content with examples being messages referring directly to the player on an individual level. This point also extends to the design of characters in the game where the persuasiveness of a character, acting as the source of information and the aforementioned messages, is linked to its perceived trustworthiness and likeability (Thompson, 2012). As such, the protagonist, or who the player assumes control of, should embody these traits while the antagonists, being the main opposition found in the game, should not.

Finally, “Fun trumps all” which deals with the fact that regardless of what insight research gives in terms of maximising behavioural change, the players will still expect to have fun when playing a video game (Thompson, 2012). For this reason, it is recommended that the development team of a serious game should not only include behavioural scientists, but also experts and specialists dealing with the content and ensuring it is entertaining. If the serious game can be perceived as fun, then the player is more likely to be motivated to continue playing (Thompson, 2012).

The following categorisation and description of games is an ontological meta-model that allows for the comparison of individual models, as well as providing the four main layers a game can comprise (Aarseth & Grabarczyk, 2018). This model comprises four main layers, namely the physical, structural, communicational, and mental layers. The physical layer refers to how games, while abstract and digital entities, have some grounding in physicality through representing physical objects and being played by physical entities (Aarseth & Grabarczyk, 2018). This layer is then further broken down into three additional sub-layers. Platform refers to the material medium used for the implementation which could be the console or computer used to

play or an analogue game board. Physical interface then refers to how a player interacts with the game, such as the use of a keyboard or baseball bat. The last sub-layer, behavioural, describes the physical actions a player needs to undertake to play the game which can, for example be pressing buttons (Aarseth & Grabarczyk, 2018).

The next layer is the structural layer which describes several abstract aspects of games. These aspects are the computational layer, referring to the code base, the mechanical layer, referring to the mechanics of the game and the economic layer which is concerned with how the game is initiated, sustained, and finished (Aarseth & Grabarczyk, 2018).

The communicational layer consists of the presentational layer which refers to the aesthetics of the game, the semantic layer which consists of all semantics from simple instructions to the narrative, and the interface layer which is the non-diegetic information, or information shown through non-immersive means, such as menus, presented to the player (Aarseth & Grabarczyk, 2018).

The last layer is the mental layer and is concerned with the game being played by an agent. The first sub-layer is the phenomenal layer which is how the player experiences the game. The next is the conceptual layer which is how the player will understand the game. Lastly, the social layer refers to how the player would interact and perceive others in the game (Aarseth & Grabarczyk, 2018).

The next approach to be discussed is the Mechanics, Experiences and Change model which focuses specifically on serious games for behavioural change (Robertson et al., 2021). This model is split, as the name implies, into the categories of mechanics, experiences, and change. A part of the study (Robertson et al., 2021) that discusses this model is a set of steps to follow. The steps to follow for this model are:

- The first step is to define the problem in behavioural terms, which includes identifying the target population and the relevant behaviours,
- The second step is to select a target behaviour from those identified in the first step and to consider the impact of each, the likelihood of change, effect on other behaviours and how to measure the behaviour,

- The third step is to specify the target behaviour from step two and to discuss who performs the behaviour, what needs to be done differently for change, when will it be done, where will it be done, how often is it done and with whom will it be done,
- The fourth step is to identify what needs to change and can be done through a behavioural analysis which identifies what psychological constructs need to change to change the behaviour,
- The fifth step is to identify the primary intervention functions of the game to target each of the constructs in step four and the mapping of construct to intervention can be done using a behavioural change wheel,
- The sixth step is to identify target player experiences which entails identifying experiential objectives to make the game compelling and can be integrated into the intervention functions,
- The seventh step is to identify behavioural change techniques to be featured in the intervention,
- The eighth step is to identify game mechanics through the use of a taxonomy and map the mechanics to the information identified from previous steps to illicit participant experiences, and
- The ninth step is to identify mode of delivery which deals with how a participant will engage with the game.

All of the discussed approaches to game design allow for a thorough design of a serious game, but could also be used in tandem with the other fields in this chapter to base most design decisions on information from said relevant fields.

2.3.3 Analysis of Serious Game Implementations

In this section, various serious game implementations, their design choices, and any notable features a particular game may have are covered. The games discussed are presented in Table 2.5 according to the authors, game name(s), type and topics covered. The full analysis of this can be found in Appendix D.

TABLE 2.5: List of Games (Esterhuizen et al., 2023)

Source	Game Name	Game Type	Topic
Aladawy et al. (2018), Goeke et al. (2020)	“Persuaded”, “Protect”	Digital Card	Social Engineering
Delnevo et al. (2022)	Unnamed	Web App	Passwords
Fatima et al. (2019)	Unnamed	Analogue Card	Privacy
Gasiba et al. (2021)	CyberSecurity Challenges	Capture-the-Flag	Secure Coding (Awareness)
Ghazvini and Shukur (2018)	InfoSecure	Quiz	Multiple IS Topics
González-Tablas et al. (2020)	Crypto Go	Analogue Card	Cryptography
Graham et al. (2020)	Cyberspace Odyssey	Team-based Puzzle	Computer Network Security
Hart et al. (2020)	Riskio	Board and Card	Cyber Security Education
Jaffray et al. (2021)	SherLOCKED	Puzzle Quiz	Cyber Security Education
Jayakrishnan et al. (2020)	Passworld	Platformer	Passwords
Jayakrishnan et al. (2022)	PickMail	Quiz Simulation	Phishing
Kletenik et al. (2021)	Cyber Secured	Quiz	Multiple IS Topics
Lima et al. (2022)	Immunitates	Quiz	Vaccination
Løvgren et al. (2019)	Data-Driven Security Game	Tower Defence	Information Security
Luh et al. (2019)	PenQuest	Board Game RPG	Cyber Attack Awareness
Misra et al. (2017)	Phish Phinder	Digital Mobile	Phishing
Mittal et al. (2021)	CBET Game	Adaptive Sandbox	Blockchain Security
Muhly et al. (2021)	Unnamed	TTRPG	Social Engineering
O’Connor et al. (2021)	SCIPS	Digital Team-based	Cyber Security Education
Yamin et al. (2021)	Unnamed	Real-time Strategy	Cyber Security Education
Yasin et al. (2019)	CSRAG	Card	Software Security Awareness
Zhao et al. (2021), Zhao et al. (2023)	CATS	Virtual Board	Cloud Security Awareness

With regard to the design of these serious games, only the design of the game itself is considered and the design of the content in these games, i.e., how cards were designed for a card game, was not.

There are quite a few analogue games within this selection (Fatima et al., 2019; González-Tablas et al., 2020; Hart et al., 2020; Luh et al., 2019; Muhly et al., 2021; Yasin et al., 2019)), and the main reasoning for those given is that it increased the players' engagement with the game and as such would be more effective as a learning tool, as these games likely take more advantage of experiential learning practices due to the increased engagement. Another prominent type is the quiz-based games (Ghazvini & Shukur, 2018; Jaffray et al., 2021; Jayakrishnan et al., 2022; Kletenik et al., 2021) as these are likely due to the fact that it is the norm within traditional teaching where students take part in written tests or multiple-choice quizzes.

Regarding the design choices, ontologies and frameworks used, there is a divide between distinct principles to follow, such as the concept of increasing difficulty seen in (Jayakrishnan et al., 2022), and more abstract or subjective ones, such as implementing it so that the game is "fun". Throughout all of the sources of design choices, there are some that are common between the distinct frameworks or ontologies that may have different names, but have the same, or similar, descriptions. Table 2.6, shows a breakdown of all main design choices utilised across the serious games selected and is reused from the article (Esterhuizen et al., 2023) with some of the least used ones removed.

There is also seemingly a need for a common framework to use, however, the reason a variety of frameworks are used is that each game requires different guidelines. In the paper for InfoSecure (Ghazvini & Shukur, 2018), the authors review multiple serious game models and exclude several for being "too general", and "too basic" or only including the serious game evaluation and not the design. From this, it becomes clear which design choices are the most used. Certain design choices were placed in the table under different names; these are a progress report (Jaffray et al., 2021) or checker (Misra et al., 2017) being placed under feedback, progressive difficulty (Jayakrishnan et al., 2022) being placed under challenge, entertainment (Muhly et al., 2021) under fun and limited resources (Yasin et al., 2019) under constraints. While listed here, these design choices will be discussed further in Section 2.3.4.

TABLE 2.6: Design Principles Listed by Usage (Esterhuizen et al., 2023)

Design Principle	Times used
Feedback	9
Ease of use/Usability/Simplicity	6
Story/Narrative	5
Rewards	5
Challenge	4
Constraints	4
Reflection	3
“Fun”	3
Competitiveness/Competition	3
Consistency	3
Adaptability	2
Conceptual-Procedural Principle	2
Real-World Content	2
Clear Objectives/Goals	2
Visibility	2
Mapping	2
Affordance	2

2.3.4 Game Design

Several key design elements identified as a part of prior research (Esterhuizen et al., 2022) are reflection, feedback, narrative, and structuring. Through an analysis of 23 serious games focused on a security topic, additional frequently used elements and design choices were identified, these being again feedback, narrative, challenge, rewards and simplicity (Esterhuizen et al., 2023). The descriptions of the following design choices or principles therefore come from these studies (Esterhuizen et al., 2022; Esterhuizen et al., 2023). Some design factors may not be discussed here as they are under-represented in literature because they have specific use cases, such as competitiveness being restricted to games with a multiplayer component, or are too general and abstract, such as with “Fun” where without it, users might feel forced to play instead of it being enjoyable (Drevin et al., 2023).

Firstly, there is **Narrative** which refers to the inclusion of some form of story which can be done in multiple ways. More precisely it can be done:

1. Contextually, by having the story presented through when or where the game takes place and what role the player will take on,
2. As the main focus, by having the story be what educates the player, or
3. Making use of an agent that guides the player through the game.

A game should allow for a narrative to take place during the teaching that takes place and this is possible. The use of a story-based agent can be utilised to guide the user through the game which falls under the “Learner Guidance” point in the First Principles (Merrill, 2002). The goal of using a narrative is to motivate the player and keep them engaged with the game, prompting further play and thus learning. However, the main disadvantage of a narrative is that it can have the opposite effect. If the story is based on a wholly different frame of reference for the player, it may cause them to become disinterested. For example, if a student were to play a game set in an office environment, they fail to relate to the story and as such not find the game fun and it will end up being ineffective in respect of the goal of teaching (as seen in the test groups of Riskio (Hart et al., 2020)). A serious game’s narrative should be aligned with the target audience to some extent. Additionally, making use of a narrative alone is insufficient, as it is not suitable when attempting to educate players on certain types of content, such as pattern recognition or physical skills (Pérez-Colado et al., 2021).

Naul and Liu (2020) examined the experiential impact of a narrative in serious games. The experiential approach to understanding these design principles is also mentioned as a key contributor to maintaining player engagement and motivation (Esterhuizen et al., 2023) and as such is also a dimension under narratives with immersion and learning gains being other such dimensions (Naul & Liu, 2020).

Feedback is also an integral aspect to a serious game if it is to be effective. It can be the audio-visual design of the game, in game statistics (such as health or points) or relaying to a user how well they are progressing and performing. In terms of indicating performance to a player, this can be done through a progress report or providing information when choices are made in certain game modes, such as quizzes. Four means of the latter are presented by Yusoff (2010), namely fixed or

variable ratio and fixed or variable interval. The former two types provide feedback according to a ratio of correct:incorrect responses from the player which can be every *n*th response (fixed) or intermittently at random (variable). Intervals refer to providing feedback after either a set or random time spent playing the game following the player giving a response or taking a certain action (Yusoff, 2010). These can easily be added to a quiz-style game and into others in the form of end of section or level screens. Additionally, feedback, in-line with certain pedagogical principles (Merrill, 2002), should also vary in accordance with how the player is performing, providing more in-depth feedback if the player is struggling to progress and less if they are competent in their actions or responses.

Simplicity can refer to multiple concepts, such as the game being easy to learn with little preparation or learning from the player and having the interface designed in a simplistic and easy-to-follow manner. Essentially, this means that the player having to first learn how the game operates should be set a simple task in order to not hinder the overall learning experience (Esterhuizen et al., 2023).

Structuring is concerned with how the game's content, instructions and difficulty are designed (Esterhuizen et al., 2022). This then includes aspects of challenge and simplicity (Esterhuizen et al., 2023) and dynamic difficulty (Hunicke, 2005). Ideally, the game's structure is centred around the problems presented to the player or the knowledge being taught if it is affective in nature or dealing with soft skills (these will be discussed within the gamification section) while the problems, tasks or questions are varied to promote engagement, as well as consistency in how a player interacts with them. Therefore, the game must be structured to present simple goals and clear expectations to the player in such a manner that they are motivated to continue playing and therefore learning. The difficulty, or **challenge**, of the game should also follow a similar pattern as that with feedback, namely increasing the difficulty as a player progresses and gets tasks or questions correct and decreasing if they struggle.

In line with the above discussed design principle of structuring is the concept of dynamic difficulty adjustment (DDA). This offers a means of changing the difficulty of the game, based on a player's performance in the game by having the in-game systems changing over a session of play (Hunicke, 2005). Pérez-Colado et al. (2021) also mention the shifting difficulty of gameplay when discussing how the difficulty of a mini game can change depending on overall game progression, alongside other

factors such as style or visibility of select features. It is possible, with the implementation of the correct algorithms, to alter everything within the game from the narrative to the layout of levels during a play session. This can also apply to the availability of rewards for the player, with the example of more powerful weapons being more difficult to acquire or spreading out healing for a player, depending on their performance.

The game this study made use of was a 3D shooter and the control policy used consisted of an estimation algorithm, based on a player's damage, and adjustment goal, based on the desired player experience and a set of intervention strategies (Hunicke, 2005). While the policy discussed is for a 3D shooting focused game, the concept can still be applied to most other types of game, such as a quiz-focused game, using the player's number of correct answers as the metric for the estimation algorithm.

Furthermore, this study also allowed for player feedback on the DDA system where participants mentioned better audio and visual cues, help with targeting, hints to object locations or behaviour of enemies and obstacles (Hunicke, 2005). From these responses, it shows that what a DDA system could change during a play session could involve virtually any aspect of the game if the proper algorithms for it are provided and it allows for the game to be re-structured, based on a player's performance during a level, making it better suited to their skills. This also aligns with user responses for digital wellbeing intervention applications with respect to accepting an application more if it has some form of feedback (Almourad et al., 2021).

Another aspect to consider when designing a game is how it can be designed in such a way as to accommodate a wide variety of user preferences. In Section 2.2.3 the user responses to various digital wellbeing application features were discussed and some users preferred certain features over others while another user might have a reversed opinion. This leads to another design principle, referred to as **Tailoring**, which deals with designing and developing a game in such a manner that the user has some form of control on how they will interact with the game.

This can be as simple as allowing them to choose the platform on which they play the game or more complicated by adding features to change certain game elements, such as by disabling level times for a more relaxed playing experience. An example of this

approach to design is shown in “Mission: Schweinehund” where users are able to set the time intervals the game has set for how often they interact with it (Höchstmann et al., 2019). Additionally, this design choice can also include the development of accessibility features, which would allow a wider range of users to play the game, such as a colour-blind mode, allowing control rebinding or changing text size. Making use of this principle aligns with what digital wellbeing intervention application users like about them, as it allows for some level of customisation or personalisation (Almourad et al., 2021).

Rewards are a tool often used to keep players engaged and interested in playing the game or cause them to play in a specific manner (Esterhuizen et al., 2023). Rewarding the player typically comes in the form of points, levels, leaderboards, and achievements within the game. These are used to drive a player’s intrinsic motivation by having something to work towards.

Lastly, **Reflection** refers to providing a player with a section of time to internalise the information with which they have been engaging (Esterhuizen et al., 2022).

In this section, serious games and the results of an analysis of several academic implementations of them were discussed. From this, a set of design principles most frequently used was distilled and will likely form the basis for the design of the serious game as a part of this study. However, the design process may still benefit from the incorporation of knowledge from other fields which is what the following sections will revolve around.

2.4 Gamification

Gamification is a field that deals with employing game-like mechanics, aesthetics and thinking to create motivation, solve problems and produce an optimal learning environment (Kapp, 2012). It is often used, as it allows for the ability to overcome the shortcomings of traditional learning methods and could offer new experiences to learners (Park & Kim, 2019). For this reason, the inclusion of literature from this field in the design of a serious game could prove beneficial, as it provides a similar, but different approach to new educational mediums.

2.4.1 Digital Gamified Environments and the Differences to Serious Games

As both ludology and gamification can result in a similar output, these being a serious game and digital gamified environment, it is important to distinguish between them. The main difference between the two fields is that gamification takes certain game elements, such as badges, points, or leaderboards, and adds them onto existing material to make it more fun, while a serious game is built to meet specific needs of some form of training or education (Almeida & Simoes, 2019).

For example, an educator may start rewarding students for taking part in a class discussion with points for a leaderboard to get them to engage with the class's material more whereas a serious game would be designed around getting the students prepared for the class, based on the learning outcomes.

2.4.2 Components of Gamification

As defined above, gamification makes use of certain mechanics from games. These include the use of badges, leaderboards, points, levels, virtual goods, and avatars (Park & Kim, 2019) to name a few of the more prominent ones in order or usage. In this section, badges, player types and how to facilitate a "flow state" will be covered, as these seem to be the most applicable to the aforementioned design principles, with badges representing rewards, player types aiding with tailoring and attempting to cause a "flow state" to help with creating a general feeling of fun.

Badges are designed on the experimental judgement of the designer or teacher taking part in gamification; however, badges based on previous evidence and relevant theories make badges more efficient in their use (Park & Kim, 2019). The use of badges in a digital education environment allows for an affordance-based learning environment which allows learners to identify their individual progress with a given topic by making typically invisible milestones a visible achievement, encouraging them to reach certain goals (Park & Kim, 2019).

A badge in this context usually comprises an icon, issuer, issue data, details, criteria, and evidence when disclosing the badge (Park & Kim, 2019). The following figure, Figure 2.6, provides a visual representation of some of this.

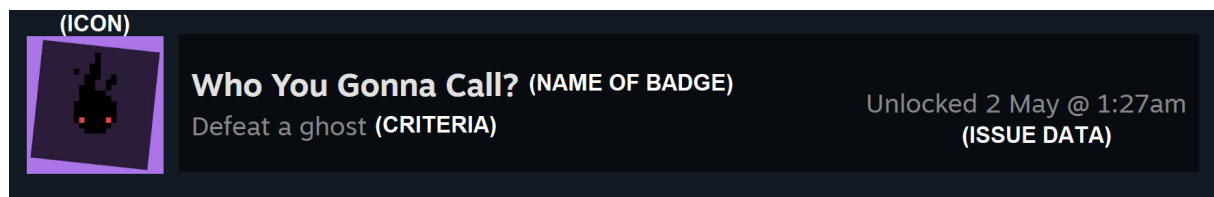


FIGURE 2.6: Example of a badge/achievement from a video game (“Cassette Beasts¹” through Steam)

Furthermore, there are also different types of badges, such as Practice, Mastery, Tikitaka, Guild, Study, Research, School, and Laboratory which are differentiated by whether it is a physical or conceptual activity, group-based or individual and how long it takes to acquire (Park & Kim, 2019). For use within a digital game-based environment, only the conceptual badges would apply, namely Study, Research, School, and Laboratory, as there would be no physical activities and then depending on the type of game, some of these would not apply as a single player game would not allow for interaction.

Each of these badges would attract a different type of learner. Knowing what the different personalities are that a learner could take on is important in order to know which badge to create. This is due to the fact that what one learner might find fun and entertaining is not necessarily true for another learner (Van Gaalen et al., 2022). Each of these personalities is described under the various player types and finding the best match between the player type and certain game elements is important, as it improves a learner’s experience, motivation, and performance (Van Gaalen et al., 2022). The different player types and their distinct characteristics are shown in Table 2.7. An important item to consider with regard to utilising player types is that another study that made use of these types on the design of a game found that the use of such personalised gamification did not affect the participant’s experience of the game (Oliveira et al., 2022). Furthermore, some player types presented more enjoyment in the non-personalised version.

¹Cassette Beasts: <https://steamcommunity.com/stats/1321440/achievements>

TABLE 2.7: Player types and associated characteristics (Van Gaalen et al., 2022)

Player Type	Characteristic
Social achievers	Like collaboration, competition and team work
Explorers	Prefer story and immersion
Competitors	Enjoy competition and individual play
Socialisers	Like sociability and interaction
Trolls	Prefer bluffing, cheating and annoying others

Under the aspects mentioned with respect to serious games and player types are those of immersion and motivation. A phenomenon that can aid in these is the “flow state” which is described as a good feeling or “optimal experience” that people have as a motivating factor in their daily activities (Oliveira et al., 2022). There are nine aspects that can be included to prompt a flow state, these are:

- Challenge-skill balance: During a flow state, there is a dynamic balance between challenges and skills which can also be modified,
- Action-awareness merging: The unity of consciousness resulting from a flow state shows the idea of growth in complexity,
- Clear goals: Goals are needed to achieve something in any endeavour and working towards a goal is integral to a flow state,
- Unambiguous feedback: Receiving feedback should not interrupt the flow state,
- Total concentration on the task at hand,
- Sense of control,
- Loss of self-consciousness,
- Transformation of time: To feel free from time dependence, and
- Autotelic experience: After the completion of an activity, upon reflection, the autotelic effect of flow is realised providing motivation for further engagement.

From these means to prompt a flow state, some either fit into or describe a design principle. With challenge-skill balance, this links to the structuring principle, specifically the aspect of ensuring the difficulty of aspects of the game is appropriate.

Clear goals are a direct design principle discussed under some of the serious games. To an extent, unambiguous feedback is linked to the feedback principle and in order to accommodate the idea of not interrupting a flow state, the feedback should be presented as a seamless part of the serious game. Lastly, the autotelic experience comes about during a period of reflection, one of the principles briefly mentioned among the others.

2.5 Pedagogy

As the serious game forming a part of this study aims to be educational in nature, it is important to look towards the field of pedagogy. Pedagogy is a field that deals with the transferring of knowledge in an educational environment through focusing on the social, political, and cultural lenses and as such involves the information pertaining to instructional design and learning theories (Li, 2012). In this section, two learning theories will be discussed to better design the game so that it is an effective learning tool. Relating back to the design principles, this would most likely add to the structuring principle.

2.5.1 Merrill's First Principles of Instruction

As this instructional model formed a large aspect of one of the publications (Esterhuizen et al., 2022), only the most pertinent aspects of it will be discussed here. None-the-less, Figure 2.7 visually shows a simple view of the model.

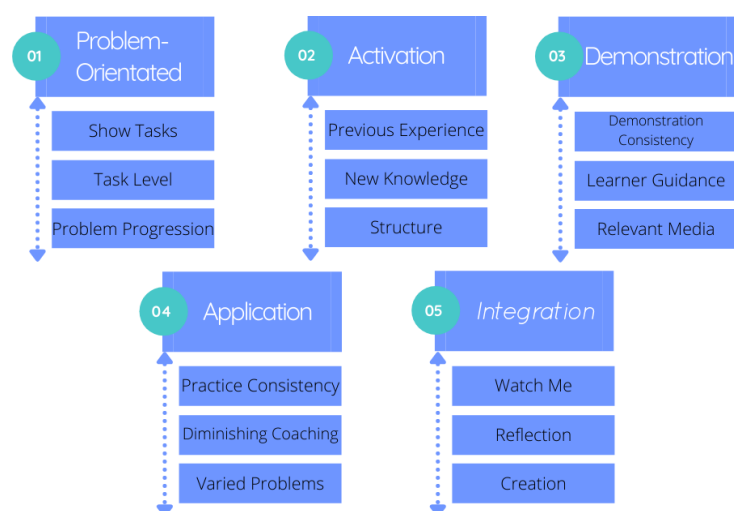


FIGURE 2.7: Summary of Merrill's First Principles (Own Creation)

With regards to the first principle of learning being problem-oriented, the main facets of this is that the difficulty of tasks as a learner progresses should progress as well which (Merrill, 2002) is in line with the structuring design principle.

The third principle, Demonstration, proposes that learning happens when the activities are shown to a learner or takes part in the activities. Additionally, any demonstration used should be in line with prior learning goals and that learners should be instructed on where they can find the relevant information (Merrill, 2002). This then lends to the fact that a serious game is an interactive experience and to the design principle of simplicity.

The fourth principle, Application, discusses that learning takes place through the solving of problems with the new knowledge a learner has acquired and the problems with which a learner is tasked should be in line with the learning goals and feedback should be provided to learners with diminishing returns while the problems they encounter are diverse in nature (Merrill, 2002). This principle then shows how to facilitate feedback and structuring, both of which are design principles.

The last principle is that of Integration which comes into effect when a learner is able to apply the knowledge learnt in their everyday life and should be able to demonstrate the knowledge or skill they have acquired and should be able to use it in a personal capacity (Merrill, 2002) which, while not specific of any design principle, is in-line with the aim of the serious game to educate people to facilitate digital wellbeing for themselves.

2.5.2 Experiential Learning Theory

The experiential learning theory is defined as “hands-on” learning that involves some form of activity, such as applying knowledge practically, learning co-operatively, internships, travelling for studies and any other experiential activity (Austin & Rust, 2015). Simply put, it is when one learns by doing. The bulk of this theory is built on six propositions. The first of these is that learning is best conceived as a process, not in terms of outcomes (Austin & Rust, 2015; Kolb & Kolb, 2005). This means that the focus of the learning process should be having students be engaged with a process that best enhances their learning which includes providing feedback on how they are progressing (Kolb & Kolb, 2005).

The second is that any form of learning is relearning meaning that the learning process should make use of a student's previous ideas and notions on a topic so that they are examined and integrated with some new more complicated knowledge (Austin & Rust, 2015; Kolb & Kolb, 2005). This then echoes the "Previous Experience" corollary under Merrill's First Principles (Merrill, 2002).

The third proposition is that learning requires the resolution of conflicts between opposed ideas of the world as the disagreements and ensuing discussions aid in the overall process of learning (Austin & Rust, 2015; Kolb & Kolb, 2005).

The fourth proposition posits that learning is a holistic process of adaptation to the world and includes more than just cognition (Austin & Rust, 2015; Kolb & Kolb, 2005). It also includes thinking, feeling, perceiving, and behaving.

The fifth proposition states that learning results from synergetic transactions between a person and their environment, meaning that learning takes place when prior knowledge is applied to new experiences and new experiences accommodate prior knowledge (Austin & Rust, 2015; Kolb & Kolb, 2005).

The last proposition is that learning is the process of creating new knowledge which results from the transformation of an experience (Austin & Rust, 2015; Kolb & Kolb, 2005).

Experiential learning has been shown to help in many areas of learning. Students who take part in a form of experiential learning are likely to quickly identify if they are suited to that discipline, bolstering their confidence in setting goals, improving their reasoning skills and better applying theoretical knowledge (Austin & Rust, 2015).

2.6 Human-Computer Interaction

Human-Computer Interaction is a field that is an intersection of social and computer sciences that deals with analysing design-specific user interfaces to improve the process of technology development (Carroll, 1997). As it is concerned with the design of the user experience when using technology and software, the subject of information visualisation will be discussed, as it may prove useful in designing the

visuals of the game and how people might interact, based on that. Additionally, interaction design based on conceptual, behavioural and interface levels will also be discussed. This will contribute to the design principle of simplicity in addition to the general visual design of the serious game.

2.6.1 Information Visualisation

Information visualisation is the design of graphical representations with a degree of purpose in mind so that the viewer is able to gain facts, identify unexpected items in data and engage with a visualisation (Benoît, 2019). Information visualisation attempts to have viewers “converse” with the data and through this internal conversation and an external discussion with others the viewer is able to understand the data in a meaningful way.

Visualisations are useful, as they can be used as part of the explanation of a problem, answer a question more deeply and reduce the amount of information presented into more manageable pieces (Benoît, 2019). The reason this is being discussed is because it forms a part of interaction design, albeit mixed with some data analysis and graphic design, and should, hopefully, prove useful in the user interaction and user experience side of the artefact.

Within this context, information is defined as *“the result of a cognitive and communicative engagement to establish meaning in otherwise static data or facts or opinions, that enable one to operate more effectively in one’s “lifeworld”, by actively/consciously accepting the reasoning behind the content in an intentionally created and purposively shared communication, regardless of physicality”* (Benoît, 2019, p.25). Some of the key properties of information, relevant to this study are that it is intentional, comprehensive, communicable, and has social context and cognition.

As the artefact accompanying this study takes the form of a serious game and the information to be represented is concepts in digital wellbeing, the game itself takes on the role of the visualisation, as well as having aspects within it also being visualisations of information. With regard to appearances, at least, the artefact will make use of the following visual design choices.

The first of these is the so-called “rule of thirds” which deals with the composition of, typically, posters and web sites. In essence, it entails having no more than three colours, typefaces, and display areas in a design composition (Benoît, 2019) and is depicted in Figure 2.8. There are also other types of common design layout as shown in Figure 2.9 when relating to posters, some of which can be used in the artefact as the design of user interfaces. Each of these has three main functional areas, namely a graphic, a user control panel for interaction and a graphic display area for details on demand (Benoît, 2019).

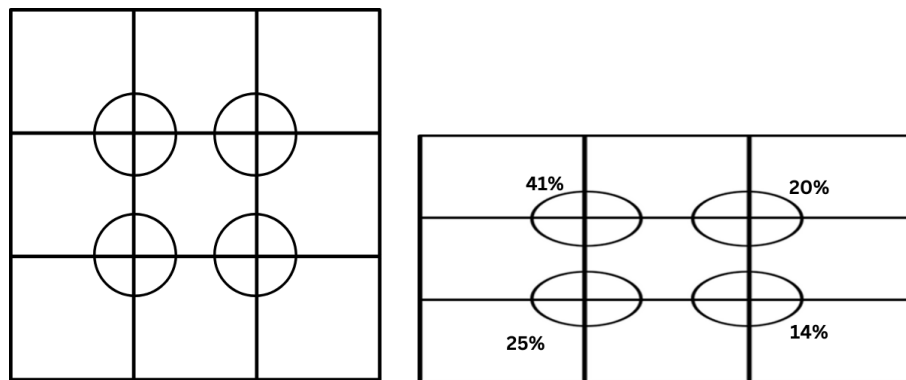


FIGURE 2.8: Rule of Thirds (Adapted from Benoît, 2019)

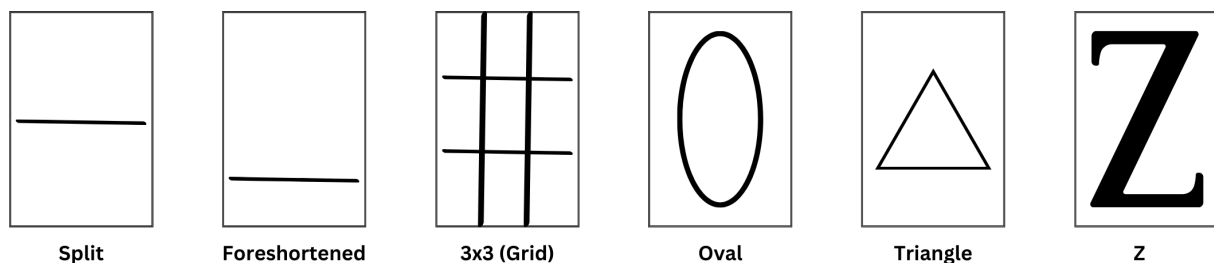


FIGURE 2.9: Common Poster Layouts (Adapted from Benoît, 2019)

Furthermore, there are certain visual elements used across most information visualisation. These describe various means to order, arrange and scale visual elements. Achieving some of these aspects may be beneficial to the serious game being developed, as it allows for a more visually appealing design. Table 2.8 provides brief descriptions of the elements.

TABLE 2.8: Visual Elements (Benoît, 2019)

Aspect	Visual Elements
Unity/Harmony	Proximity: sensible spacing between element Similarity: repeating an element with similar ones Continuity: prolonging a line or pattern, Repetition: copying items repeatedly Rhythm: graphic elements have a central point of interruption
Equilibrium	Symmetry: elements on an axis are positioned symmetrically Asymmetry: elements have different shapes creating equilibrium Circularity: elements are positioned to create a circular form
Hierarchy	Tree structure: elements are ordered according to a structure Parent-child relationship Size: elements of the same thickness belong to the same class
Scale/Proportion	Size: elements of different sizes are related to each other Ratio: elements are linked by a ratio, creating a visual harmony Divisions: multiple focal points create a sense of comparison
Accenting	Highlighting: using a different shape to accentuate an item Colour: distinguish an element from a series of similar forms Size: the elements have different sizes
Similar/Contrast	Lightness/Shadow: separate the foreground and background Lines/Shapes: varying the texture of elements to effect a contrast

In addition to these elements, there are also multiple approaches to visual design, each of which has a differing focal point. With regards to these, the data-centric approach is not too helpful, as it is a problem-solving approach with a focus on charting large data sets (Benoît, 2019). The user-centric approach may prove more useful as the data, which in the case of this study is information regarding digital wellbeing, is less important to the design of the user experience. The visual-centric approach deals with the core fundamentals of graphic design, such as composition, colour, or typography and how to use it effectively. Lastly, the communications-centric approach is concerned with the purpose of visualisation which is to foster discussion by allowing the viewer to arrive at conclusions based on the information and to take further action (Benoît, 2019).

From these approaches, all but the data-centric approach should prove useful in one way or another for the design of the serious game.

2.6.2 Interaction Design Principles

Interaction design principles can be broken up into three major categories, although the distinction between them may be “fuzzy”. These categories are conceptual, behavioural, and interface-level principles. While most of these principles can be applied for multiple platforms, there are some platforms that may need special considerations, as the platform may have innate restrictions, such as with a smaller screen on mobile devices (Cooper et al., 2014). Cooper et al. (2014) present concise design principles intermittently throughout the discussion of these categories and it is these that will be focused on, as they succinctly explain the main point of a given chapter or section.

For the conceptual principles, the first is that of digital etiquette which follows the idea that if a user is to like a technological product it should behave as if it is a likeable and supportive person (Cooper et al., 2014). The first principle from this is that *“The computer does the work, and the person does the thinking”* which means the computer should handle most of the access, analysis, organisation, and visualisation while any decisions arising from this are made by the person. The next is that *“If it’s worth it to the user to do it, it’s worth it to the application to remember it”* which means that once a person takes an action in the software, the software should be able to remember that the action was taken and act accordingly (Cooper et al., 2014).

Under the discussion of optimising for intermediaries the principle of *“Don’t weld on training wheels”* is presented which revolves around having the piece of software allow for use by absolute beginners in some way, but not only catering to them and allowing more experienced users to begin using the software instead of being forced to go through some on-boarding process (Cooper et al., 2014). In line with this is the principle, *“Imagine users as very intelligent but very busy”* where a general user’s time should be respected.

The next idea is that of flow with the first principle being, *“No matter how cool your interface is, less of it would be better”* which means that the interface should be designed in such a way that it does not cause interacting with the software as a whole

unpleasant and slow down the user (Cooper et al., 2014). Another aspect to consider with interaction design is that of the direct manipulation caused by a user. Therefore *“Rich visual feedback is the key to successful direct manipulation”* is needed to show the user clearly that their actions have a tangible effect within the software (Cooper et al., 2014).

The behavioural principles are mostly focused on how software should act in certain scenarios or on certain platforms. The first aspect under these deals with data entry and storage with the first principle being *“Save documents and settings automatically”* (Cooper et al., 2014) which in the context of a serious game may not seem applicable but the idea of handling certain aspects automatically is one that can be applied. Similarly, the principle of *“Put files where users can find them”* (Cooper et al., 2014) may not apply directly, but the concept can be applied to in-game objects.

In line with the previous section on information visualisation, the design principle of *“Visually distinguish elements that behave differently”* means that items on an interface should be distinct enough from others provided that the function is also different (Cooper et al., 2014).

The last category of principles, the interface level, describes effective strategies for the organisation, navigation, and communication of an interface (Cooper et al., 2014). Furthermore, these principles are the ones that are mostly platform specific as the interface of a piece of software will change, depending on if it is to be used on a desktop computer, mobile device, or the internet through a browser. *“Support both mouse and keyboard use for navigation and selection tasks”* is a desktop computer design principle, which could be applied to browser design as well, and is important as it covers users who may prefer using one or the other or both (Cooper et al., 2014).

With respect to the use of the mouse, users should be allowed to withdraw from a mistaken click as per the principle, *“Mouse-down over controls means proposing an action; mouse-up means committing to an action”* where the user can move the mouse away from an element to not execute the function associated with it (Cooper et al., 2014).

Another design principle that is platform independent is to *“Make errors impossible”* which means that if something does go wrong with the application it should not halt the process of using it (Cooper et al., 2014). In line with the behaviour of an

application is the principle of *“Users get humiliated when software tells them they failed”* which can directly be tied to the design principle of feedback where negative feedback is not favoured by a person (Cooper et al., 2014).

These principles target more specific aspects of design for an application and can be used in the context of a serious game with some minor alterations or applying the general idea behind a given principle.

2.7 Summary

In this chapter, the focus was on research needed to design the serious game effectively. The first section dealt with the information needed for the content of the game, as it is the topic it will address. Digital wellbeing was then defined as having three major aspects to it, namely physical health, mental health, and digital security. For each of these a few issues were discussed in the form of what it is and how a person can deal with or mitigate it. Furthermore, the rest of the chapter focuses on information to design the serious game itself. This included looking into the fields of pedagogy, ludology, gamification, and human-computer interaction. Each of these fields helps contribute in some way to the design of the serious game. Most notably are the design principles derived from studying other serious games and their development process which are supplemented by the information from the other aforementioned fields. The main design principles identified are narrative, feedback, simplicity, structuring, tailoring and rewards. While gamification and pedagogy directly bolstered these, the section on human-computer interaction presented some smaller principles to keep in mind when designing certain aspects of the serious game. Each of the main design principles are to be used in some form for the development of the serious game while the interaction design principles should provide for a better user experience, all of which will be discussed in the following chapter.

3 Development of the Serious Game

The development of the artefact will be discussed, detailing the stages and steps taken in the design and development of the serious game for this study.

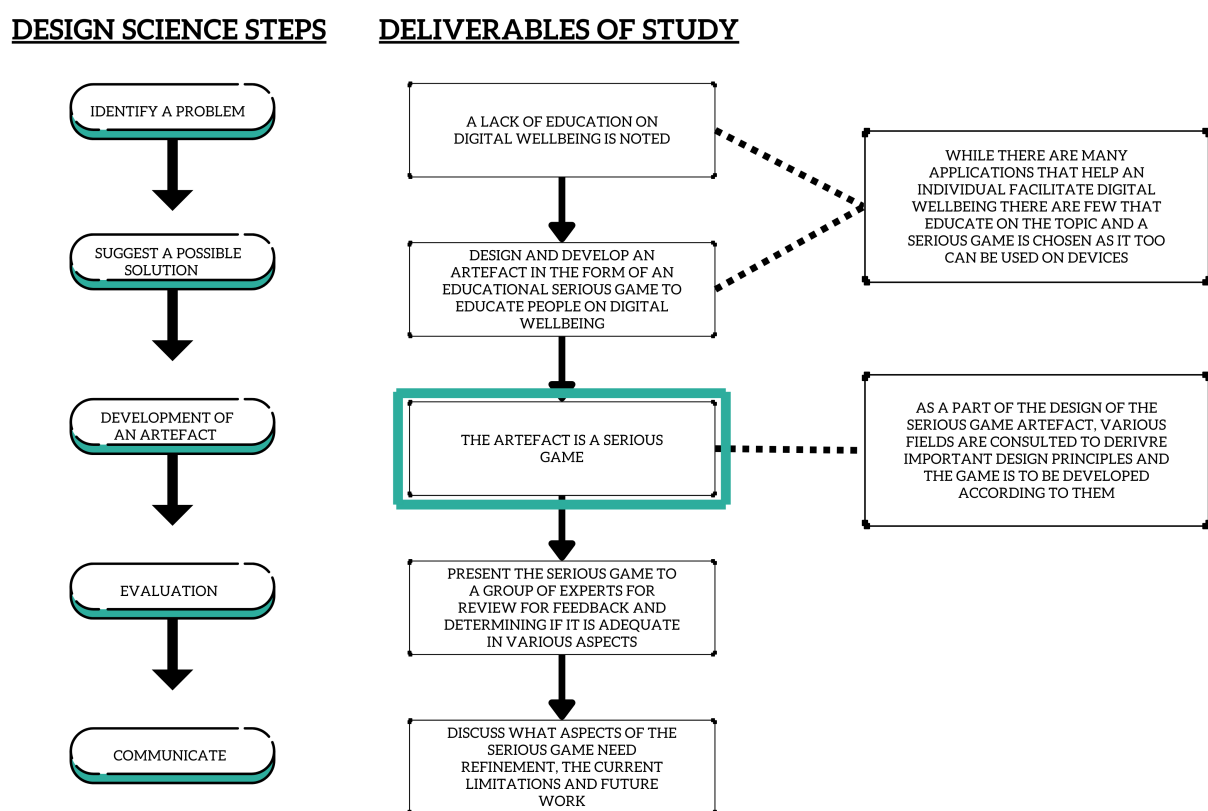


FIGURE 3.1: Research Methodology Process - Artefact Development Stage (Design and Development)

3.1 Terminology Relating to Games Development

As this chapter deals with specifics to game development, there are a few definitions that are presented in order to make reading the rest of the chapter easier to understand. The definitions for these terms are taken from the Godot documentation (Linietsky &

Manzur, 2024) and are specific to the Godot engine which was the tool used to develop the serious game.

- A **scene** can be used in two different contexts. The first deals with packaging an arrangement of nodes, scripts, and objects such that they can be placed in other scenes. The second relates to the latter use of the word previously and refers to the separate levels or menus present within a game.
- A **node** acts as the objects you use akin to “building blocks” and can be used for many things such as images, sounds or music, act as a camera, etc.
- A **script** is a file containing code that adds functionality of any node it is attached to and is typically written in GDScript which is the proprietary language used in Godot.
- A **collision object** is a node that is given a 2D or 3D geometric shape in the game environment and allows for interaction with other physics objects within a scene.
- A **raycast** is an entity that, when attached to another game object, emits a signal when it detects a collision with another object.

3.2 Design Phases

The following sections, 3.2.1 to 3.7.3, discuss the phases of all that was needed to design the game and these also fall under Step 3 of the research methodology.

3.2.1 Research

The first phase of designing the game was to accumulate a body of literature and to identify what design principles of importance. This was in the form of the literature review in Chapter 2 which examined the fields of ludology, gamification, and pedagogy, as they each contribute to finding potential principles that would fit into the design of the game. This also included analysing various other serious games and noting what principles or frameworks were used and discovering the most used. Additionally, research was done into the aspects digital wellbeing to aid in writing questions for the game.

3.2.2 Design Document

A game design document is a document that acts as the framework for what the game will entail and how it will be achieved. The contents of this document are what generated Sections 3.3 to 3.7.3.

3.3 Design Principles

This section draws from information discussed in Chapter 2, as well as Appendices C and D. The definition for each principle used is given in addition to some ways in which they can be incorporated and what features or mechanics are possibly needed.

3.3.1 Reflection

“Reflection is described as giving a user time after being presented with new knowledge or a task to garner a better understanding through internalisation.” (Esterhuizen et al., 2022, p.63)

In order to facilitate reflection as defined above, once a user is presented with new information pertaining to a topic under digital wellbeing there should be some form of “down time” in the game which can be simulated in the middle of a particular level as a somewhat lengthy walk to the next objective or a mini game between learning the information and needing to use it in a quiz.

The above considerations may lead to the need for the following to be implemented:

- Scrollable text on the screen,
- An animated camera where the player is locked out of (most) controls, and
- Being able to shift between scenes and levels.

3.3.2 Feedback

“A user should be presented with feedback on how they are progressing on a given set of tasks within the game. As they progress, the amount of feedback should be slowly diminished. The feedback amount should also be tied to the performance of the user - increasing if they begin to struggle and decreasing if not. Since feedback can take on many different forms, the type of

feedback, as well as the method of delivery, is dependent on the topic being taught. As part of this quality, a serious game should also be designed to create an environment in which users are able to complete smaller tasks and are rewarded for these smaller successes.” (Esterhuizen et al., 2022, p.63)

Due to the nature of the topic being dealt with, it may not be advisable to diminish the feedback presented, as it is meant as an educational experience, but users are not expected to learn in a similar manner to that of formal education. As such, the feedback provided should inform them of any mistakes made during a level and/or a score sheet at the end of a level in compliance with the “leaderboard” idea within gamification. Smaller successes can be accomplished through the gameplay itself, an example being that the user would have to successfully complete a platforming section in a given level.

The above considerations may lead to the need for the following to be implemented:

- Persistent scores of a given player,
- Some form of pop-up dialogue box system, and
- Tracking of player answers.

3.3.3 Story

“A game should then allow for a story to take place during the teaching of a topic. Another means to accomplish this is to make use of an agent that guides the user through the game.” (Esterhuizen et al., 2022, p.63)

From this definition, it is clear that a “guide” through the story is one way to urge the player along. Additionally, with the game intending to follow three aspects of digital wellbeing, it is likely there will not be an overall narrative, but instead multiple self-contained ones per each aspect.

The above considerations may lead to the need for the following to be implemented:

- A character dialogue system, and
- Intractable non-player characters.

3.3.4 Structuring

“A serious game should be structured with simple goals and clear expectations for the user and by structuring a game’s instructions in this manner the user will be motivated to continue playing and therefore learning. The problems and tasks within the game should be increasing in difficulty as a user gets them correct and lowering the difficulty when they are struggling to keep engagement once again with the game at a high level. As such, a serious game’s structure should be centred around the problems themselves or the knowledge being taught when dealing with affective knowledge and soft skills. The tasks given to a user should be both varied to keep the users’ attention as well as be consistent in the ways the user interacts with them.” (Esterhuizen et al., 2022, p.63)

This principle is by far the most involved in the design of the serious game, as it impacts the core idea of an education-based serious game. In terms of the difficulty, digital wellbeing is tricky to divide into easy versus difficult content. The most likely way to do this is by the answers to questions a user can provide and make multiple seemingly correct answers to a given question. As for the structuring of play and instruction, a user will be sent on a “quest” to gather information relating to a sub-topic of digital wellbeing and then have to answer questions based on that information. There could be set questions that have no variation from each play session, or a pool of questions can be set up for a given topic and chosen at random. Each “quiz” could include questions of varying difficulty, ranging from general knowledge ones to ones that the user must use the information presented and extrapolate the answer(s) from that.

The above considerations may lead to the need for the following to be implemented:

- Questions and answers for the “quizzes”,
- A database to hold questions and answers,
- A means to randomise game UI elements (change answer locations so that the correct ones are not always on the same button), and
- A means to randomly select questions for each play through of a level.

3.3.5 Tailoring

As described in Chapter 2, This deals with a user being able to tailor the game to their liking, be it through an avatar or how they play the game.

For the avatars, either a predetermined number of fixed avatars can be presented to the user, or a character creation screen could be utilised. In terms of how the game can be played, this could include a difficulty selection

The above considerations may lead to the need for the following to be implemented:

- A character selection/creation screen, and
- Management of global variables.

3.3.6 Features from Interaction Design

The principles discussed in Section 2.6.2 provided insight into the more general design of the game. The following implementations and considerations are presented:

- The game does not exit outright and instead presents the player with some form of error message,
- A system can be designed to identify when a player has taken a certain action in the game and have a response to it,
- Allow for players inexperienced with games a means to learn how it works while others can start playing immediately,
- Allow for a brief playtime especially on following play sessions,
- Have a simplistic consistent interface design,
- Have objects a player is looking for being distinct from the surroundings, and
- Controls should allow for multiple inputs for a single action.

3.4 Specification

Target group - This game is targeted to anyone wishing to learn more about digital wellbeing regardless of any other identifiers. There are, however, some limitations to this description, as a person must have access to a computer to play the game.

Genre - This game is classified as a serious game (additionally a serious game for health and behavioural change) under ludology and will fall into the main genre of education while other descriptors include a top-down, pixel graphics and narrative-driven.

Art style - This game will make use of a pixel art style with 2D graphical representation. Figure 3.2 below provides an example of the character art style.



FIGURE 3.2: Art example of a character

Forms of engagement - Players will be able to engage with this game in several ways. The main focus will be on the narrative experience provided as it relays the pertinent information of digital wellbeing. There will also be elements of challenge in the form of smaller challenges the player will have to face in order to progress in the game and further the story.

3.5 Gameplay and Game Setting

3.5.1 Story

The game will take users through various scenarios relating to aspects of digital wellbeing which include security, mental health, physical wellbeing, etc. The player will either be or encounter a specific non-player character who is struggling with a certain aspect of digital wellbeing on each level and then be tasked to gather information on that specific aspect.

The overall story, whether presented in-game or only in design, will be as follows. You are a student at a university. Lately, you and a few of your friends are having trouble with technology and how to interact with it. Luckily, you recently met DigiBot, a robot intent on developing good relationships with technology for humans. In order to gather information on digital wellbeing, DigiBot will take the player to certain areas within a digital world. Following the presentation of what the level will be about, DigiBot will appear and send the player off to go and collect more information.

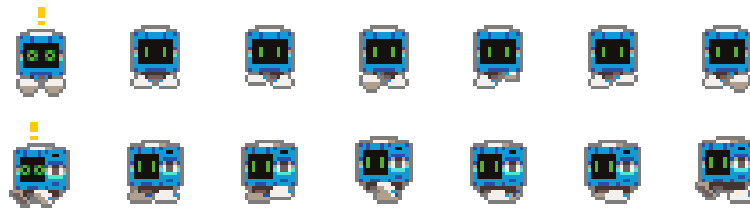


FIGURE 3.3: Partial Section of DigiBot's Sprite Sheet

Specifically, each level will have a narrative focused on the topic:

- Level 1:** The player will start the level after exiting either a class using computers or getting off their own computer after some time and complaining about sore eyes, back pain, etc.
- Level 2:** A friend complains to the player about feeling down after making use of some social media application that was full of news about some recent global and local events.
- Level 3:** The player will be presented with an assignment relating to security, specifically concerning phishing, malware, and password security.

3.5.2 World/Environment

The environment will be that of a university and surrounding areas, such as accommodation and local parks. The player will be able to move around a specific section of the campus or surrounding area in each scenario. Additionally, the player may move to different areas not connected to the campus in certain scenarios as a part of the narrative. Specifically, level 1 includes a room and an outdoors garden-like area, level 2 includes a local outdoors area and indoors of a large house, and level 3 includes a classroom and a technology-/digital-inspired room.

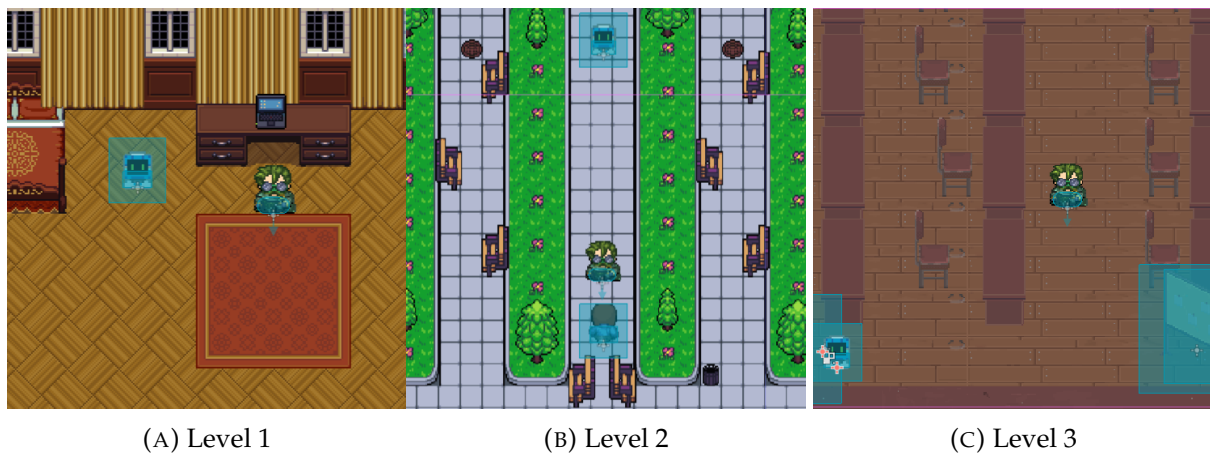


FIGURE 3.4: Starting Environment per Level

3.5.3 Characters in the Game

The game will include a few characters with the main ones being the player character and Digibot. Other than this, there may be other characters with whom the player can interact, such as a friend, or characters appearing in a mini game, such as enemies.

3.5.4 Main Objective and Core Mechanics

The objective of the game itself is to educate the player about digital wellbeing. Following this, there will be multiple objectives for each section of the game however, the overarching objective for the player is to gather some information relating to digital wellbeing for a reason required by the specific scenario.

The core mechanics of the game are fairly simple, as a player must travel around a set environment and gather information relating to some aspect of digital wellbeing. Once enough information is gathered, the player will be able to complete the level once they answers questions on the specific aspect for the level through some dialogue. During this final section on each level, the player will be presented with a question and have a selection of answers, based on the information gathered and must select the correct option. If the player selects a wrong answer, DigiBot will explain what is wrong with that answer and maybe hint towards the correct answer. Following this, the player will have completed that specific level.

The overall game loop flows as follows:

1. A player selects the level to play, based on the main concept with which it deals,
2. The narrative scenario is presented to the player,
3. The player will roam around a level and gather information pertaining to the scenario,
4. The player plays a mini game,
5. The player is presented with a quiz and tries to answer questions, based on the information gathered,
6. The player is given their performance on how they performed on the level, and
7. The player is taken back to the main menu where they can select another level.

3.5.5 Controls

The game will be playable on PC/Desktop computers.

The PC controls are as follows:

- The **W,S,A,D** or **Arrow** Keys for movement,
- **Left mouse click** for selecting options in dialogue and menus,
- The **E** key for interacting with characters,
- The **Esc** key for pausing the game, and
- The **Spacebar** for continuing dialogue or selecting a highlighted response option.

3.6 Front End

For each menu-related screen, the player can see a wireframe is presented in this section, as well as a brief explanation of the visual design.

3.6.1 Start Screen

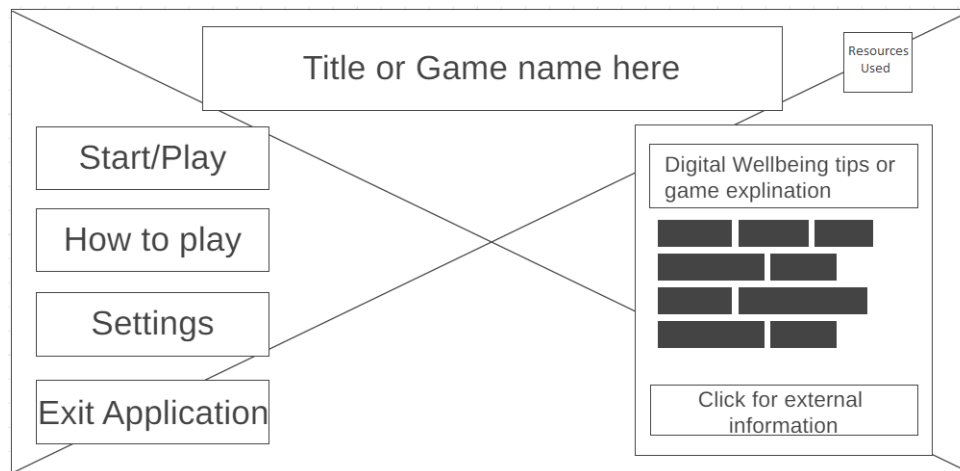


FIGURE 3.5: Title Screen Wireframe

This, or similar design, should work both on PC and mobile, as everything is large and clear; the only issue might be that of accessibility with the explanation section on the right where text might be too small for some users.

3.6.2 Menus

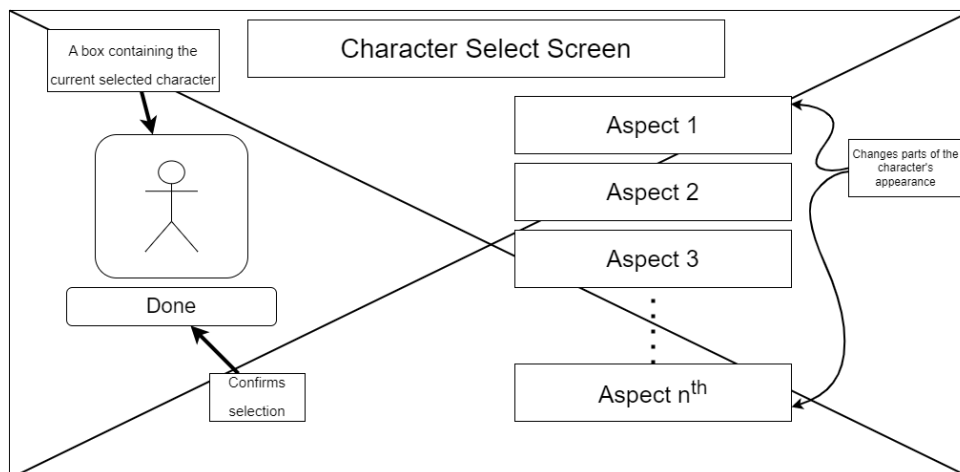


FIGURE 3.6: Character Selection Screen Wireframe

A player is able to cycle through options for their character representation with the buttons on the right, a visible representation on the left and a confirmation button below that.

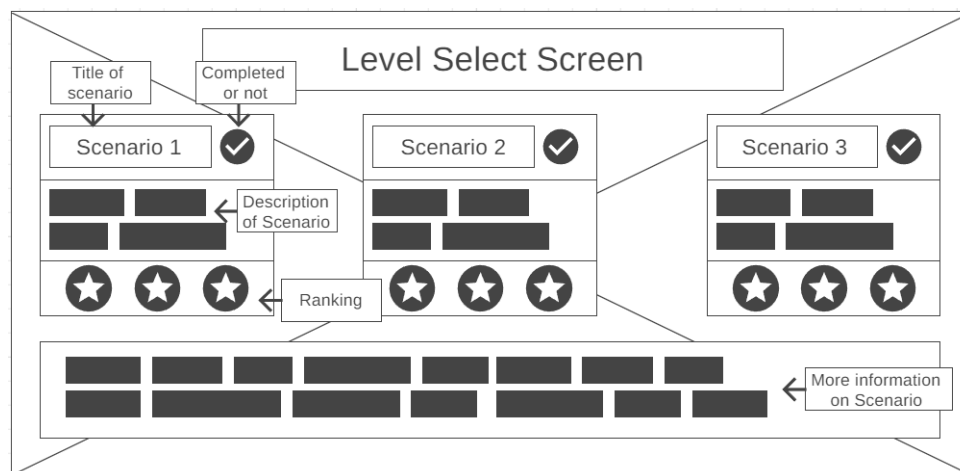


FIGURE 3.7: Level Selection Screen Wireframe

A player is able to select on which level they wish to play on this screen. Information is presented to the player on what each level entails as well as, if they have completed the level before, how well they did on a particular level.

3.6.3 Credits Screen

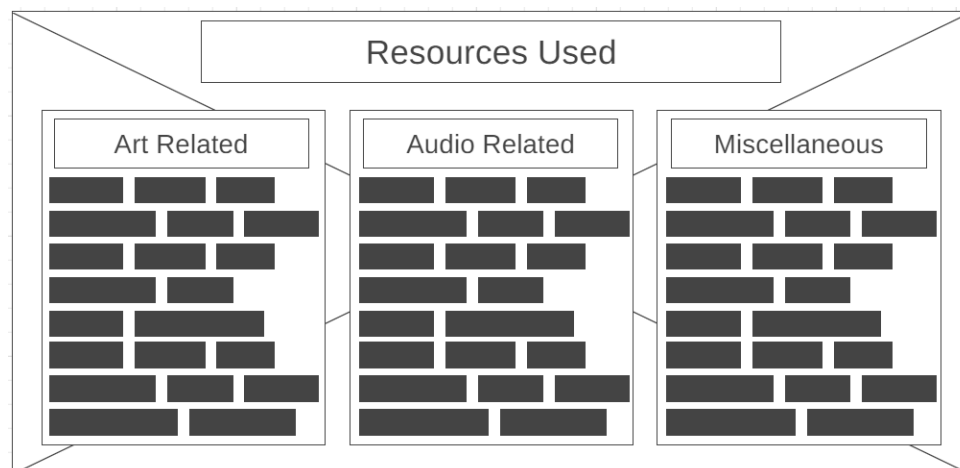


FIGURE 3.8: Resources Used Screen Wireframe

This screen is mostly for the legality of some game assets requiring attribution if used. While separating them into art, audio or other is one way to do it, this method may have one section be vastly longer than the others and could be changed to mix them all together as one.

3.7 Technology

3.7.1 Target Systems

This game is initially intended for play on PC/Desktops as a stand-alone executable and potentially in browser (albeit as a similar, but different package, as certain buttons or functions may not work in both, such as an “Exit Game” button not working in browser).

3.7.2 Hardware

No intensive hardware is required in terms of CPU and GPU specifications, as the game is a 2D game. An initial internet connection would be required to download the executable and a constant connection for the browser version. Additionally, some form of desktop system with a keyboard and mouse is needed.

3.7.3 Development Systems and Tools

The game is being developed with the Godot game engine (specifically Godot4). Source control is accomplished, using GitHub through the GitHub Desktop application. For the art tools used, most art and music will be acquired from opengameart.org or itch.io and in the instances where art does need to be generated and/or edited GIMP and Aseprite are to be used.

A third-party extension for Godot, Dialogue Manager, is used to streamline the creation of the dialogue system for the game. This extension allows for the dialogue to be written while within the engine in place of the typical use of .JSON files, as well as allowing a much easier and simple way to set up the quizzes and call functions from other scripts during dialogue.

3.8 Development Phases

Once enough of the design was completed, the development of the game began and went from a prototype to developing and testing individual features to finally creating the individual levels and mini games.

3.8.1 Learning the Godot Engine

Before beginning development on the artefact game, the first step was to learn how the engine functions and to develop a basic game to understand the basics. This was done briefly and resulted in a simplistic 2D platformer-type game.

3.8.2 Basic Prototype

The first aspect to the development process was to create an initial prototype that allowed for the basic and most used features, such as movement and collision to demonstrate and test what the bulk of the game would comprise.

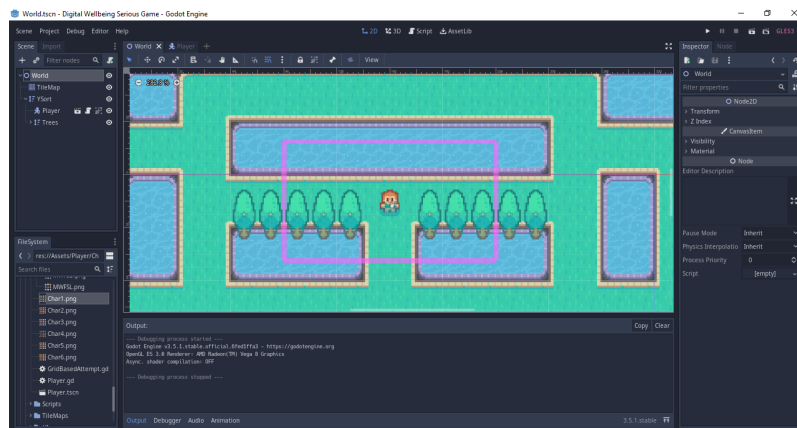


FIGURE 3.9: Initial Prototype

3.8.3 Scenes

Following the initial and basic prototype, the reusable scene for the player and other reoccurring characters are set up. This included compiling all necessary objects needed, such as a sprite for the art, a script to handle movement and interactions, a collision box so that the character has interaction with the in-game walls and boundaries and a raycast to determine when the player can interact with an object or non-player character in front of them.

Testing scenes were set up to test future mechanics, such as dialogue. This involves setting up only the necessary entities required for the testing. For example, with the dialogue it was only the player character and two non-player characters to interact with and nothing else. Figure 3.10 also demonstrates the most basic elements of setting up a scene (in the playable level sense).

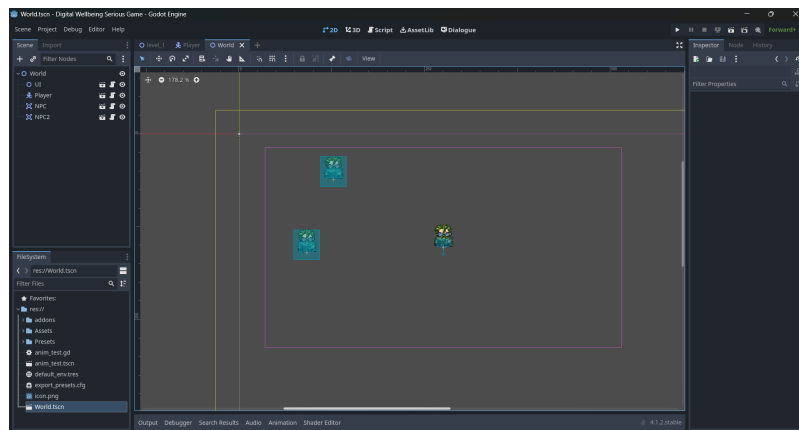


FIGURE 3.10: Basic Setup of a Level Scene

3.8.4 Dialogue

The next major aspect of the game to develop is the dialogue which was set up in a barren scene in order to only test the dialogue and non-player character interaction. The testing of the dialogue entailed setting up two characters with which to interact, both of which included responses, but one focused on setting up how the quizzes in the game would play out.

In addition to testing the general dialogue system with the scene shown in Figure 3.10 and 3.12, a rudimentary quiz system was also set up with a function to randomly select questions from a pool and present them with a random ordering of the answers.

As mentioned earlier under what technologies are used, the extension Dialogue Manager was a large proponent in setting up the quiz system, as it relies on reading text and responding. For this, there is a specific dialogue file per level containing all the questions, in addition to ones for each intractable character or object on a given level. Additionally, there are several functions that facilitate the randomness of the quizzes.

Firstly, there is a function to randomly pick several questions from the overall pool. This is done in two steps with the first one picking a random number from a list, as well as a random letter from another. The number represents the question while the letter is the position of the answer. This is done so that with each run-through of a quiz both the question as well as the answer layout is different.

The second step is done within the dialogue where, depending on the number and letter combination, the appropriate text is shown to the player. This had to be done through multiple *if* statements, as the version of the extension used did not have the function to point to a section of the dialogue based on a variable, as it needed to be hard set in the form “=> Q3d” for the text found in the section labelled the same to be displayed. Figure 3.11 illustrates this.

```
1 ~ questionSelection
2 if Global.qNum == 1
3 >| do Global.qAns = Global.setAnswer(1)
4 >| if Global.qAns == "a"
5 >| >| => Q1a
6 >| elif Global.qAns == "b"
7 >| >| => Q1b
8 >| elif Global.qAns == "c"
9 >| >| => Q1c
10 >| elif Global.qAns == "d"
11 >| >| => Q1d
12 >| else
13 >| >| => somethingIsWrong
14 elif Global.qNum == 2
```

FIGURE 3.11: Navigating to the appropriate question in the dialogue manager

With regard to the question and information content of the game, the information used is what is presented in Section 2.2.4. From this, the information a player will look for was generated and made simple to understand. Then a set of 15 questions per level was written with four possible answers for each. These questions are derived from the information on digital wellbeing in Section 2.2.4 and are intended, coupled with the player searching for information on a given level, to educate the player on a given aspect of digital wellbeing. These questions are presented in Appendix B.

Due to the constraints of the dialogue manager, setting up the questions in the required manner would result in four variations of each and as such a python script to take the question-and-answer combinations and output the needed variations with proper formatting was developed. Feedback is also given in the form of an explanation whenever a player selects the incorrect answer. This explanation goes over what the correct answer should be, as well as why the others are incorrect.



FIGURE 3.12: Testing Dialogue

3.8.5 User Interface

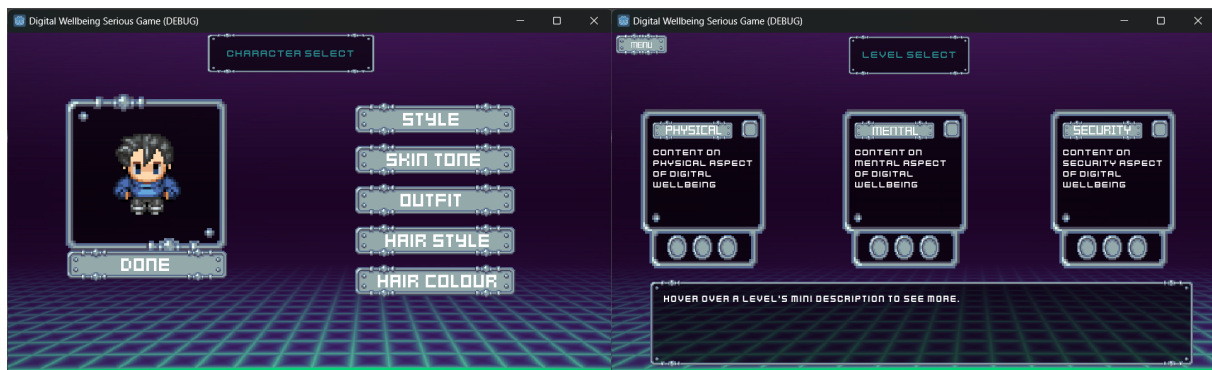
The following step was to take the wireframes created during the design phase and begin creating them in the game. During the set-up of some of the menu scenes, due to the visual assets chosen to be used, as well as screen size and font, the final outcome is different for some, most notably the credits scene, as shown from Figure 3.8 to 3.15 (A). On the main menu scene, the “External Information” button and intention (as in Figure 3.5) was changed to bring up a larger explanation of digital wellbeing as shown in Figure 3.13 (A) and (B).



(A) Main Menu Scene

(B) Main Menu More Information Pop-up

FIGURE 3.13: Final Main Menu

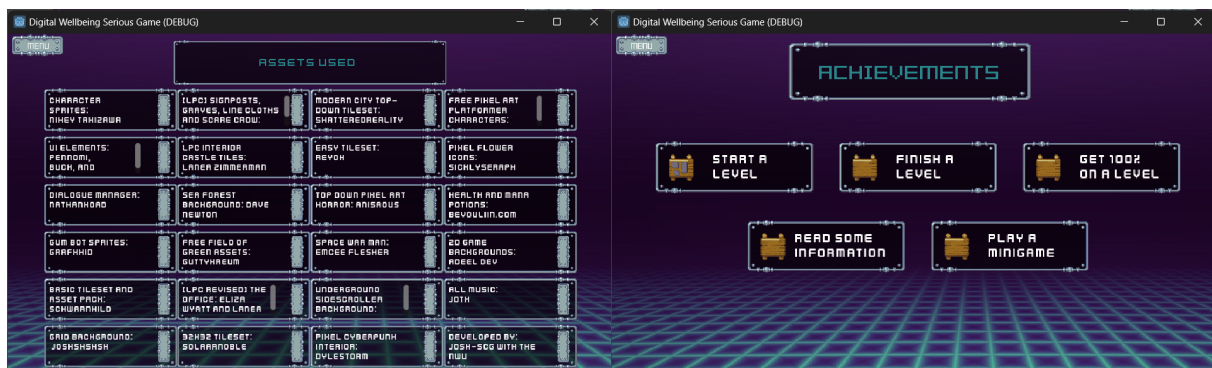


(A) Final Character Select Scene

(B) Final Level Select Scene

FIGURE 3.14: Player and Level Select Scenes

In addition to the menu screens that had wireframes, an achievement screen was also created, following information from gamification, as shown in Figure 3.15 (B).



(A) Final Credits Scene

(B) Final Achievements Scene

FIGURE 3.15: Credits and Achievements Scenes

3.8.6 Playable levels

For each of the three playable levels, as shown on the level select screen in Figure 3.14 (B), there are three main aspects. The first is the starting and ending scene which is the same environment visually, but with different dialogue and interactions. The starting one provides the player with information on the scenario, while the ending one is where the player answers the questions for the quiz.



FIGURE 3.16: Level Start Example (Level 2: Mental Health)

Following this, the player is taken to an open area where they are tasked with roaming around and reading information from objects in the environment which differ, based on the level. For each level there are five objects placed around the level for the player to find.

In level 1, which focuses on physical health, the object a player is looking for is a signpost. In level 2, which focuses on mental health, the object a player is looking for is a painting. In level 3, which focuses on security, the object a player is looking for is a cork board. Once a player has read each of these objects in a given level and has returned to the narrative guide, they are promoted to leave the level section.

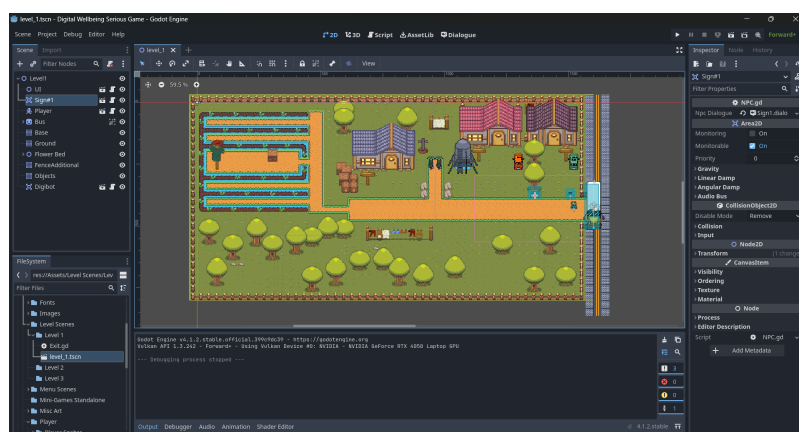


FIGURE 3.17: Roaming Level Example (Level 1: Physical Health)



FIGURE 3.18: Reading Information Example (Level 1: Physical Health)

3.8.7 Mini games

Each level has a mini game that is played after the player has completed the “roaming” section of the level. These mini games are unique to each level in that they are three distinct mini games.

For the physical health level, the mini game is in the form of an “endless runner” where the player is constantly moving to one direction and must collect a certain item, in this case a laptop, and avoid another, a sign. This mini game ends when the player hits a sign with the character.



FIGURE 3.19: Minigame for Level 1: Physical Health

For the mental health level, the mini game is in the form of a “matching” game where the player is tasked to match the coloured water to the corresponding flower and finishes the mini game when all flowers are grown to completion. When the incorrect water is matched to the wrong flower, the flower will wilt slightly.

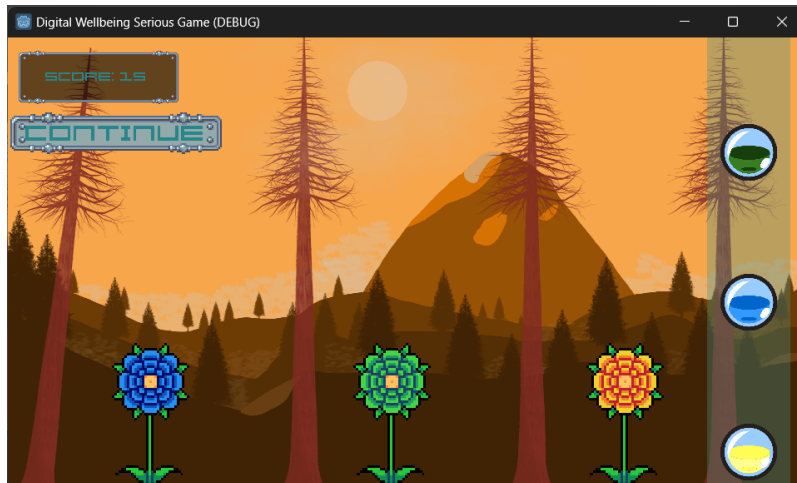


FIGURE 3.20: Minigame for Level 2: Mental Health

Lastly, for the security level, the mini game is a “top-down shooter” where the player is tasked to click on enemies in an attempt to protect certain walls. The mini game is completed when the player reaches a certain score.



FIGURE 3.21: Minigame for Level 3: Security

3.8.8 Exporting and Hosting

The Godot Engine allows for exporting a game to multiple platforms and as mentioned above, the game is exported as a stand-alone executable file that players can run on a Windows-based system. The game is also exported as an HTML5 playable version that the players can play directly in their browser from the same place they would download the executable. The files to run and play the game are being hosted on the web site itch.io where the aforementioned exported files are available. The source code and project files are hosted on repository. The game can be accessed online where it can either be downloaded or played in the browser¹.

To play the game in the browser, the “Run serious game” button can be clicked. To play the executable version of the game:

1. Click the “Download” button near the bottom of the web page,
2. Launch the executable file,
3. You may be presented with a “Windows protected your PC” pop up where you will need to click on “More info” and then “Run anyway”, as the file does not have a code signing certificate.

3.9 Navigating the Game from Launch to Completion

Once a player launches the game, be it through the downloadable executable or in the browser, they are presented with the main menu of the game.

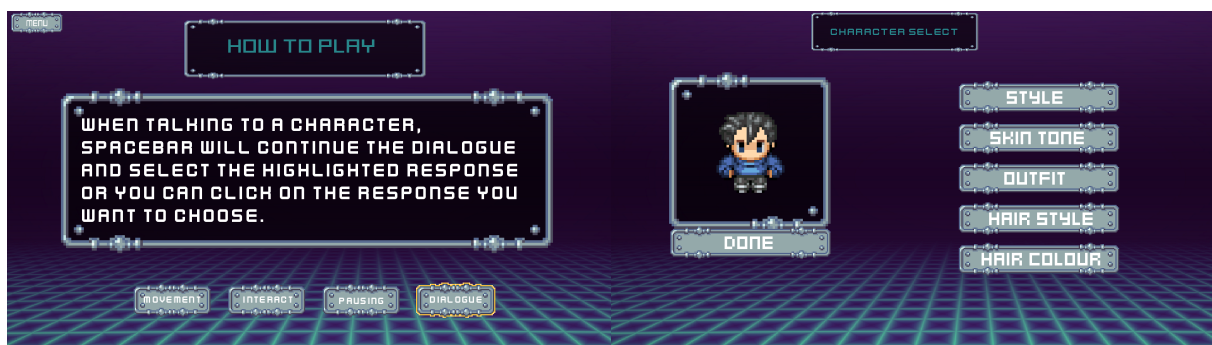
From the main menu, a player is able to navigate to other menus. These include a page to explain the controls, changing the appearance of the character, seeing what achievements there are and which ones they have, viewing a page listing all the resources used in the game, displaying a popup with an explanation of digital wellbeing as a whole and lastly, the screen to select what level to play. Figure 3.22 shows the menu of the HTML5 browser version, and it differs from the executable version, as it does not have the “Exit” button.

¹<https://josh-scg.itch.io/digital-wellbeing-serious-game>



FIGURE 3.22: Main Menu of the Game

The “How to Play” screen allows a player to learn the controls of the various systems in the game, while the “Character Select” screen allows them to customise the player’s character, both of which are shown in Figure 3.23.

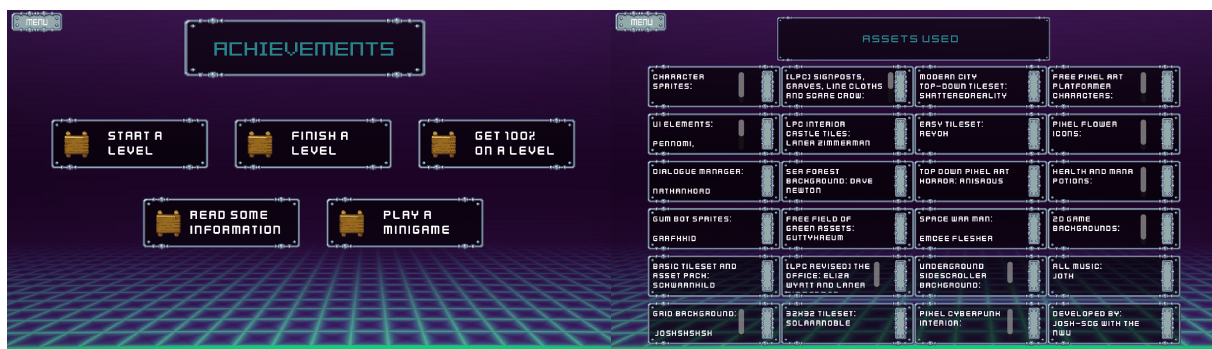


(A) The 'How to Play' Screen

(B) The 'Character Select' Screen

FIGURE 3.23: Menu Screens 1

The “Achievements” screen shows a player five different goals the player can work towards while playing the game and the “Resources Used” page lists all the art, music and other assets used to develop the game with a button on each to take the player to where they were acquired as shown in Figure 3.24.

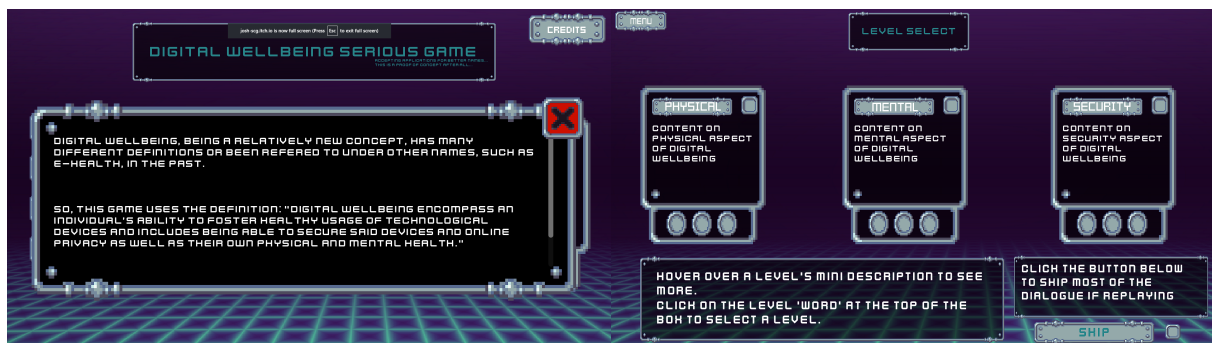


(A) The 'Achievements' Screen

(B) The 'Resources Used' Screen

FIGURE 3.24: Menu Screens 2

The “More Information” pop-up presents the player with the definition for digital wellbeing in general, while the level select screen allows the player to pick a level/scenario to play while hovering over each will show a brief description of the narrative as shown in Figure 3.25.



(A) The 'More Information' Pop-up

(B) The 'Level Select' Screen

FIGURE 3.25: Menu Screens 3

Once a player selects a level, the first thing that happens is that they are presented with the narrative in a given level. For the purpose of running through the game, the level on security is used in the figures below. As shown in Figure 3.26 the player is informed about a security class assignment they must complete.

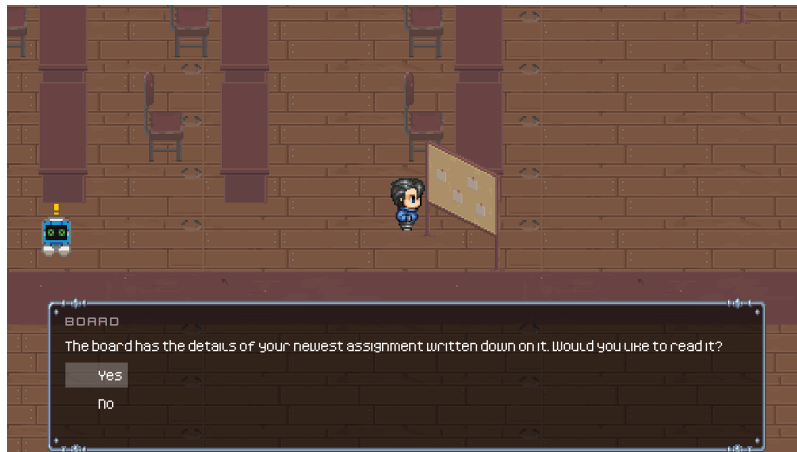


FIGURE 3.26: Introducing the Narrative

Following the introduction of the narrative of a given level, the player is taken to another area where they must gather information, based on the narrative. During this process, they must find five objects, such as the cork boards shown in Figure 3.27. During this process, the Digibot character will also give the player hints at where the objects could be on the level when interacted with.



FIGURE 3.27: Gathering the Information

Once the player has found all the objects and returns to Digibot, they are then tasked with playing a brief mini game. For the security level, as shown in Figure 3.28, the player must click on enemy characters to progress.

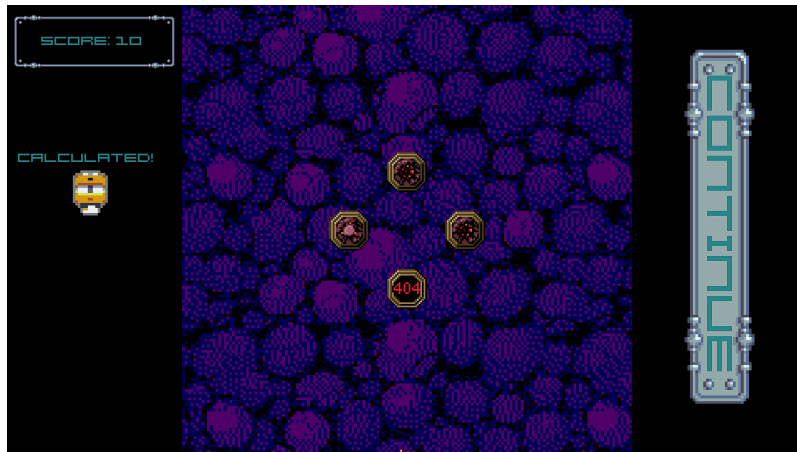


FIGURE 3.28: Playing a Minigame

After the mini game, the player must begin taking a quiz, based on the information for which they were previously looking. The quiz presents the player with 10 questions out of a pool of 15, each with four answers and must select the correct option. An example of a question is shown in Figure 3.29. Whenever the player gets a question wrong, feedback is given in the form of an explanation of what the answer should be or why the other answers were wrong.

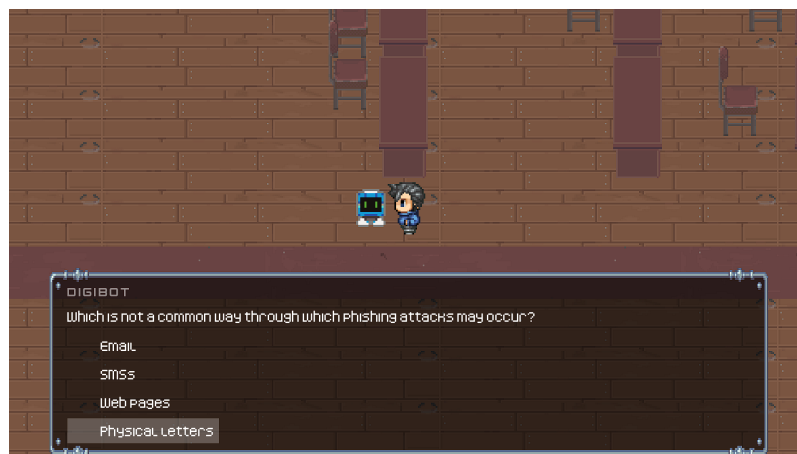


FIGURE 3.29: Taking the Quiz

Once the player completes the quiz or attempts it again for a second time when promoted, they are given feedback on how they performed in the form of their score out of 10 for the quiz and how many points they got in the mini game.

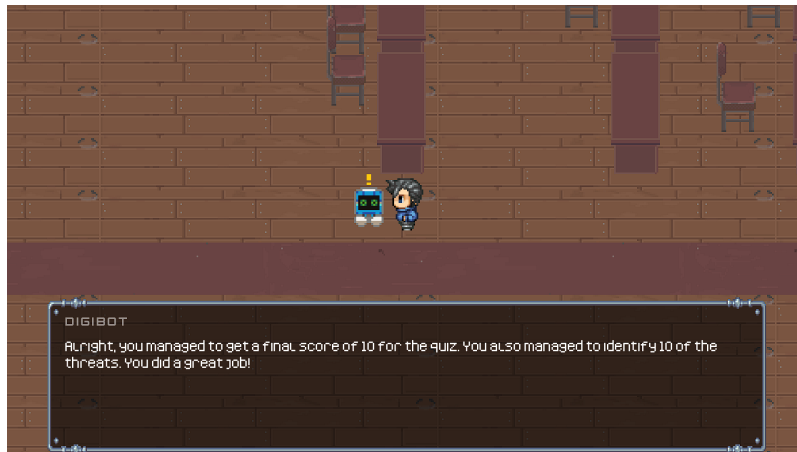


FIGURE 3.30: Getting End-of-Level Feedback

Now that the player has completed a level, they are taken back to the main menu and can follow the process again for a different level or exit the game. Additionally, the achievement screen would have updated if the player has achieved the mentioned task. On the level select screen, the box for the level would have updated with a check mark showing they have played the level to completion and the circles underneath would fill, based on their quiz performance. For example, Figure 3.31 shows how this would look if a player got 10/10 on the quiz.



FIGURE 3.31: Level Select Changing to Match Player Performance

Additionally, in between this process while the player is in a level, they are able to pause the game, stopping the processes, as well as giving them an option to return to the main menu. This screen is shown in Figure 3.32.

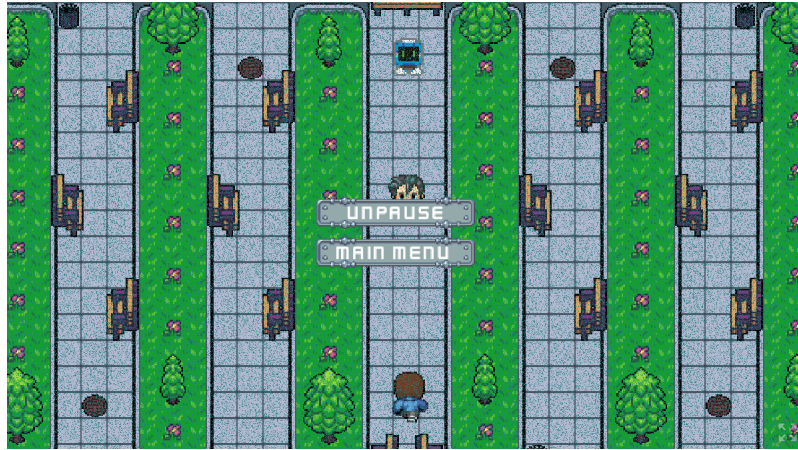


FIGURE 3.32: Pausing the game

3.10 Summary

The artefact as a part of this study is an educational serious game. It was designed with information from various academic fields and developed in Godot 4. The final result is one that had three distinct levels with each focusing on a different aspect of the definition for digital wellbeing described in this study. Each level consisted of an introduction section which led into an area where the player searches for information on the topic. Following this, the player then plays a mini game before taking a quiz, based on the information which is the end of the level.

4 Evaluation

The results of, and setup for, an expert review of the artefact are discussed.

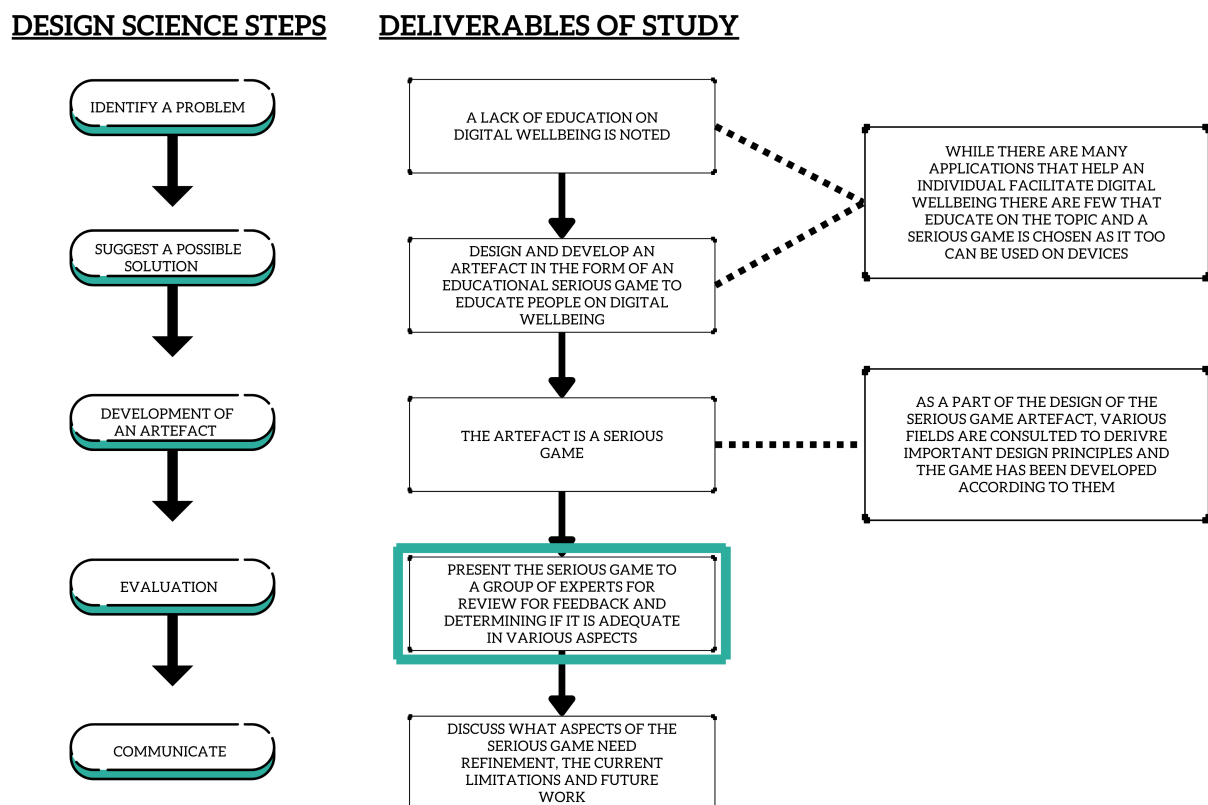


FIGURE 4.1: Research Methodology Process - Evaluation Stage

4.1 Expert Review Setup

The expert review for this study makes use of a questionnaire-based methodology to collect feedback from various experts. This is in the form of a Google Form where an expert will first read the informed consent form, play the game, and then provide feedback through several questions. The questionnaire used is attached as Appendix A.

The questions within the survey mainly make use of a Likert scale from 1 to 5 with each end having some form of descriptor. For example:

How did you find the game controls? Were the controls intuitive?

1 - Frustrating to use, 5 - Easy to use

Certain questions are presented where each expert is able to provide feedback specific to their respective field. These questions are presented in an open-ended manner due to the various fields from which an expert could come. For example:

How did you find the flow and structure of the game? Would you prefer a different approach? (i.e. Level select > scenario > information gathering > minigame > quiz)

As this game is designed with principles discussed in Chapters 2 and 3, the questions for the questionnaire are centred on identifying if the game is effective in those areas.

Two studies focusing on heuristic evaluation are referenced. The first of these is the Playability Heuristics Evaluation for Educational Computer Game (PHEG) which discusses the usability of an educational game through five categories which are interface, educational, content, playability, and multimedia (Mohamed & Jaafar, 2010). Each of these categories has between seven and ten heuristics and, taking into account the design principles used for the game, questions based on the heuristics were written. For instance, "CO2: Clear and understandable structure of contents" was used to develop the question "Was dealing with the game simple?".

The other is the Heuristic Evaluation for Educational Games (HEEG) which divides heuristics into four categories, namely gameplay, enjoyment, usability and game mechanics, and educational design (Barbosa et al., 2015). Each of the heuristics in these categories has a criterion for assessment and it is from these that certain questions are drawn. For example, the "Game controls are consistent within the game and follow standard conventions" criterion led to the question asking "How did you find the game controls? Were the controls intuitive?"

As these two heuristic evaluation studies are used to set out questions most of the questions focus on specific aspects of the game in a user experience level in place of actively criticising the content of the game. Regardless, experts included are asked if what they played is suitable to educate others on the basics of their respective field.

For the expert review, requests for participation were primarily sent out to people who are either involved in academia linked to a certain aspect of the game or people who are working in an industry related to aspects of the game. The latter included educators, game developers or security analysts for example. Additionally, information about the reviewer is limited to what their specific field of expertise is and what section(s) of the game was played.

4.2 Feedback on the Serious Game

For the expert review, there were a total of eight responses. While more responses would be beneficial for further feedback the feedback provided by the respondents covered all aspects of the game with varied feedback. Table 4.1 provides a breakdown of the reviewers' knowledge and what levels were played. The former two will add up to more than the total number of reviewers as the reviewers were able to select multiple options for them. An option to add their own area of knowledge was made available and two of the reviewers made use of it resulting, in addition to the prescribed fields, the inclusion of "Development" and "Cybersecurity".

TABLE 4.1: Reviewer Information

Aspect	Number of Reviewers
Reviewer expertise knowledge	
Research/Academia	4
Game Design/Development	1
Education/Teaching	1
Digital security	3
Cybersecurity	1
Development	1
Levels played	
Physical	6
Mental	5
Security	7

In addition, each reviewer was also asked about their experience with playing games and the average response, on a linear scale from 1 to 5, was a score of 4,125 which

means most of the reviewers have moderate experience with playing games, as the lowest score given was a 3. While collecting this information may not directly contribute to the results of the expert review, it does provide critical context to some of the elaborations provided. For example, a reviewer who responds with having little experience with playing games and that the controls were intuitive for them shows that the controls are friendly to anyone who would play the game.

The reviewers were also asked about their prior knowledge concerning digital wellbeing and all but one reviewer was aware of the concept. Furthermore, when asked how much more knowledgeable they felt after the game, the scores ranged from 3 to 5 with a mean and mode of 4.

With regard to the scoring questions, Table 4.2 shows the results from the questionnaire. The questions are rated on a linear scale from 1 to 5. With most questions, a higher score indicates a more positive answer. For example, with the question of how easy it was to interact with the other characters, a 5 would mean it was very easy and a 1 would indicate it was difficult.

TABLE 4.2: Expert Review Scores

Question Topic	Average Score	Range
User interface satisfaction	4,625	4-5
Game controls usability	4,75	4-5
Ease of character movement	4,75	4-5
Ease of dialogue and interaction	4,5	4-5
Game simplicity	4,875	4-5
Narrative helping with engagement	4,375	3-5
Narrative agent helping with engagement	4,375	2-5
Different setting detraction	4,5	3-5
Character customisation influence enjoyment	2,375	1-5
Achievement motivation	4,25	3-5
Satisfaction with question difficulty	3,875	2-5
Quiz feedback helpfulness	4,5	3-5
Time between learning and quiz helpfulness	3,75 ¹	1-5
Overall fun of game	4,625	3-5
Game usable for introduction of digital wellbeing	4,75	4-5

These scores indicate that the serious game is a success as most of the numerical feedback is positive. The only areas that seemingly have issues is that of the *character customisation and question difficulty*, where the former is lower than 3 and the latter is the second worst performing area with a score under 4, while still slightly positive. Taking the ranges into account, it seems that the inclusion of the *narrative agent, character customisation, question difficulty, and time between learning and the quiz* were varied depending on the reviewer. With respect to the literature, the narrative agent and customisation were already noted to have mixed results, which is also demonstrated here.

The questions were designed to receive feedback on the effective implementation of certain design principles, based on certain aspects of the game in the form of both a numerical rating and allowing for comment on the score provided. Tables 4.3 through 4.13 provides some comments from the reviewers from the open-ended questions and some interpretations taken from them.

TABLE 4.3: User Interface Comments

Reviewer	Reviewer Comment	Interpretation and Understanding
2	<i>“Very easy [to] understand and know what is expected of me when playing the game. Music was amazing!”</i>	This highlights the principle of simplicity was implemented adequately.
5	<i>“The visuals and audio were engaging.”</i>	While not a major principle, keeping the audio and visual aspects similar arrives from the information visualisation discussion.
8	<i>“I thought it was good. The font within gameplay was just a bit off. I also got annoyed by the beeping sound as the words were laid out.”</i>	The font, as depicted in various figures, is a pixel-based font and was mentioned by this reviewer as well as reviewer 7 as an issue.

¹This value has been reversed to match with the others for comparison as for this question a 1 would indicate a higher approval from the reviewer.

TABLE 4.4: Controls Comments

Reviewer	Reviewer Comment	Interpretation and Understanding
1	<i>"The controls are easy to use since when you hover over a control you can see that you are on it."</i>	This was from one of the interaction design principles and is seen as a positive inclusion.
3	<i>"I sometimes like skipping dialogue but this is not necessarily a good thing in game design in my opinion."</i>	This feature was implemented so reviewers could save time on a subsequent play-through but for the purpose of the review its purpose could have been made clearer.
7	<i>"I knew exactly what controls to use as I have played other games before but it would be useful to display the controls when you start the game or as a first challenge for individuals who have never played games before and know to check the menu."</i>	The controls are well suited to someone with experience with games but, as this comment suggests, it could be made more beginner friendly.

TABLE 4.5: Simplicity Comments

Reviewer	Reviewer Comment	Interpretation and Understanding
2	<i>"Never wondered what I should do in a level. Nicely Done."</i>	Each of these comments highlight the effectiveness of the simple instructions and explanations given on what they are meant to do at various points of the game.
5	<i>"Explanations were clear and concise."</i>	
7	<i>"I had fun and it was not complicated to follow along and just enjoy the experience, there was no overload of information at any point."</i>	

TABLE 4.6: Narrative Comments

Reviewer	Reviewer Comment	Interpretation and Understanding
1	<i>"It did not affect since it actually makes me a learner and I am learning something from it."</i>	This shows it is possible for a game to overcome the drawback of a differing setting from the player's.
5	<i>"The inclusion of a narrative assists in understanding why something is being done, as well as helps when a user is stuck."</i>	The narrative then seems to aid in the learning process.
7	<i>"Yes he [Digibot] did add the element of not being alone in the world and having a side kick to guide me through."</i>	The narrative agent means of implementation is viable.

TABLE 4.7: Customisation Comments

Reviewer	Reviewer Comment	Interpretation and Understanding
6	<i>"Different characters don't perform differently hence no effect."</i>	This reviewer found no impact from the customisation and was looking for gameplay effects.
7	<i>"I enjoyed creating my own character and did this before I even played so it got me hooked for just a bit longer, I appreciated the little details that were added!"</i>	This reviewer did find the inclusion beneficial, which as per the previous comment, highlights the split in views on such a feature.

TABLE 4.8: Achievements Comments

Reviewer	Reviewer Comment	Interpretation and Understanding
5	<i>"The inclusion of a score and the option to better that score made it feel like a competition between myself and the highest score."</i>	While competition is not used in the game, providing elements from it can bring about intrinsic motivation.
6	<i>"Basic psychology makes achievement based games more motivational."</i>	The inclusion of achievements provides intrinsic motivation in the player.

TABLE 4.9: Quiz Comments

Reviewer	Reviewer Comment	Interpretation and Understanding
3	<i>"Depending on the target audience some questions can be harder."</i>	Depending on the target audience, a serious game can involve more complex topics.
6	<i>"Good to know where or why you went wrong"</i>	Providing feedback on where a player went wrong has been received positively.
7	<i>"Not always do we know everything and an explanation really helps turn a failure into something lasting."</i>	

TABLE 4.10: Fun Comments

Reviewer	Reviewer Comment	Interpretation and Understanding
5	<i>"The game made learning topics enjoyable, and the overall experience was good."</i>	Fun is subjective to each individual and from these comments and the scores, the game is fun and enjoyable but might still not be for others.
7	<i>'It was relaxing and easy to play with a couple of laughs at the dialogue and game play of the game.'</i>	

Another aspect the reviewers were asked about was the over structure of the game (i.e. moving from menu to the gameplay to mini game to quiz) and specifically about the mini game between gathering the information on a given level and the quiz:

TABLE 4.11: Gameplay Structure Comments

Reviewer	Reviewer Comment	Interpretation and Understanding
1	<i>“The structure is good, the mini game gives you a reading break and clears your mind a bit before the quiz.”</i>	Providing time to internalise the information, from reflection principle, is positively received in its implementation.
7	<i>“The topics were clearly explained and easy enough to stick even with a break in-between and no prior knowledge that there was a quiz at the end. The relaxed nature of the game also gives a sense that it is for fun and is okay to not know everything but gives a chance to improve and learn with explanations.”</i>	This reviewer highlights how the overall flow adds to the enjoyment of the game and the implementation of the reflection and feedback principles aided this.

TABLE 4.12: Potential Improvements Comments

Reviewer	Reviewer Comment	Interpretation and Understanding
3	<i>“Other minigames during the information gathering could be fun.”</i>	More interactivity during sections can help keep engagement.
6	<i>“Game can be expanded based on a person’s prior knowledge, like integrating questionnaire of sorts prior to starting.”</i>	Increasing the difficulty is an aspect of the structuring principle and could be considered.
7	<i>“As the game goes on it could be fun to add more to the knowledge already learned by giving more insightful knowledge hence having old and new information built on as time passes.”</i>	Basing the questions and information from a players prior knowledge is a concept under Merrill’s First Principles and the structuring principle.

Regarding if the reviewers thought the game as it is can be a viable means to introduce people to the topic of digital wellbeing:

TABLE 4.13: Introductory Viability Comments

Reviewer	Reviewer Comment	Interpretation and Understanding
5	<i>“The game would serve as an easy solution or order for people to gain entry level knowledge into various concepts.”</i>	This reviewer speaks to the effectiveness of the serious game for education on basic concepts.
7	<i>“The reason I would highly recommend this as a viable means to introduce people to the topic of digital wellbeing is that it was accessible through the browser and simple for anyone to pick up in a few minutes and thus distribute to anyone with a simple link who could benefit from the information.”</i>	The game being easy to access allows it to be easily distributed to anyone allowing for people to recommend it to others.

Reviewers were also asked if they felt the game was able to fulfil its set goals respective to their area of knowledge as an optional question. One comment regarding this was that *“The game achieved its goal and in my opinion was enough to teach but not get too technical as it can be when dealing with Security topics.”* which illustrates that the serious game’s content, specifically the security-based information, is ideal for an individuals beginning to encounter these topics.

Lastly, there was an option to provide open feedback if a concern a reviewer had was not addressed in the questionnaire or they wanted to provide any other comments they may have had. From this, two notable answers were provided:

Reviewer 1: *“This game is very engaging since it offers instructions from the main menu screen and gives a definition of digital wellbeing from the start. The game makes it easier to find the signs since they flash and fade when you are done reading them. The game is easy to navigate since it also shows you the levels you have already played. It could be better if Digibot specifies from the start how many signs need to be read. Overall the mini-games are fun and*

very interesting but we could benefit if there are replay buttons and instructions when it comes to winning (i.e. If the score reaches 10, you win). Finally, the game is fun and easy to play. You gain insightful information in a enjoyable way."

This comment provides three points of discussion. Firstly, the method in which the instructions were implemented are satisfactory but needs to be clearer in certain areas, such as with the mini games or directly stating how many items are to be found. Secondly, the visual cues for the objects, as per one of the interaction design principles, is an effective implementation. Lastly, while the game is fun to play the option to replay the mini games on their own could be something to consider.

Reviewer 7: *"The industry really needs solutions like this to cement topics and ways of thinking as we are relying on technology more and more without guidance most times of how to conduct ourselves. As someone who works in the Cyber security industry I see it way too often that the basics are not followed."*

From this comment it is apparent that, even though the current serious game implementation is most suited to beginners or individuals with little experience on a topic, it can be targeted towards individuals that already have a high-level understanding of a topic as a means to re-learn the fundamentals.

These comments and the overall scores demonstrate that the game is sufficiently effective in its aim of acting as a learning tool. However, there are some aspects of the game that need improvement.

4.2.1 Current Limitations of the Game

While the game reviewed was mostly positive, some reviewers provided feedback that highlighted issues with the current implementation.

The first of these is certain aspects of the user experience. Two of the reviewers mentioned that the font was difficult to read and sometimes caused issues with identifying the correct answer for a question, as some questions are dependent on specific characters, numbers, or letters, such as with the one asking about picking a password.

Additionally, the inclusion of a sound that plays as the dialogue text is displayed can be seen as annoying. Another issue is with the explanation of controls because while it is available under a screen accessed from the main menu, some players might miss this, as they are new to playing games and simply might not access that menu.

The option to skip the dialogue was also brought up as a potential issue, as players might miss context needed to understand what is required of them. However, as mentioned above, this feature was intended so that reviewers could save time on a subsequent play-through and as such should be removed if the serious game is developed further.

The aspect of customising the character which falls under the personalisation or tailoring of the experience received a mixed response which does fall in line with its implementation under gamification, where certain player types did not feel as engaged due to it.

The instructions could also be clearer, as one reviewer mentioned that it would be helpful if the number of signs that needed to be found was explicitly stated and that the instructions on winning the mini games were made clearer.

4.3 Summary

The expert review takes the form of a questionnaire which consisted of questions derived from heuristic evaluation frameworks with a focus on the design principles of the serious game developed. It was sent out to various potential experts and the feedback and comments they provided illustrate that the game as a whole is sufficiently successful with respect to being an educational tool.

However, there are some issues with the current implementation most notably with regards to explaining clearly what is expected of a player if they have minimal experience with playing games.

5 Reflection

A discussion on all outcomes of this study is provided. This includes the serious game artefact that has been developed, and any articles written throughout the study.

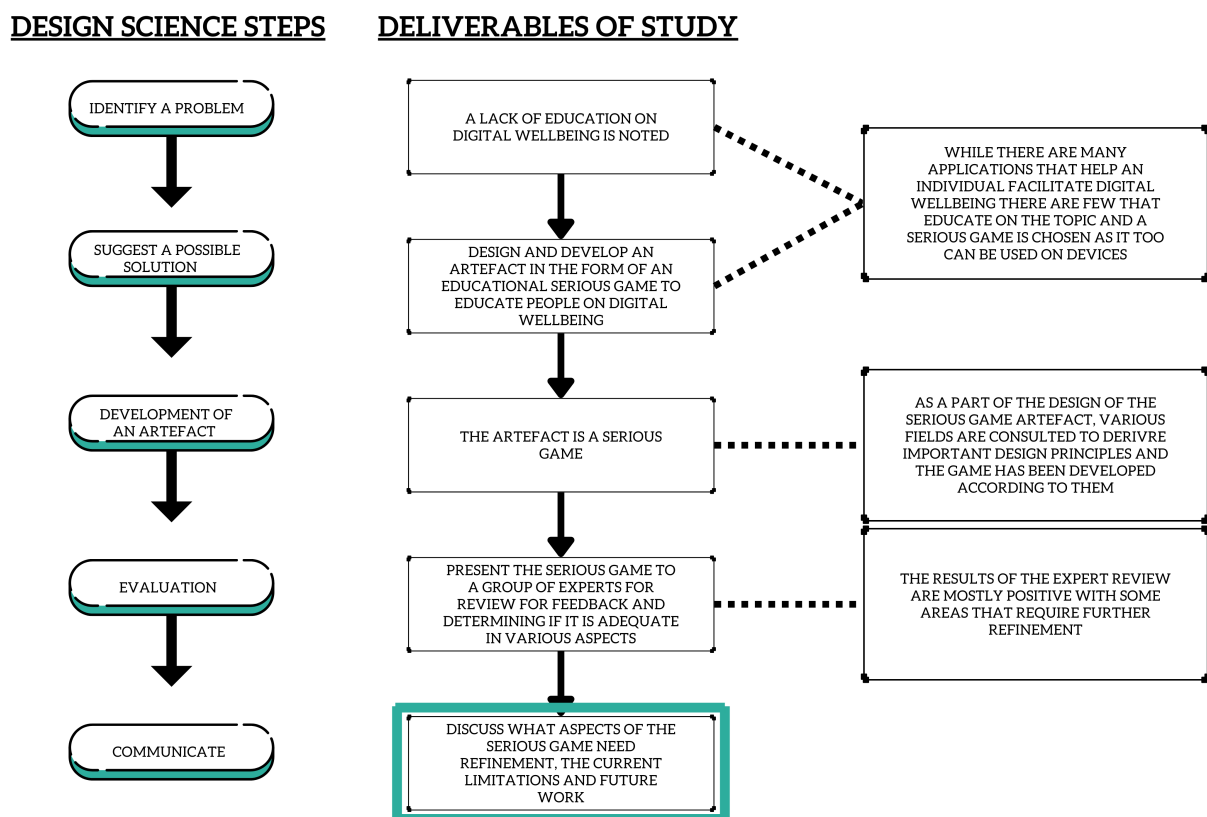


FIGURE 5.1: Research Methodology Process - Communication Stage

5.1 Articles

As a part of this study, two academic articles were published. The research that went into these articles is based on aspects of this study and as such, some of the information is within Chapter 2.

5.1.1 CELDA 2022

The first article, attached as Appendix C, was presented virtually at the 19th International Conference on Cognition and Exploratory Learning in the Digital Age which took place in Lisbon, Portugal during November of 2022. The article is titled “Linking gamification, ludology and pedagogy: Principles to design a serious game” and aims to detail design principles that could be used when designing a serious game (Esterhuizen et al., 2022). These principles were generated from the fields of ludology, pedagogy, and gamification, as well as the design process of several serious games.

5.1.2 ICERI 2023

The second article, attached as Appendix D, was virtually presented through a video recording at the 16th Annual International Conference of Education, Research and Innovation which took place in Seville, Spain during July of 2023. The article is titled “Design choices among recent security-related serious games” and collected 22 serious games to analyse and found the overlapping design choices made by developers and explained the most common of these (Esterhuizen et al., 2023).

5.2 Serious Game Artefact

The serious game formed the artefact of this dissertation and how it was designed and developed, in addition to how a player will interact with it is discussed in Chapter 3. From the expert review, it is apparent that it is mostly successful in achieving the aim of educating people on digital wellbeing with albeit with some shortcomings and recommendations on how it could be improved is discussed in the following section.

5.3 Recommendations based on Expert Review Feedback

As mentioned in the previous chapter, the serious game does have some issues that can be addressed in future iterations. In addition to this, there are also other recommendations provided through the expert review.

The issues regarding the user experience ranged from the font used to providing clearer instructions. The first change that can then be implemented is to identify a

font better suited for use in the dialogue boxes. This would require a font that is easy to read and allows for a clear distinction between certain characters. With regard to the audio played during dialogue being printed on screen, only one reviewer made mention of it, hence it should either be changed or removed, as it can be seen as “annoying” and can detract from either enjoyment or the learning process.

The controls were found to be intuitive for people familiar with gaming and should be suitable for people with minimal experience with gaming as well. However, as the explanation of the controls is not required before playing the game, there could be a means to show when a player can press a key to interact with something, for example having a depiction of the “E” key above the player character’s head when they can interact with something or having the movement keys appear briefly at the start of the level to show which keys cause which movement.

Regarding the current instructions presented at various points in the game during each mini game, the player is presented with text explaining what to do for the mini game, but the “win condition” is explained in the previous scene by a character and as such, this could be moved to the mini game scene as well so that it ensures a player will take notice of it.

Another recommendation was to include more mini games during the sections where the player is looking for information. Including this would prove beneficial to maintain engagement with the game; however, they would need to be smaller in scope than the ones already included, as it would need to be contained within the section. This then could result in introducing more engaging gameplay during these sections, for example, as the reviewer mentioned, having “*random malware attacks*” where the player might have to avoid them.

Lastly, three of the reviewers who marked digital security and development as their area of expertise mentioned that the content of the game could be expanded upon with more in-depth concepts being presented, either based on a player’s prior experience or as the game progressed.

5.4 Summary

On the practical side of this study, an artefact in the form of an educational serious game was developed which focuses on the topic of digital wellbeing. Stemming from the expert review as a part of the evaluation of the serious game came recommendations on how it could be improved. Furthermore, during the research phase of this study, two academic articles were published, with one focusing on making use of other academic fields to develop design principles needed for a serious game and the other analysing various serious game implementations to identify the most commonly used design principles and frameworks.

6 Conclusion

In this chapter, a summary is provided of what the study has accomplished alongside a reflection of the choices made and potential future work.

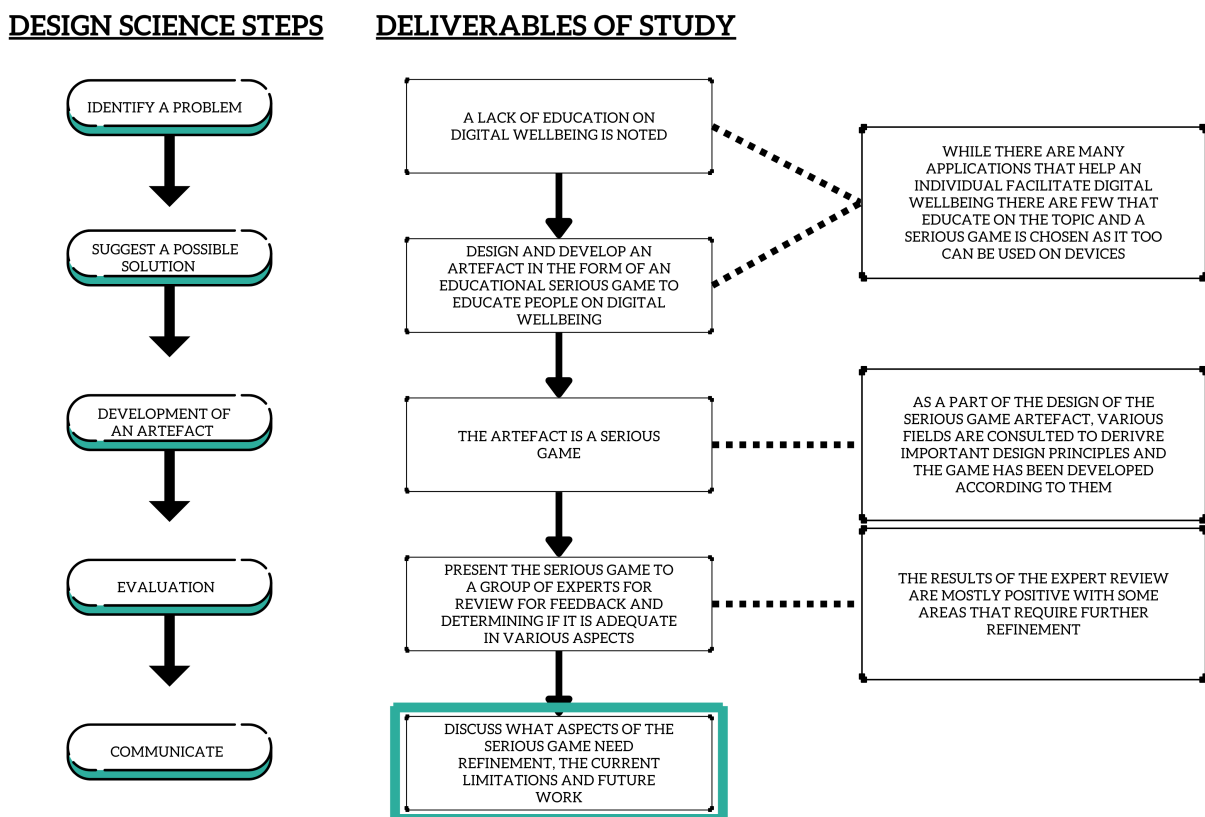


FIGURE 6.1: Research Methodology Process - Communication Stage

6.1 Study Overview

The purpose of this study was to design and develop a serious game to educate users on the topic of digital wellbeing. In support of this, a literature study was done to identify design principles and content for the game. These principles and content were then used in the development of a desktop- and browser-based serious game.

The game was sent to experts in various fields to provide feedback and evaluate the game in the form of a questionnaire designed from heuristic evaluation frameworks.

In Chapter 1, the background for the study was presented which included the problem statement, research objectives and questions and design of the study. In Chapter 2, the focus was on research into multiple fields and topics needed to design and develop the serious game. This included digital wellbeing, as it is the main concept being presented in the game, ludology to identify main design principles and pedagogy, gamification, and human-computer interaction to supplement those principles. In Chapter 3, the stages of design and development take with regard to the serious game were discussed. The setup and results of the expert review were presented in Chapter 4. All outcomes from this study, being the serious game, recommendations to improve the serious game and two academic articles, are described in Chapter 5.

In this chapter, a summary for this study is provided which covers how the main research aim was accomplished and what future work can be done.

6.2 Research Aim, Objectives, and Questions

The main aim of this study was to *design and develop a serious game to teach users about certain aspects of digital wellbeing*. In order to achieve this, there were several sub-objectives and research questions which needed to be addressed first.

6.2.1 Research Objectives

The research objectives were stated as being:

1. Various case studies and literature centred on designing or developing a serious game and accompanying fields on education and digital wellbeing will be **studied**,
2. **Development** of the serious game,
3. **Evaluation** of the serious game through expert review, and
4. **Critical reflection** on the results of the evaluation.

Each of these objectives was resolved in various phases of this study. Table 6.1 shows in which chapter(s) a given objective was accomplished.

TABLE 6.1: Objective completion

Objective	Chapter Addressed
1	Chapter 2 covered the various fields and information required
2	Chapter 3 covered the design and development of the serious game and Chapter 5 explains the final state of the game
3 and 4	Chapter 4 explains the setup and feedback of the expert review and Chapter 5 provides recommendations based on the feedback

6.2.2 Research Questions

In addition to the objectives above, several research questions also needed to be answered. The answers to these are primarily reflected in Chapter 2 where aspects within various academic fields were discussed. This subsection then provides summarised answers to these questions.

1. What are the digital threats that users face that can be mitigated by increased knowledge and understanding of digital wellbeing?

Once the definition for digital wellbeing was decided on, it involved three main aspects, namely physical health, mental health, and digital security. For each of these, common threats were identified and discussed, as well as means to counter them.

In the case of physical health, the first threat was that of digital eye strain which is caused by prolonged use of a screen. The second threat related to sleep, where technology, mainly screens emitting blue light, may affect a person's sleep schedule. Lastly, mention was made of the musculoskeletal pain caused while using technology, be it looking down at a phone or bad posture while at a desk.

Regarding mental health, the first issue identified was that of internet addiction and explaining mitigation strategies on how to handle it. The second issue was how social media and instant communication can lead to stress and this was discussed alongside the third concept of digital detoxes and setting clear work-life boundaries.

Concerning digital security, the first point was that of setting up strong passwords and how to do so, followed by phishing attacks and how a person can try to identify a phishing message or link. Lastly, dealing with malware was discussed and how to avoid it and protect against it.

2. What type of serious game would be most beneficial for the teaching of digital wellbeing?

In order to adequately answer this question, there was other needed information which is why the sub-questions below were researched as well. The final answer to this resulted in a 2D pixel art game that is able to be played within a browser or downloadable.

2a. What type of game can reach the most users?

To reach as wide an audience as possible, the serious game would need to be able to run on very limited hardware. From this, the best type of game would be one that could run off a system with only a processor and no graphical processing unit. This then results in a game that is not demanding graphically which is a 2D game, as it is easy to render the game. Additionally, having the game available on multiple platforms will facilitate it reaching more people and therefore having the game run in a browser, on a computer and a smartphone would be ideal.

2b. What platforms allow for the full scope of the serious game?

This question uses the answer from the previous question to begin answering it. As the game would be a 2D game, the platform for development is narrowed slightly. The main game engines used are Unity, Unreal and Godot. Unreal specialises in 3D games and is therefore not chosen. Unity and Godot both excel at creating 2D games and the deciding factor for the platform is then merely a matter of preference. As Godot has its documentation available in the engine for offline use, it was chosen.

In terms of hosting platform, the game could just be sent to the experts for review or be hosted like any other game. In the latter case, most avenues require payments for the game to be hosted, such as Steam, Xbox, PlayStation or Nintendo. Hosting on the web site itch.io was chosen, as it allows for an HTML5 game, as well as downloadable files up to 1GB.

2c. Where is the intended venue of play?

As the game would require someone to focus, it is best played without any major distractions and for this reason playing it at a desk is what is intended.

2d. When is the intended time of play?

The time to play this game is intended to be during a person's free time or during a dedicated time slot in a given class, focusing on digital wellbeing or one of the related aspects.

3. What qualities are needed within a serious game to educate a user on the topic of digital wellbeing?

The qualities needed are numerous and can change, depending on the type of game being made, for example a single player would not need to focus on competitiveness in the same way that a multiplayer would. The qualities are described fully in Chapter 2 and the ones used in the game are discussed in Chapter 3.

6.3 Future Work

There is still work that can be done after the conclusion of this study. With respect to the serious game, it can be improved, using the feedback provided. As it stands, the game is only playable in a browser or through an executable file on Windows machines. Therefore, future work could include making it possible to run on other operating systems, as well as smartphones.

For other operating systems, it would need to be tested if the current build can just be exported, using Godot's export system as with the Windows executable or if changes would need to be made. The smartphone version would need certain additions to the game and would need to take other factors into account. Touch controls are the first addition that would need to be added and a rework of the dialogue popup to facilitate tapping the options in a quiz would need to be implemented. Other aspects that would need to be considered would include making all font sizes larger, as smartphones have a smaller screen. Additionally, the feedback and recommendations from the expert review could also be incorporated.

Furthermore, the serious game can additionally be played by and reviewed by the target audience either in a similar method of sending it out for review or in a controlled setting and being observed. This would allow for further feedback on the serious game and determine how effective it is from a player's perspective.

With regard to the research into the design principles, the research could be furthered by developing a framework for designing a certain type of serious game or a framework to evaluate a serious game. The former would involve the presented definitions and expanding them while the latter could include taking aspects of the design principles and using them as a form of heuristic evaluation. Additionally, another academic article could be written based on this study as a whole describing how the serious game was developed with the design principles described.

6.4 Summary

This study aimed to design and develop a serious game to educate people on the concept of digital wellbeing. By identifying and then expanding upon design principles through a multidisciplinary approach, the study culminated in the development of a serious game application. Feedback from experts across various fields indicated a generally positive resulting implementation, affirming the effectiveness of the design principles used. While some issues were identified which require further refinement, the overall response illustrates the potential impact of a serious game being used to introduce and educate people on digital wellbeing.

From this study, two academic articles were published contributing to the pool of knowledge on serious game design and a freely available serious game for anyone to play. This research then not only adds to the pool of knowledge on serious game design and development, but also highlights the importance of an interdisciplinary approach in fostering educational innovation.

Reference List

- Aarseth, E., & Grabarczyk, P. (2018). An ontological meta-model for game research. *Proceedings of the 2018 DiGRA International Conference: The Game is the Message*.
- Adedoyin, R., Idowu, B., Adagunodo, R., & Idowu, P. (2003). Musculoskeletal pain associated with the use of computer systems in Nigeria. *The Internet Journal of Pain, Symptom Control and Palliative Care*, 3(2).
- Ahearne, C. E., Dilworth, S., Rollings, R., Livingstone, V., & Murray, D. M. (2015). Touch-screen technology usage in toddlers. *Archives of Disease in Childhood*, 101, 181–183.
- Aladawy, D., Beckers, K., & Pape, S. (2018). Persuaded: Fighting social engineering attacks with a serious game. *Trust, Privacy and Security in Digital Business: 15th International Conference, TrustBus 2018, Regensburg, Germany, September 5–6, 2018, Proceedings 15*, 103–118.
- Aldawood, H., & Skinner, G. (2018). Educating and raising awareness on cyber security social engineering: A literature review. *2018 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE)*, 62–68.
- Alkhalil, Z., Hewage, C., Nawaf, L., & Khan, I. (2021). Phishing attacks: A recent comprehensive study and a new anatomy. *Frontiers in Computer Science*, 3, 563060.
- Almeida, F., & Simoes, J. (2019). The role of serious games, gamification and industry 4.0 tools in the education 4.0 paradigm. *Contemporary Educational Technology*, 10(2), 120–136.
- Almourad, M. B., Alrobai, A., Skinner, T., Hussain, M., & Ali, R. (2021). Digital wellbeing tools through users lens. *Technology in Society*, 67, 101778.
- American Psychiatric Association. (2022). *Diagnostic and statistical manual of mental disorders* (5th). American Psychiatric Publishing.
- Arfi, N., & Agarwal, S. (2013). Knowledge of Cybercrime among Elderly. *International Journal of Scientific & Engineering Research*, 4(7), 1463–1468.

- Austin, M. J., & Rust, D. Z. (2015). Developing an experiential learning program: Milestones and challenges. *International Journal of Teaching and Learning in Higher Education*, 27(1), 143–153.
- Barbosa, M. B., Rego, A. B., & De Medeiros, I. (2015). Heeg: Heuristic evaluation for educational games. *Brazilian Symposium of Games and Digital Entertainment*, 224–227.
- Benoît, G. (2019). *Introduction to information visualization : Transforming data into meaningful information* (L. H. Charles Harmon Michael Tan, Ed.). Rowman & Littlefield.
- Capcom. (2017). *Monster Hunter Generations Ultimate* (Switch version).
- Carroll, J. M. (1997). Human–computer interaction: Psychology as a science of design. *International Journal of Human-Computer Studies*, 46(4), 501–522.
- Cecchinato, M. E., Rooksby, J., Hiniker, A., Munson, S., Lukoff, K., Ciolfi, L., Thieme, A., & Harrison, D. (2019). Designing for Digital Wellbeing: A Research & Practice Agenda. *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, 1–8.
- Cho, E. (2015). Therapeutic interventions for treatment of adolescent internet addiction—experiences from south Korea. In C. Montag & M. Reuter (Eds.), *Internet addiction: Neuroscientific approaches and therapeutical interventions* (pp. 167–181). Springer International Publishing.
- Coles-Brennan, C., Sulley, A., & Young, G. (2019). Management of digital eye strain [PMID: 29797453]. *Clinical and Experimental Optometry*, 102(1), 18–29.
- Combertaldi, S. L., Ort, A., Cordi, M., Fahr, A., & Rasch, B. (2021). Pre-sleep social media use does not strongly disturb sleep: A sleep laboratory study in healthy young participants. *Sleep Medicine*, 87, 191–202.
- Cooper, A., Reimann, R., Cronin, D., & Noessel, C. (2014). *About face: The essentials of interaction design* (Fourth). Wiley Publishing.
- Dau, W., Hoffmann, J. D. G., & Banger, M. (2015). Therapeutic interventions in the treatment of problematic internet use—experiences from Germany. In C. Montag & M. Reuter (Eds.), *Internet addiction: Neuroscientific approaches and therapeutical interventions* (pp. 183–217). Springer International Publishing.
- de Carné de Carnavalet, X., & Mannan, M. (2014). From very weak to very strong: Analyzing password-strength meters [In Press]. *Network and Distributed System Security (NDSS) Symposium 2014*.
- Dell’Amico, M., Michiardi, P., & Roudier, Y. (2010). Password strength: An empirical analysis. *2010 Proceedings IEEE INFOCOM*, 1–9.

- Delnevo, G., Deluigi, L., Evangelisti, D., & Magnani, S. (2022). On increasing password security awareness using a serious game. *2022 IEEE 19th Annual Consumer Communications & Networking Conference (CCNC)*, 82–87.
- Digital Wellbeing through technology* | Google. (n.d.). <https://wellbeing.google/>
- Dincelli, E., & Chengalur-Smith, I. (2020). Choose your own training adventure: Designing a gamified SETA artefact for improving information security and privacy through interactive storytelling. *European Journal of Information Systems*, 29(6), 669–687.
- Dresch, A., Lacerda, D. P., & Antunes, J. A. V. (2015). Design Science Research. In *Design science research: A method for science and technology advancement* (pp. 67–102). Springer International Publishing.
- Drevin, G., Snyman, D. P., Drevin, L., Kruger, H. A., & Allers., J. The story of safety snail and her e-mail: A digital wellness and cybersecurity serious game for pre-school children. In: *In Proceedings of the 9th International Conference on Information Systems Security and Privacy - ICISSP*. INSTICC. SciTePress, 2023, 519–527. ISBN: 978-989-758-624-8.
- Esterhuizen, J., Drevin, G., Snyman, D., & Drevin, L. (2022). Linking gamification, ludology and pedagogy: Principles to design a serious game. In D. Sampson, D. Ifenthaler, & P. Isaías (Eds.), *Proceedings of the 19th International Conference on Cognition and Exploratory Learning in Digital Age (CELDA 2022)* (pp. 57–65). IADIS.
- Esterhuizen, J., Drevin, L., Drevin, G., & Snyman, D. (2023). Design Choices Among Recent Security Related Serious Games. In L. Chova, C. Martínez, & J. Lees (Eds.), *Proceedings of the 16th annual International Conference of Education, Research and Innovation (ICERI 2023)* (pp. 8807–8816). IATED Academy.
- Fatima, R., Yasin, A., Liu, L., Wang, J., Afzal, W., & Yasin, A. (2019). Sharing information online rationally: An observation of user privacy concerns and awareness using serious game. *Journal of Information Security and Applications*, 48, 102351.
- Feerrar, J. (2020). Supporting digital wellness and wellbeing. In *Student wellness and academic libraries: Case studies and activities for promoting health and success* (pp. 169–185). ACRL Press.
- Frasca, G. (2002). Ludology: From Representation to Simulation. *Proceedings of the 29th International Conference on Computer Graphics and Interactive Techniques. Electronic Art and Animation Catalog.*, 134–137.
- Frasca, G. (2013). Simulation versus narrative: Introduction to ludology. In *The video game theory reader* (pp. 221–235). Routledge.

- Gasiba, T. E., Lechner, U., & Pinto-Albuquerque, M. (2021). Cybersecurity challenges: Serious games for awareness training in industrial environments. *CoRR*, *abs/2102.10432*.
- Ghazvini, A., & Shukur, Z. (2018). A serious game for healthcare industry: Information security awareness training program for Hospital Universiti Kebangsaan Malaysia. *International Journal of Advanced Computer Science and Applications*, *9(9)*.
- Giraldo-Luque, S., Aldana Afanador, P. N., & Fernández-Rovira, C. (2020). The Struggle for Human Attention: Between the Abuse of Social Media and Digital Wellbeing. *Healthcare*, *8(4)*.
- Goeke, L., Quintanar, A., Beckers, K., & Pape, S. (2020). Protect—an easy configurable serious game to train employees against social engineering attacks. *Computer Security: ESORICS 2019 International Workshops, IOSec, MSTEC, and FINSEC, Luxembourg City, Luxembourg, September 26–27, 2019, Revised Selected Papers 2*, 156–171.
- González-Tablas, A. I., González Vasco, M. I., Cascos, I., & Planet Palomino, Á. (2020). Shuffle, cut, and learn: Crypto go, a card game for teaching cryptography. *Mathematics*, *8(11)*.
- Graham, K., Anderson, J., Rife, C., Heitmeyer, B., R. Patel, P., Nykl, S., C. Lin, A., & D. Merkle, L. (2020). Cyberspace odyssey: A competitive team-oriented serious game in computer networking. *IEEE Transactions on Learning Technologies*, *13(3)*, 502–515.
- Hama Saeed, M. A. (2020). Malware in computer systems: Problems and solutions. *IJID (International Journal on Informatics for Development)*, *9(1)*, 1–8.
- Hart, S., Margheri, A., Paci, F., & Sassone, V. (2020). Riskio: A serious game for cyber security awareness and education. *Comput. Secur.*, *95*, 101827.
- Höchsmann, C., Infanger, D., Klenk, C., Königstein, K., Walz, S. P., & Schmidt-Trucksäss, A. (2019). Effectiveness of a behavior change technique-based smartphone game to improve intrinsic motivation and physical activity adherence in patients with type 2 diabetes: Randomized controlled trial. *JMIR Serious Games*, *7(1)*, e11444.
- Huizinga, J. (1949). *Homo ludens. a study of the play-element in culture*. [translated by rfc hull.] London: Routledge & Kegan Paul.
- Hunicke, R. (2005). The case for dynamic difficulty adjustment in games. *IFAC Symposium on Advances in Control Education*.

- Hunicke, R., LeBlanc, M., Zubek, R., et al. (2004). MDA: A Formal Approach to Game Design and Game Research. *Proceedings of the AAAI Workshop on Challenges in Game AI*, 4(1).
- Jaffray, A., Finn, C., & Nurse, J. R. C. (2021). SherLOCKED: A detective-themed serious game for cyber security education. In *Human aspects of information security and assurance* (pp. 35–45). Springer International Publishing.
- Jayakrishnan, G., Banahatti, V., & Lodha, S. (2022). Pickmail: A serious game for email phishing awareness training. In *Usable security and privacy (usec)*.
- Jayakrishnan, G., Sirigireddy, G. R., Vaddepalli, S., Banahatti, V., Lodha, S. P., & Pandit, S. S. (2020). Passworld: A serious game to promote password awareness and diversity in an enterprise. *Proceedings of the Sixteenth USENIX Conference on Usable Privacy and Security*.
- Jisc. (2019). *Jisc digital capabilities framework: The six elements defined* (tech. rep.). Jisc. <https://doi.org/https://repository.jisc.ac.uk/7278/1/BDCP-DC-Framework-Individual-6E-110319.pdf>
- Kapp, K. M. (2012). *The gamification of learning and instruction: Game-based methods and strategies for training and education*. John Wiley & Sons.
- Khonji, M., Iraqi, Y., & Jones, A. (2013). Phishing detection: A literature survey. *IEEE Communications Surveys & Tutorials*, 15(4), 2091–2121.
- Kletenik, D., Butbul, A., Chan, D., Kwok, D., & LaSpina, M. (2021). Game on: Teaching cybersecurity to novices through the use of a serious game. *J. Comput. Sci. Coll.*, 36(8), 11–21.
- Koh, Y.-S. (2015). The Korean national policy for internet addiction. In C. Montag & M. Reuter (Eds.), *Internet addiction: Neuroscientific approaches and therapeutical interventions* (pp. 219–233). Springer International Publishing.
- Kolb, A. Y., & Kolb, D. A. (2005). Learning styles and learning spaces: Enhancing experiential learning in higher education. *Academy of Management Learning & Education*, 4(2), 193–212.
- Li, G. (2012). *Culturally contested pedagogy: Battles of literacy and schooling between mainstream teachers and Asian immigrant parents*. State University of New York Press.
- Lima, I., Ponce de Leon, C., Ribeiro, L., Silva, I., Vilela, D., Monti, F., & Góes, F. (2022). A Serious Game (Immunitates) About Immunization: Development and Validation Study. *JMIR Serious Games*, 10(1:e30738), 1–13.
- Linietsky, J., & Manzur, A. (2024). *Godot Engine documentation in English*. <https://docs.godotengine.org/en/stable/index.html>

- Løvgren, D. E. H., Li, J., & Oyetoyan, T. D. (2019). A data-driven security game to facilitate information security education. *2019 IEEE/ACM 41st International Conference on Software Engineering: Companion Proceedings (ICSE-Companion)*, 256–257.
- Luh, R., Temper, M., Tjoa, S., Schrittwieser, S., & Janicke, H. (2019). Penquest: A gamified attacker/defender meta model for cyber security assessment and education. *Journal of Computer Virology and Hacking Techniques*, 16, 19–61.
- Mannell, K., & Meese, J. (2022). From doom-scrolling to news avoidance: Limiting news as a wellbeing strategy during covid lockdown. *Journalism Studies*, 23(3), 302–319.
- McMahon, C., & Aiken, M. (2015). Introducing Digital Wellness: Bringing Cyberpsychological Balance to Healthcare and Information Technology. *2015 IEEE International Conference on Computer and Information Technology; Ubiquitous Computing and Communications; Dependable, Autonomic and Secure Computing; Pervasive Intelligence and Computing*, 1417–1422.
- Meates, J. (2021). Problematic digital technology use in children and adolescents: impact on physical well-being. *Teachers and Curriculum*, 21(1), 77–91.
- Merrill, M. D. (2002). First principles of instruction. *Educational technology research and development*, 50(3), 43–59.
- Misra, G., Arachchilage, N. A. G., & Berkovsky, S. (2017). Phish Phinder: A game design approach to enhance user confidence in mitigating phishing attacks. In S. Furnell & N. L. Clarke (Eds.), *Proceedings of the eleventh international symposium on human aspects of information security & assurance (haisa 2017)* (pp. 41–51). DBLP computer science bibliography.
- Mittal, A., Gupta, M., Chaturvedi, M., Chansarkar, S. R., & Gupta, S. (2021). Cybersecurity enhancement through blockchain training (cebt) – a serious game approach. *International Journal of Information Management Data Insights*, 1(1), 100001.
- Mohamed, H., & Jaafar, A. (2010). Development and potential analysis of heuristic evaluation for educational computer game (p heg). *5th International Conference on Computer Sciences and Convergence Information Technology*, 222–227.
- Muhly, F., Leo, P., & Caneppele, S. (2021). A serious game for social engineering awareness creation. *Journal of Cybersecurity Education, Research and Practice*, 2022(1), 5.

- Naul, E., & Liu, M. (2020). Why story matters: A review of narrative in serious games. *Journal of Educational Computing Research*, 58(3), 687–707.
- Nguyen, M. H. (2021). Managing social media use in an always-on society: Exploring digital wellbeing strategies that people use to disconnect. *Mass Communication and Society*, 24(6), 795–817.
- O'Connor, S., Hasshu, S., Bielby, J., Colreavy-Donnelly, S., Kuhn, S., Caraffini, F., & Smith, R. (2021). Scips: A serious game using a guidance mechanic to scaffold effective training for cyber security. *Information Sciences*, 580, 524–540.
- Oliveira, W., Hamari, J., Joaquim, S., Toda, A. M., Palomino, P. T., Vassileva, J., & Isotani, S. (2022). The effects of personalized gamification on students' flow experience, motivation, and enjoyment. *Smart Learning Environments*, 9(16).
- Park, S., & Kim, S. (2019). A Badge Design Framework for a Gamified Learning Environment: Cases Analysis and Literature Review for Badge Design. *JMIR Serious Games*, 7, e14342.
- Pérez-Colado, V. M., Pérez-Colado, I. J., Martínez-Ortiz, I., Freire-Morán, M., & Fernández-Manjón, B. (2021). Extending narrative serious games using ad-hoc mini-games. In W. Zhou & Y. Mu (Eds.), *Advances in web-based learning – icwl 2021* (pp. 63–74). Springer International Publishing.
- Robertson, M., Baranowski, T., Thompson, D., Basen-Engquist, K., Swartz, M., & Lyons, E. (2021). Using the behaviour change wheel program planning model to design games for health: Development study. *JMIR Serious Games*, 9(4), e29964.
- Roffarello, A. M., & De Russis, L. (2019). The Race Towards Digital Wellbeing: Issues and Opportunities. *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, 1–14.
- Satici, S. A., Gocet Tekin, E., Deniz, M. E., & Satici, B. (2023). Doomscrolling scale: Its association with personality traits, psychological distress, social media use, and wellbeing. *Applied Research Quality Life*, 18, 833–847.
- Scott, D. A., Valley, B., & Simecka, B. A. (2017). Mental health concerns in the digital age. *International Journal of Mental Health and Addiction*, 15, 604–613.
- Sheng, S., Magnien, B., Kumaraguru, P., Acquisti, A., Cranor, L. F., Hong, J., & Nunge, E. (2007). Anti-phishing phil: The design and evaluation of a game that teaches people not to fall for phish. *Proceedings of the 3rd Symposium on Usable Privacy and Security*, 88–99.
- Sheppard, A. L., & Wolffsohn, J. S. (2018). Digital eye strain: Prevalence, measurement and amelioration. *BMJ Open Ophthalmology*, 3(1).

- Statista. (2023). *Most concerning types of cyber threats according to it security decision makers worldwide as of November 2022*. <https://www.statista.com/statistics/500946/worldwide-leading-it-security-threats/>
- Thompson, D. (2012). Designing Serious Video Games for Health Behavior Change: Current Status and Future Directions. *Journal of diabetes science and technology*, 6, 807–811.
- Van Gaalen, A. E. J., Schönrock-Adema, J., Renken, R. J., Jaarsma, A. D. C., & Georgiadis, J. R. (2022). Identifying player types to tailor game-based learning design to learners: Cross-sectional survey using q methodology. *JMIR Serious Games*, 10(2), e30464.
- Vanden Abeele, M. M. P. (2020). Digital Wellbeing as a Dynamic Construct. *Communication Theory*, 31(4), 932–955.
- Wærsted, W., Hanvold, T. N., & Veiersted, K. B. (2010). Computer work and musculoskeletal disorders of the neck and upper extremity: A systematic review. *BMC Musculoskeletal Disorders*, 11(79).
- Widdicks, K. (2020). When the Good Turns Ugly: Speculating Next Steps for Digital Wellbeing Tools. *Proceedings of the 11th Nordic Conference on Human-Computer Interaction: Shaping Experiences, Shaping Society*, 1–6.
- Yamin, M. M., Katt, B., & Nowostawski, M. (2021). Serious games as a tool to model attack and defense scenarios for cyber-security exercises. *Computers & Security*, 110, 102450.
- Yasin, A., Liu, L., Li, T., Fatima, R., & Wang, J. (2019). Improving software security awareness using a serious game. *IET Softw.*, 13, 159–169.
- Yusoff, A. (2010). *A conceptual framework for serious games and its validation* (Doctoral dissertation). University of Southampton.
- Zhao, T., Gasiba, T. E., Lechner, U., & Pinto-Albuquerque, M. (2021). Exploring a board game to improve cloud security training in industry (short paper). *International Computer Programming Education Conference*.
- Zhao, T., Lechner, U., Pinto-Albuquerque, M., Ata, E., & Gasiba, T. (2023). Cats: A serious game in industry towards stronger cloud security. *Ubiquitous Security: Second International Conference, UbiSec 2022, Zhangjiajie, China, December 28–31, 2022, Revised Selected Papers*, 64–82.

Appendices

A	Expert Review Questionnaire	112
B	Game Quiz Questions	125
C	Research Article 1	134
D	Research Article 2	143
E	Ethical Clearance	153
F	Language Editing Certificate	155

A Expert Review Questionnaire

RESEARCH STUDY: Designing and Developing a Serious Game to Teach Digital Wellbeing Response Form

Thank you for taking part in this study.

* Indicates required question

Informed Consent Form

Participation in this study is in the form of playing a serious game focusing on digital wellbeing and provide feedback on the content within and the serious game itself. The game currently is a prototype/proof-of-concept and not a full commercial ready game. Furthermore, feedback is in the form of an expert review which includes answering questions as part of a questionnaire and additional open feedback.

1. **GENERAL:** Participation in this review is voluntary. If you wish to decline or withdraw at any time, you may do so. If you agree to participate in the review, you are not likely to experience any risk or unique discomfort from answering the surveys and providing feedback. You will not receive any payment or direct personal benefit or reward from this research.

All expert reviewers will need to complete this ICF in order to get access to the survey. Once the survey is completed, the researcher will use the feedback for further potential modifications to the serious game and other modes of analysis.

2. **PURPOSE:** The purpose of this study is to design and develop a serious game to educate users about the topic of digital wellbeing – simply being the relationship with technology. It is intended for any user regardless of other identifiers but does have the limitation that they need access to and basic knowledge of how to use a computer.

Should you have any inquiries before, during and after your participation, please send an email to the researcher or associated supervisor under CONTACT DETAILS below.

The results of this study will contribute to scientific knowledge and promote better management of a person's digital wellbeing but should have no risks to you as a reviewer. The entire review process should take around hour to complete.

3. **CONFIDENTIALITY:** Any information that is provided will be kept strictly private, confidential, and anonymous. Your name will not be recorded with your survey responses in any way and as such no response can be connected to an individual. Results of this study will be presented as summaries of feedback and other analysis results, but no information will be presented about individual expert reviewers.

4. CONTACT DETAILS:

Joshua Esterhuizen (Researcher)
Masters Student,
North-West University - Unit for Data Science and Computing,
South Africa,
Email – 30285976@mynwu.ac.za (or joshua.esterhuizen27@gmail.com)

or

Dr Dirk Snyman (Study Supervisor)
Lecturer,
North-West University - Unit for Data Science and Computing,
South Africa,
Email – dirk.snyman@uct.ac.za

Thank you for your willingness to participate in this study.

1. I have read the ICF and wish to continue. *

Mark only one oval.

Yes

Reviewer Information

As stated in the ICF, none of your personal details will be recorded. This section aims to collect relevant information relevant to the knowledge and expertise of the reviewer.

2. What is your "expert" area of knowledge? *

Check all that apply.

Physical Health

Mental Health

Digital Security

Game development or design

Research/Academia

Education/Teaching

Other: _____

3. What is your experience with playing games? *

Mark only one oval.

1 2 3 4 5

No experience Extensive experience

Play the game.

The rest of the survey requires you to have played the game. For this study, you should play through at least one of the levels of your choice (these being either physical, mental or security).

It can be played in the browser by clicking the "Run serious game" button or through the downloadable executable file and both versions are the same. For the executable, when you run it you will need to click "More info" and "Run anyway" on the "Windows protected your PC" pop-up as it does not have a code signing certificate.

The link to where it can be found is [HERE](#).

Game related short questions

4. Which level(s) did you play? *

Check all that apply.

- Physical
 Mental
 Security

5. Were you aware of what digital wellbeing was before taking part in the study? *

Mark only one oval.

- Yes
 No
 Other: _____

6. Do you feel you are more knowledgeable on the topic of digital wellbeing after playing the game (or in the case of only having played a specific level, within that part of digital wellbeing)? *

Mark only one oval.

- Yes
 No

7. How more knowledgeable would you say you are? *

Mark only one oval.

1 2 3 4 5

Not Very much

Game related long questions

For this section, select 1 through 5 depending on your experience or expert knowledge. While not required, there is a follow-up question to each scale for further elaboration.

8. Did you find the user interface and general user experience satisfactory? *

Mark only one oval.

1 2 3 4 5

Not Excellent

9. With regards to the previous question, please explain your choice.

10. How did you find the game controls? Were the controls intuitive? *

Mark only one oval.

1 2 3 4 5

Frustrating Easy to use

11. With regards to the previous question, please explain your choice. (Was the explanation sufficient? What recommendations would you give for the controls?)

12. Did you find it easy to move around in the game? *

Mark only one oval.

1 2 3 4 5

Not Very easy

13. Did you find it easy to interact with characters and continue dialogue? *

Mark only one oval.

1 2 3 4 5

Not Very easy

14. With regards to the previous **two** questions, please explain your choice.

15. Was dealing with the game simple? (i.e. Were instructions given to you easy to understand? Were you able to have clear goals or expectations?) *

Mark only one oval.

1 2 3 4 5

Con Very Simple

16. With regards to the previous question, please explain your choice.

17. Did the inclusion of a narrative help keep you engaged with the game? (i.e. Gathering information for a security class assignment, getting information to later help a friend, getting information to better understand why you have body pain after working on the computer) *

Mark only one oval.

1 2 3 4 5

Dist Kept engagement

18. With regards to the previous question, please explain your choice.

19. Was the inclusion of Digibot (the blue robot character) to guide you through the game and story helpful and engaging? *

Mark only one oval.

1 2 3 4 5

Not Quite helpful

20. With regards to the previous question, please explain your choice.

21. If the setting (story and area the game takes place in) *is different* from your own, did this detract from your enjoyment and engagement of the game? (eg. The security level taking place in a class with the player as a student) *

Mark only one oval.

1 2 3 4 5

Detri Did not affect at all

22. With regards to the previous question, please explain your choice.

23. Did the option to alter the character you play as influence your enjoyment of the game at all? *

Mark only one oval.

1 2 3 4 5

Had Much more enjoyable

24. With regards to the previous question, please explain your choice.

25. Did the inclusion of achievements to work towards motivating you to play through multiple levels or replay one to get a perfect score? Did getting them all motivate you to continue playing? *

Mark only one oval.

1 2 3 4 5

Had Much more motivating

26. With regards to the previous question, please explain your choice.

27. How did you find the mix of difficulty regarding the questions in the quiz section? *

Mark only one oval.

1 2 3 4 5

Too Nicely varied

28. With regards to the previous question, please explain your choice. (Would you have liked to see more/less easier/harder questions?)

29. How helpful did you find the feedback provided during the quiz? (i.e. Getting a wrong answer resulted in a brief explanation) *

Mark only one oval.

1 2 3 4 5

Did Very helpful

30. With regards to the previous question, please explain your choice.

31. With regards to your specific field of knowledge, was the game able to fulfill it's set goals? (i.e. if Education, is the game able to act as a learning tool or if Security, is it able to explain concepts simply enough while being factual?) *

Mark only one oval.

1 2 3 4 5

Not Excellently

32. With regards to the previous question, please explain your choice.

33. Did the break between learning the information in a level and taking the quiz coming in the form of a minigame detract in your retention of information? *

Mark only one oval.

1 2 3 4 5

Not Yes

34. With regards to the previous question, please explain your choice.

35. How did you find the flow and structure of the game? Would you prefer a different approach?

(i.e. Level select > scenario > information gathering > minigame > quiz)

36. With regards to the previous questions, what could be done to better apply the knowledge of your field? (i.e. if one of the specific levels content, could it be made simpler or more complex. If game development or education, what could be improved in the game itself or the delivery of content?)

37. Overall, was the game fun to play? *

Mark only one oval.

1 2 3 4 5

Not Very enjoyable

38. With regards to the previous question, please explain your choice.

39. Do you find the game as a viable means to *introduce* people to the topic of digital wellbeing? *

Mark only one oval.

1 2 3 4 5

Not Easy recommendation

40. With regards to the previous question, please explain your choice.

Open Feedback

If there is anything else you wish to mention about the game that was not a part of a specific question, feel free to include it here.

41. Open Feedback: Please provide and other comments you may have for the game that the above questions did not address.

B Game Quiz Questions

Physical Wellbeing Questions

Question 1:

What is another name for digital eye strain (DES)?

- (a) Computer Vision Syndrome (CVS) (Correct)
- (b) Electronic Visual Fatigue (EVF)
- (c) Optic Nerve Exhaustion (ONE)
- (d) Screen Fatigue Syndrome (SFS)

If incorrect: Digital Eye Strain is also referred to as computer vision syndrome (CVS)

Question 2:

How could you get digital eye strain?

- (a) Staring at a screen for too long (Correct)
- (b) Not wearing sunglasses outdoors
- (c) Reading a book for too long
- (d) Eating carrots excessively

If incorrect: The screen would cause digital eye strain while the other options may result in regular eye strain. And carrots help your eyes as they say, with the vitamin A and all.

Question 3:

Which of the following is NOT a symptom of digital eye strain?

- (a) Muscle pains (Correct)
- (b) Blurred vision
- (c) Light Sensitivity
- (d) Teary eyes

If incorrect: Symptoms can include tired, burning or dry eyes, tearing, light sensitivity, blurred or double vision and trouble focusing at objects in the distance.

Question 4:

Who is more likely to be at risk of digital eye strain?

- (a) A programmer (Correct)
- (b) A doctor
- (c) A chef
- (d) A musician

If incorrect: Remember, digital eyestrain is caused by screens, and a programmer needs to always use a screen while the others only do occasionally.

Question 5:

How would you treat digital eye strain?

- (a) Using eye drops for dry eyes (Correct)
- (b) Eliminate blue light
- (c) Applying heat packs to the eyes
- (d) Rubbing the eyes vigorously

If incorrect: To treat digital eye strain means you already have it and should look at how to help with the symptoms while eliminating blue light will help 'prevent' it.

Question 6:

How should your environment be like to avoid digital eye strain?

- (a) Screen and room brightness should be equal (Correct)
- (b) Dim lighting conditions
- (c) Harsh overhead lighting
- (d) Using a bright desk lamp

If incorrect: Your lighting should be adequate, dim lighting may cause you to need to squint causing eye strain and bright lights may too.

Question 7:

You should look at an object __ away for __ every ___.

- (a) 20ft, 20 seconds, 20 minutes (Correct)
- (b) 1m, 1 seconds, 1 minutes
- (c) 20ft, 10 seconds, 5 minutes
- (d) far, a bit, so often

If incorrect: Remember, it is the 20/20/20 rule!

Question 8:

What about screens affects your sleep schedule?

- (a) Blue light being emitted (Correct)
- (b) Screen resolution
- (c) Screen size
- (d) Screen brightness

If incorrect: The brightness, size and resolution may lead to digital eye strain but it is the blue light that affects sleep.

Question 9:

When should you limit your exposure to blue light?

- (a) In the evening (Correct)
- (b) In the morning
- (c) The whole day
- (d) Around midday

If incorrect: Since blue light affects sleep, reducing exposure near when you do is best.

Question 10:

How can you lessen the effects of blue light?

- (a) Specialised software (Correct)
- (b) Turning up screen brightness
- (c) Staring at screens for longer periods
- (d) Wearing red-tinted glasses

If incorrect: There is special software that will reduce it and red-tint likely won't help unless it's specifically designed to reduce blue light.

Question 11:

How can you NOT develop physical pain from using technology?

- (a) Holding your phone level with your face (Correct)
- (b) Holding your phone above your head
- (c) Hunching over at the desk
- (d) Having a screen at 90 degrees

If incorrect: Keeping your phone around eye level is best and the other options will all impose some strain to the neck.

Question 12:

What causes the physical pain while working at a desk?

- (a) Likely bad posture (Correct)
- (b) Ergonomic furniture
- (c) Standing too frequently
- (d) Having elbows on the desk

If incorrect: The pain comes from not sitting properly or for too long.

Question 13:

How can you reduce the risk of muscle pain from technology use?

- (a) Stretching often (Correct)
- (b) Taking breaks at your desk
- (c) Using uncomfortable chairs
- (d) Ensure adequate lighting

If incorrect: Stretching often while standing up helps to reduce the pain and risk of pain.

Question 14:

How often should you stand up from your desk?

- (a) Every 30 minutes (Correct)
- (b) Every 2 hours
- (c) Every 4 hours
- (d) Only when necessary

If incorrect: It's best to stand up every 30 minutes and not sitting longer than 1 hour at a time without break.

Question 15:

If you are using a second screen, what is the best placement of it?

- (a) Level with your eyeline (Correct)
- (b) To the left of your other screen
- (c) To the right of your other screen
- (d) In a completely different room

If incorrect: The screen being on other side of your main one does not matter so long as it is within eye level and you are not turning your neck too much to look at it.

Mental Wellbeing Questions

Question 1:

Which of the following is a common sign of internet addiction?

- (a) Withdrawal symptoms when not using the internet (Correct)
- (b) Spending more time in other hobbies
- (c) Decreased urge to use the internet
- (d) Limited internet access without any repercussions

If incorrect: As with other kinds of addiction, a person may have symptoms of withdrawal.

Question 2:

What behaviour might indicate loss of self-control regarding internet usage?

- (a) Inability to resist the urge to use the internet (Correct)
- (b) Moderation in online activities
- (c) Setting specific time limits for internet usage
- (d) Easily switching focus to other activities

If incorrect: Being unable to stop oneself from using the internet is a sign of loss of self-control.

Question 3:

What is identified as a potential downside of instant communication in the described world?

- (a) Difficulty in separating work from personal life (Correct)
- (b) Enhanced work-life balance
- (c) Increased personal connections
- (d) Limited professional opportunities

If incorrect: Instant communication means we can ask questions or update colleagues about work at any time even after hours when at home.

Question 4:

How does the inability to separate work from home impact individuals?

- (a) It causes stress and issues in personal and professional lives (Correct)
- (b) It leads to increased productivity
- (c) It fosters better time management skills
- (d) It promotes a healthier work environment

If incorrect: No separation or boundary means you will always be working and will be stressing over work constantly.

Question 5:

What role do clear boundaries play in mitigating the negative effects of constant connectivity?

- (a) They help to separate work and personal life, reducing stress (Correct)
- (b) They make stress levels rise
- (c) They blur the lines between personal and professional life
- (d) They encourage constant work engagement

If incorrect: Being able to have time to yourself without worry of work is important and allows us to relax better.

Question 6:

What is the action of not using social media or the internet to read about current events?

- (a) News avoidance (Correct)
- (b) Digital disengagement
- (c) Information disconnection
- (d) Media hiatus

If incorrect: Not using the internet to read about what is happening is known as news avoidance.

Question 7:

What is the negative behaviour associated with excessive consumption of current events?

- (a) Doom-scrolling (Correct)
- (b) News bombardment
- (c) Information obsession
- (d) Scroll-frenzy

If incorrect: Excessively trying to read news about current events is doom-scrolling.

Question 8:

How might "doom-scrolling" impact individuals?

- (a) It leads to feelings of depression, anxiety, and stress (Correct)
- (b) It fosters a sense of joy and fulfilment
- (c) It allows them to have better communication with others
- (d) It keeps them informed about everything

If incorrect: The news is often negative and constantly absorbing those types of stories will have an effect on a person leading to feelings of depression, anxiety, and stress.

Question 9:

What concept is described as a method to help people disconnect from technology and the internet?

- (a) Digital detoxing (Correct)
- (b) Digital overload
- (c) Cyber retreat
- (d) Virtual escape

If incorrect: When you stop using technology or the internet for a time, it is called a digital detox.

Question 10:

How can digital detoxing be achieved?

- (a) By disconnecting from devices or specific applications (Correct)
- (b) By increasing technology usage
- (c) By constantly staying connected to the internet
- (d) By avoiding personal interactions

If incorrect: You can disconnect from entire devices to specific applications for whatever amount of time you feel you need.

Question 11:

What is important to consider regarding the approach to digital detoxing?

- (a) The need for constant connectivity for some professions (Correct)
- (b) The severity of withdrawal symptoms
- (c) Where to put all the technology not being used
- (d) The availability of alternative activities during detoxing

If incorrect: A digital detox has many ranges in time and from what and the main thing to consider is that you might still need technology to do your job in which case you can limit specific applications.

Question 12:

How can reduced social media or phone usage help when it comes to doing work?

- (a) Improved productivity and focus on tasks (Correct)
- (b) Increased bombardment of physical news
- (c) Less time for hobbies
- (d) Makes communication difficult

If incorrect: Leaving social media and spending less time on your phone lets you rest easier and as such feel more refreshed and focus better.

Question 13:

How does a digital detox help with your state of mind?

- (a) Feeling less overwhelmed and having a better peace of mind (Correct)
- (b) Less to think about from the news
- (c) Increased bombardment of physical news
- (d) Less time for hobbies

If incorrect: Leaving social media and spending less time on your phone gives you extra time each day to spend as you wish and relax more often.

Question 14:

What is the nature of the benefits of disconnecting from technology and the internet?

- (a) The benefits vary from person to person (Correct)
- (b) Everyone will experience the same benefits uniformly
- (c) The benefits of disconnecting are not significant
- (d) Disconnecting has no impact on personal well-being

If incorrect: Disconnecting for a day may help one person feel better while others need more or less time to reach that level.

Question 15:

Why is it important to find what works for you when it comes to disconnecting from technology and the internet?

- (a) Because benefits may not be guaranteed for everyone (Correct)
- (b) To conform to societal expectations
- (c) To ensure uniformity in experiences
- (d) To minimize the time spent on hobbies

If incorrect: It is important to remember that everyone is different and will have different reactions to things which means what helps one person may not always help the next.

Security Questions

Question 1:

Which of these is NOT a way to make a strong password?

- (a) Using your birthday and name (Correct)
- (b) Turning a sentence into a password
- (c) Add punctuation to a password
- (d) Make a long password

If incorrect: Using information that people maybe able to find out about you is not a good idea.

Question 2:

Which of the following is the stronger password?

- (a) P@5sW0rD (Correct)
- (b) password
- (c) 1234password
- (d) 23password!

If incorrect: While all the options can be uncovered by an attacker, P@5sW0rD is the stronger of the bunch as it requires more effort.

Question 3:

What would "Whispers of twilight linger, shadows dance beneath the Moon!" look like as a password?

- (a) Wotl,sdbtM! (Correct)
- (b) wotlsdbtm
- (c) WotlsdbM
- (d) wotl,sdbtm!

If incorrect: Using a sentence as a password means including all of the capitalisation and punctuation!

Question 4:

What should you try when setting up a password?

- (a) Utilizing the first letter of each word in sentence (Correct)
- (b) Using common song lyrics as password phrases
- (c) Including only lowercase letters and numbers in the password
- (d) Keep it short to make them easier to remember

If incorrect: Using a sentence to set up a password is a good way to make a password strong against dictionary attacks.

Question 5:

Which of the following would make a good sentence for a password?

- (a) "I can do anything? Even shuffle all the cards!" (Correct)
- (b) "May the force be with you."
- (c) "You're a wizard, Harry!"
- (d) "Somebody once told me, the world is gonna roll me."

If incorrect: The choice of sentence for a password should be memorable like these, but it shouldn't be something popular like a song or movie quote.

Question 6:

Which of the following is a characteristic of phishing attacks?

- (a) Targeting individuals to obtain sensitive information (Correct)
- (b) Targeting only computer systems
- (c) Typically involving physical intrusion
- (d) Exclusively conducted through social media platforms

If incorrect: Phishing attacks target people and are done through a wide array of places such as email, SMSs or social media.

Question 7:

Which is not a common way through which phishing attacks may occur?

- (a) Physical letters (Correct)
- (b) Email
- (c) SMSs
- (d) Web pages

If incorrect: Due to how quickly, and how automated, phishing attacks can be done, sending a message through email or SMS, or even creating a fake website, is most common.

Question 8:

What is NOT a way to spot a phishing link or account?

- (a) Looking for a business you know (Correct)
- (b) Misspelling in the account name.
- (c) Extra letters where there shouldn't be
- (d) Switching letters for other letters or numbers

If incorrect: Spelling mistakes, extra letters and switched or swapped characters are common ways used to impersonate an account. If you look for a business name you know, the link may still be bad. For Example, while google.support@email.com looks legitimate, such a google account would use gmail.com as the domain and has misspelled support.

Question 9:

How can phishing attempts often be identified?

- (a) They may exhibit signs of rushing the recipient (Correct)
- (b) They always come from a businesses
- (c) They are impossible to detect
- (d) They are exclusively caught by automated systems

If incorrect: Remember, automated systems may miss some phishing attempts and attackers can also impersonate people, not only businesses. They also try to rush you and have questionable account names imitating legitimate ones.

Question 10:

Which of the following is NOT an aim of phishing?

- (a) To provide you with free software (Correct)
- (b) To get you personal information
- (c) To gain access to one of your accounts
- (d) To get you to download malware

If incorrect: Phishing attempts aim to get your information, account and password or to download malware. Providing you with free software may be the claim made in a phishing attack, but it is not an aim.

Question 11:

You get an email from your friend, Digibot, through your school emails. Which of the following emails would you trust?

- (a) Digibot@school.edu (Correct)
- (b) Digibot@school1.edu
- (c) Digiboot@school.edu
- (d) Digibot@school.com

If incorrect: Always be vigilant for accounts adding extra letters, "Digiboot", using a different domain, "school.com". or swapping out letters, "school1". While these could be blatant, swapping out an lower case L for an upper case i might be difficult to see.

Question 12:

What is the primary purpose of ransomware?

- (a) To demand payment for regaining access to the computer (Correct)
- (b) To render a computer unusable
- (c) To delete random files
- (d) To steal sensitive data

If incorrect: While ransomware does make a computer unusable, the main goal of it is to get payment from a victim.

Question 13:

What is a common function of spyware?

- (a) Stealing data and monitoring user activity (Correct)
- (b) Making a computer unusable
- (c) Deleting random files
- (d) Encrypting files and demanding ransom

If incorrect: Spyware is made to spy on you, see what you are doing and access information and send it to the attacker.

Question 14:

What caution should individuals exercise when downloading files from the internet?

- (a) Only download files from known and trusted sources (Correct)
- (b) Ignore the source of the file if it looks legitimate
- (c) Avoid files with extensions like ".exe" altogether
- (d) Always share downloaded files with others for verification

If incorrect: Files downloaded online should only come from a known and trusted source. You can't ignore all exe files as some are legitimate and you should never send files you are suspicious of to others and rather delete them.

Question 15:

Why is it advised to be cautious when downloading files with the ".exe" extension?

- (a) Because the source of the file matters; files from unknown sources may be malware (Correct)
- (b) Because all files with ".exe" extension are malware
- (c) Because ".exe" files are harmless and should be freely downloaded
- (d) Because ".exe" files are exclusive to malicious websites

If incorrect: A file being an exe file is not enough to call it malware, where it comes from is an important factor to consider.

C Research Article 1

19th International Conference on Cognition and Exploratory Learning in Digital Age (CELDA 2022)

LINKING GAMIFICATION, LUDOLOGY AND PEDAGOGY: PRINCIPLES TO DESIGN A SERIOUS GAME

Joshua Esterhuizen, Günther Drevin, Dirk Snyman and Lynette Drevin
School of Computer Science and Information Systems, North-West University, Potchefstroom, South Africa

ABSTRACT

Education is shifting towards a more technology focused mode of delivery, or at least combining technology use with standard methods. A potential effect of this could be the introduction and use of games in classrooms. This study looks at the possibility of adapting various domains of knowledge into digital games referred to as serious games. The implementation of serious games within teaching may help keep certain students engaged with the content being presented and create further interest in the topic. However, before reaching this stage the means to transform these knowledge domains into serious games must be studied. This is done by focusing on three fields: gamification, ludology, and pedagogy. Through the use of a literature analysis, both a literature review and a focus on previous implementations, several key principles for the design of a serious game were identified, namely reflection, feedback, a story-based environment, and thorough structuring of content. These principles stem from the design choices of the previous implementations and pedagogical theories - Merrill's First Principles and the ARCS model. The aim of the study is to investigate the possibility of using digital games as a means to encourage learning in teaching environments.

KEYWORDS

Education, Gamification, Ludology, Pedagogy, Serious Games

1. INTRODUCTION

In the years leading up to the new century there was a shift into the "information age". This age is characterised by the fact that information is being transmitted and generated at an ever-increasing rate due to further technological developments (Gibson *et al.*, 2006; Reigeluth, 1996). The most notable changes from the previous "industrial age" are that the previous focused on conformity and compliance while initiative and diversity – where greater value is placed on each individual's strengths and contribution to a project or organisation – is the focus of the information age (Reigeluth, 1996).

Due to these aforementioned paradigm shifts between the ages, and in what requirements are desired by most organisations in the information age, a shift in instructional theory is also taking place. With the recent developments in technology and the fact that technology in general is becoming more accessible, many institutions have adopted some forms of digital learning or supplemented traditional teaching with digital assistance such as having virtual sessions of a class and having courses entirely online (Tirziu & Vrabie, 2015).

Deshpande and Huang (2011) state that the current generation of students is the first to grow up with abundant access to technology. On average, these students spend almost double the time playing video games that they do reading (Deshpande & Huang, 2011). Virvou, Katsionis and Manos (2005) echo the point that computer games are popular among individuals who are in schools and as such could provide a means to deliver content in an interesting and engaging manner. The movement for the inclusion of digital games to be used in teaching and training environments first started in 2003, two years after the field of *ludology*, the study of games, began to gain traction in academic literature (Annetta, 2008). This initiative is what started the concept of a serious game as one that can be used in an academic sense to relay information. Furthermore, gamification has recently garnered focus from a technology specific view and due to the use of game elements, it can have an impact on how a serious game is designed albeit the result of a digital gamified environment differs to a serious game (Kalogiannakis *et al.*, 2021).

ISBN: 978-989-8704-43-6 © 2022

As such, the motivation behind this study is to further investigate the possibility of using digital serious games as a means to encourage learning in teaching environments due to the aforementioned interest and uptake of digital technologies in education as well as the potential improvements they can bring (Zourmpakis *et al.*, 2022). This study aims to present a set of design principles for serious games through answering the question *what qualities are required for a serious game to be effectively used in an educational environment on several topics*. This will be accomplished through a literature analysis focusing on the fields of ludology, gamification, and pedagogy with a focus on Merrill's First Principles and the ARCS Model resulting in the synthesis of design principles.

2. RESEARCH METHODOLOGY

This research study primarily made use of a literature analysis to answer the aforementioned primary question. This was done in two major phases. The first is that of a literature review on the fields of ludology, gamification, and pedagogy while the second focused on previous implementations of serious games. Firstly, the three key fields were studied, and notable definitions and theories were selected. These were used to provide an informed background on what design principles to look for. Following this, the design principles of the previous implementations were noted down and then compared with each other and the major ones identified and then, with the information from the literature review, expanded upon.

3. LITERATURE REVIEW

3.1 Serious Games and Ludology

Ludology is the formal and academic study of games and has roots in studying games through a cultural and social lens by discussing how each interacts with the so-called "spirit of play" (Huizinga & Hull, 1949). The field also encompasses the study of digital computer-based games and has a focus on discussing and understanding the individual elements of games as well as creating models to explain the various mechanics and rules of games (Frasca, 2013). As such, this study will use the definition that, "*Ludology can be defined as a discipline that studies games in general, and video games in particular*" (Frasca, 2013, p. 222). Serious games were introduced as a concept in 2002 with the intention of them to be used as a means of training certain tasks and skills which was typically done through simulation type games (De Gloria *et al.*, 2014).

Simulations attempt to model reality in a consistent manner usually through modelling physical or social systems through another system which in this case would be a computer and the digital video game (Squire, 2003). There are two main types of simulations – high fidelity and low fidelity. High fidelity simulations attempt to model every interaction in a given system, phenomena, or environment as accurately as possible (Squire, 2003). In contrast, a low fidelity simulation will make use of a fair bit of abstraction as it aims to only demonstrate a few key characteristics of the phenomena or environment (Squire, 2003). Games as simulations would comprise of both of these types depending on the content that it attempts to simulate.

The endeavour to create serious games has yet to reach schools due to certain criticisms about games in general that hinders this (Virvou *et al.*, 2005). While this was previously due to the fact that discussions around games by educators focused on the social consequences of playing games (Squire, 2003) it may now be due to the resources required for a serious game to be developed (Helms *et al.*, 2015). Thus, the study of serious games became more theoretical and discussion-based at lower levels and more applied with actual use at higher levels. This can be seen by implementations in several fields including medical rehabilitation, ecological studies, learning languages, and business studies (Burke *et al.*, 2009; Costanza *et al.*, 2014; Ranalli, 2008; Tao *et al.*, 2009). These types of games have already had an impact on the military, medical, and higher education sectors early in their conception and this trend continues to this day with serious games being used within the medical fields specifically (Annetta, 2008; De Gloria *et al.*, 2014).

3.2 A Pedagogical Understanding

Pedagogy is the field that deals with the transferral of knowledge in an educational environment through several lenses such as social, political, and cultural (Li, 2012). As such it encompasses the themes and discussions of instructional design and theory as well as any learning theories.

Learning by doing functions on the principle that skills can be improved through practice and self-perfection on a particular topic or knowledge base (Fisch *et al.*, 2009). This means of instruction has become increasingly popular amongst companies where they are able to make use of “on the job” training as it allows for a person to be productive immediately as well as become more proficient at tasks gradually (Fisch *et al.*, 2009). The learning by teaching method works under the assumption that learners are able to increase their understanding of a certain topic by teaching it to other learners (Fisch *et al.*, 2009). This method of learning garners more usage in environments with too few teachers and increases the overall learning process (Fisch *et al.*, 2009). Learning methods that place the learner in control are very flexible and as such can be incorporated when attempting to teach various and different fields or subjects (Ackoff, 1991).

Gibson *et al.* (2006) list several learning and instructional design theories that have the potential to be applied to a game used for learning. This study will, however, only look at Merrill’s *First Principles of Instruction* as it is the most recent (Gibson *et al.*, 2006). Before discussing the principles that the name refers to in this theory, Merrill (2002) provides a few definitions for the terms that are used. A *Principle* in this context is a relationship that is always true regardless of the environment it is applied within. A *Practice* is any instructional activity. A *Program* is a means of instruction that makes use of several practices (Merrill, 2002). These first principles described are able to be implemented in any instructional system or environment as they are “design-oriented” and as such relate more to creating learning environments rather than describing the means of knowledge transfer. Each of the following principles is also accompanied by three “corollaries” each of which Merrill (2002) likewise explains:

The first principle is that the learning is problem centred. This principle describes three corollaries, the first of which being “Show Task” which states that learners should be shown the types of problems they will be able to solve with the knowledge that they attain. The next is the “Task Level” which explains that the problems presented should keep learners engaged due to the complexity and not just the action of solving it. The last corollary, “Problem Progression” describes that the problems presented should have some form of increasing complexity while still being comparable to the previous iteration of the type of problem (Merrill, 2002).

The second principle is “Activation” which means that learning happens whenever previous experiences are used. The first corollary, “Previous Experience”, states that the learning process is enhanced when a learner is able to draw upon relevant past experiences and apply the associate knowledge as a foundation for new knowledge. “New Knowledge” is the second and explains that learners should be provided with a relevant experience as an additional foundation to add to their knowledge base. The last corollary is “Structure” and details that learners should be encouraged to organise new knowledge according to some relevant structure (Merrill, 2002).

The third principle, Demonstration, proposes that learning takes place when the activities that are undertaken impart the knowledge instead of stating the information. “Demonstration Consistency” explains that any examples or visualisation should be kept in line with the original learning goals. The next is “Learner Guidance” and states that learners should be shown where the relevant information for problems can be found be it in the form of comparative examples or various representations of one source. “Relevant Media” explains that when media is used as a means of demonstration, distinct types can be used provided that they do not fight for a learner’s attention (Merrill, 2002).

The fourth principle is Application which states that learning takes place when learners actively solve problems with the new knowledge they have acquired. “Practice Consistency” is similar to Demonstration consistency but with a focus on the application of knowledge. “Diminishing Coaching” is where the learners are provided with relevant feedback, but it is slowly lessened over time. It is also important that the problems provided to learners for practice have a good variety, defined under “Varied Problems” (Merrill, 2002).

The fifth, and final, principle is Integration which is when the knowledge a learner has acquired is used by them in their everyday life. The first corollary, “Watch Me”, explains that learners are provided to showcase the new knowledge or skill they have acquired. “Reflection” deals with giving learners time to be able to

ISBN: 978-989-8704-43-6 © 2022

debate with others on the topic involved. Lastly, “Creation” states that learners should be able to make use of their new knowledge or skill in some personal capacity (Merrill, 2002).

The principles and corollaries provided by Merrill (2002) provide an expansive and detailed structure to be used when developing any learning opportunity making it an exceptional choice to adapt specifically for a digital game learning environment. It does, however, lack a comprehensive discussion on how to keep learners engaged with the content and, as such, this will be discussed with some theories pertaining to the role of motivation in learning.

One model for motivating learners is the **ARCS** Model which was developed by John Keller (1987) which is frequently referenced in the aforementioned field of instructional design (Kapp, 2012a). It comprises four main elements with each focusing on designing instruction in a different way (Kapp, 2012a; Keller, 1987).

The first of these is Attention and it is an element that is concerned with gaining and then keeping the learners’ interest. There are three main methods to accomplish this: gaining Attention through the use of examples, create curiosity within the learners through means such as role-playing or hands-on examples, and variability which means periodically changing the method of delivery (Kapp, 2012a; Keller, 1987).

Relevance refers to having the content be relevant to the learner (Keller, 1987). Kapp (2012a) mentions that this can be done through orienting the environment around achieving goals, creating a link between the motives of learners and that of the instruction means, displaying that the content is familiar to the learners and finally developing a model of the results of learning the presented knowledge (Keller, 1987).

Another element of this model, Confidence, is the expectations of success set by the learner and as such when they meet these expectations, they are confident in their ability to do the work (Kapp, 2012a; Keller, 1987). This can be aided by providing learners with clear expectations and requirements upfront about the required skill or knowledge. It is also helpful to provide smaller opportunities to succeed as with each success the learners will become more confident (Kapp, 2012a; Keller, 1987).

The last element in the ARCS model is Satisfaction and is concerned with giving learners a sense of accomplishment and that the effort in the learning process has some value and weight to it (Kapp, 2012a; Keller, 1987). This can be accomplished by allowing learners to see how their new-found knowledge can be used, either through the use of a real-world demonstration or via some form of simulation (Kapp, 2012a; Keller, 1987).

3.3 Gamification and the Knowledge Domains

Gamification can be defined as making use of game-like mechanics, aesthetics, and thinking to create motivation, solve problems and produce a more suitable learning environment (Kapp, 2012a). Kapp (2012b) states that while gamification makes use of game elements, it only makes use of a few of them as in a gamified system. In a gamification context, learners are not constantly engaged in playing the game as there are sections of respite from this, such as video explanations. While elements such as points and achievements are found in most games, gamification strives to add more than just these to a classroom. The absence of other elements contributes to a resulting system that is dull (Kapp, 2012b).

Gamification is often not implemented within a classroom but is rather presented to learners through some external means (Kapp, 2012b). It should be noted, while a digital gamified environment is the result of gamification and differ from serious games (Kapp, 2012a), the use of game elements within one such environment results in this field being one of interest when discussing serious games as the understanding of these systems from a gamification standpoint may prove beneficial to the design of a serious game such as with the ability gamification provides to create problems relative to a students’ skill level (Zourmpakis *et al.*, 2022). The main difference between these two systems is that learning is more direct in a serious game as the content causes learning while in gamification learning is done indirectly (Kalogiannakis *et al.*, 2021).

Kapp (2012a) describes various types of knowledge and how to begin developing a gamified system to effectively teach each of them. This provides the groundwork for answering the question this study poses and as such allows for a more in-depth discussion on how to implement serious games. Table 1 describes the knowledge domains.

One important aspect to note about these knowledge domains is that they are not mutually exclusive as one particular topic can be placed in several of them as the components of that topic may require multiple domains to be properly contained under them. Kapp (2012a) also provides some ways that each domain can be taught to best relay that particular type of knowledge. While these recommendations are derived under a gamification perspective (Kapp, 2012a), they can also be applied for a digital game as shown in Table 1.

19th International Conference on Cognition and Exploratory Learning in Digital Age (CELDA 2022)

Table 1. Knowledge Domain Recommendations (Kapp, 2012a)

Knowledge Domain	Description	Recommendation
Declarative Knowledge	Facts and jargon within a topic	Sorting games
Conceptual Knowledge	Grouping of related information with an underlying common descriptor	Demonstrations and sorting type games
Rules-Based Knowledge	Strict statements linking concepts	Demonstration of failure when not complying with the rules
Procedural Knowledge	Progression-based path to reach an outcome	Working through the procedure
Soft Skills	General strategies for dealing with various social interactions	Repeated application of a skill within various scenarios
Affective Knowledge	Subjective phenomena	Immersing the learner within a phenomenon
Psychomotor Domain	Making use of cognitive knowledge through physical skills	Observation

4. ANALYSIS OF PREVIOUS IMPLEMENTATIONS

In addition to looking at the aforementioned academic fields, it is also vital to look at how previous serious games were designed, and which principles are most commonly used. Several studies (Allers *et al.*, 2021; Dincelli & Chengalur-Smith, 2020; Sheng *et al.*, 2007) were examined in which some form of a gamified system or serious game was developed in addition to the author(s) detailing what design principles were followed during the development process.

The first of these is titled, "*Choose your own training adventure: designing a gamified SETA artefact for improving information security and privacy through interactive storytelling*" and focused on developing a gamified system to teach employees about security issues with a focus on social media and social engineering (Dincelli & Chengalur-Smith, 2020). For the development of the artefact, Dincelli and Chengalur-Smith (2020) made use of literature from instructional theory and gamification and, as a result, made use of a few key design principles. The first design principle followed is that the gamified system should make use of a story-based agent (Dincelli & Chengalur-Smith, 2020). This means that a game should include some figure or character to guide users through the content as well as making use of storytelling in some capacity which is found to create curiosity within users (Dincelli & Chengalur-Smith, 2020; Kapp, 2012a). The second design principle used was that of reflection which states that users should be given a moment of respite to comprehend on what has been presented to them (Dincelli & Chengalur-Smith, 2020; Sheng *et al.*, 2007). Feedback on various metrics of a user's performance is also a design principle which allows for users to perform self-evaluation (Dincelli & Chengalur-Smith, 2020).

The findings of this case study were that making use of a gamified system that used either visual stimuli or text were better at relaying information than traditional means. Visual stimuli were better than text in terms of recognition, recollection and ease of learning and they performed similarly in terms of recall, satisfaction, and usability (Dincelli & Chengalur-Smith, 2020).

The next case study is titled "*Anti-phishing Phil: the design and evaluation of a game that teaches people not to fall for phish*" and focused on teaching people about phishing and how to avoid becoming a victim to these attacks (Sheng *et al.*, 2007). Sheng *et al.* (2007) made use of learning science theories in the development of the game and to refine the various iterations throughout the development process. The first two design principles discussed are reflection and story-based agent environment. These have already been mentioned in the previous case study. Additionally, feedback is also discussed in this study but specifically how it was implemented. Anti-phishing Phil makes use of feedback both during, though displaying a short message for each choice made, and after a round of the game, through a score sheet and brief explanation of the links used. The next design principle followed is the procedural-conceptual principle. This principle states that these two knowledge domains, conceptual and procedural, hold a mutually supportive influence over the other. In practice, and thus the development of a serious game, this means that learners should be given context to the processes they are being taught as without the context they may incorrectly apply them (Sheng *et al.*, 2007).

ISBN: 978-989-8704-43-6 © 2022

The findings of Anti-phishing Phil showed that the serious game approach made users more knowledgeable on the topic and how to go about dealing with phishing. While the game was a success it falls behind in the aspect that some users may become more susceptible to phishing as the game provided a fixed number of indicators to be aware of (Sheng *et al.*, 2007).

The final case study used is titled "*Children's Awareness of Digital Wellness: A Serious Games Approach*" and was targeted towards teaching children, particularly pre-schoolers, about digital wellbeing and fostering cyber security awareness through a mobile-based serious game, which will be referred to as *Digital Wellnests* (Allers *et al.*, 2021). This case study focused on the design and research needed for such a serious game and stated that future work could include the development and deployment of the game (Allers *et al.*, 2021).

While this case study (Allers *et al.*, 2021) made use of instructional theory targeted towards preschool children (Callaghan & Reich, 2018; Matthews *et al.*, 2007) some of the frameworks and learning theory used can also be applied to all serious games. The first design principle followed was simplicity as it allows a user to follow the content adequately and as such learn effectively (Allers *et al.*, 2021). The study goes on to cite Matthews *et al.* (2007) on the ways children tend to learn which includes Observation, Listening Exploring, Experimentation and Asking questions. Learning through play, such as a serious game, is an effective way to implement all of these methods (Allers *et al.*, 2021) and as such provides an additional framework targeted specifically at younger children as opposed to the previous studies (Dincelli & Chengalur-Smith, 2020; Sheng *et al.*, 2007) which were focused on adults. While this does not provide direct principles to follow during the design process, including ways for these methods of learning to be present in a serious game should be taken into consideration. In addition to the above, the study also made use of several elements identified by Callaghan and Reich (2018) which are based on how young children learn. The first of these is clear and simple goals which is concerned with presenting a user with concise outcomes to work towards (Callaghan & Reich, 2018). Similarly with Anti-phishing Phil (Sheng *et al.*, 2007), is the element of quality of feedback and rewards which deals with how feedback is presented to a user - for example, pre-schoolers may not yet be able to read and as such, the feedback must be structured accordingly (Allers *et al.*, 2021). The next element is structure of the challenge consisting of setting the difficulty of tasks and changing the difficulty depending on how the user is performing (Callaghan & Reich, 2018). This element can also be described using some of the corollaries from Merrill's First Principles (Merrill, 2002) - which will be discussed in the following section. The last element Callaghan and Reich (2018) is that of Motion based learning which describes the physical interaction a user will have with applications which in this case would be designing larger touch controls to account for a preschool child's current level of motor functions. This particular aspect is certainly vital when dealing with any knowledge from the psychomotor domain.

As previously mentioned, this case study has not yet developed the serious game and as such cannot be evaluated by users. However, an expert review was conducted on the design of this serious game of which the outcomes were positive as the reviewers "found the implementation of each element was satisfactory, but there is still room for improvement" (Allers *et al.*, 2021).

The following table visualizes the major design principles of each case study.

Table 2. Design Principles Defined by Case Study (Allers *et al.*, 2021; Dincelli & Chengalur-Smith, 2020; Sheng *et al.*, 2007)

SETA Artifact	Anti-Phishing Phil	Digital Wellnests
Story-based	Story-based	Simplicity
Reflection	Reflection	Clear and simple goals
Feedback	Feedback	Quality of feedback
	Conceptual-Procedural	Structure of the challenge
		Motion-based interaction

5. SYNTHESIS FROM RESEARCH

From the literature and case studies examined, there are several key qualities that are common either under the same descriptor or with similar descriptions with different names. It is these qualities that will form the basis to answer the research question of this study.

The first quality, reflection, is shared amongst Merrill's First Principles (Merrill, 2002) and two of the case studies (Dincelli & Chengalur-Smith, 2020; Sheng *et al.*, 2007) and is vital to a serious game if intended to be used in an educational environment. Reflection is described as giving a user time after being presented with new knowledge or a task to garner a better understanding through internalisation.

The second quality a serious game should make use of is that of feedback. All of the case studies (Allers *et al.*, 2021; Dincelli & Chengalur-Smith, 2020; Sheng *et al.*, 2007) and Merrill (2002) refers to it under the diminishing coaching corollary. A user should be presented with feedback on how they are progressing on a given set of tasks within the game. As they progress, the amount of feedback should be slowly diminished. The feedback amount should also be tied to the performance of the user - increasing if they begin to struggle and decreasing if not. Since feedback can take on many different forms, the type of feedback, as well as the method of delivery, is dependent on the topic being taught. As part of this quality, a serious game should also be designed to create an environment in which users are able to complete smaller tasks and are rewarded for these smaller successes as per the ARCS model (Keller, 1987).

Another quality that should be implemented is that the serious game should showcase and teach topics through the use of storytelling. The case studies (Allers *et al.*, 2021; Dincelli & Chengalur-Smith, 2020; Sheng *et al.*, 2007) all mention the use thereof. The ARCS model (Keller, 1987), specifically under the attention element, also states that this is a proponent of keeping users engaged. A game should then allow for a story to take place during the teaching of a topic which can also be done in several ways - such as contextually with *Anti-phishing Phil* (Sheng *et al.*, 2007) or as the main focus of the topic as with the SETA artefact (Dincelli & Chengalur-Smith, 2020) and *Digital Wellness* (Allers *et al.*, 2021). Another means to accomplish this is to make use of an agent that guides the user through the game which can be used in accordance with the "Learner Guidance" corollary from Merrill's First Principles (Merrill, 2002).

The last major quality a serious game should possess is that of structuring. This quality refers to the content the game will deal with in terms of the instructions given as well as how the difficulty of problems could progress. It is derived from both Merrill's First Principles (Merrill, 2002), the ARCS model (Keller, 1987), and the framework by Callaghan and Reich (2018). From the ARCS model (Keller, 1987), specifically Confidence, and Callaghan and Reich's (2018) framework it is clear that a serious game should be structured with simple goals and clear expectations for the user and by structuring a game's instructions in this manner the user will be motivated to continue playing and therefore learning. The problems and tasks within the game should be increasing in difficulty as a user gets them correct and lowering the difficulty when they are struggling to keep engagement once again with the game at a high level. Merrill's First Principles (Merrill, 2002) discusses this quality in several principles and their subsequent corollaries with some referring to the difficulty scaling mentioned above. As such, a serious game's structure should be centred around the problems themselves or the knowledge being taught when dealing with affective knowledge and soft skills. The tasks given to a user should be both varied to keep the users' attention as well as be consistent in the ways the user interacts with them. This approach should keep users motivated to use the game according to the ARCS model (Keller, 1987) as it makes use of both the Attention and Relevance elements.

While the remaining aspects of the pedagogical theories and design principles from the case studies are also useful in the implementation of a serious game, they are specific to the content being taught and as such should be considered in greater detail if a similar game to those were to be developed. Kapp's (2012a) recommendations are a helpful starting point on how to effectively teach content relating to the knowledge domains. Referring back to Squire's (2003) descriptions of games as simulations - both high fidelity and low fidelity - these types of serious games are certainly the most useful for teaching content found in the affective, soft skills, and psychomotor domains since the best means to teach these is through immersing the user in the phenomena, repeated application of skills and observation respectively (Kapp, 2012a). Simulation-type serious games can also be used in the other domains (teaching physics as described by Deshpande and Huang (2011)). These types of games are also the most effective means for the psychomotor domain as shown by various studies (Burke *et al.*, 2009; Costanza *et al.*, 2014; Ranalli, 2008; Tao *et al.*, 2009).

ISBN: 978-989-8704-43-6 © 2022

The remaining knowledge domains tend to have some heavy overlap depending on the topic being covered. Sheng *et al.* (2007) discussed the Conceptual-Procedural principle in their game's development. To reiterate, it simply states that a topic cannot be fully understood from only the procedures or context - both are needed for a deeper understanding. As such, if the recommendations for one domain do not translate well into a digital game, the recommendations for another may.

Earlier works attempting to accomplish something similar have also identified some of the above principles. Helms *et al.* (2015) provide a "Educational Game Element Database" which includes mentions of a storyline, challenge, and feedback where challenge can refer to the structuring principle mentioned above. Additionally, Quinn (2005) discusses many approaches to designing e-learning game simulations and mention the importance of a storyline, adjusting the challenge, feedback, and reflection all of which are above.

6. LIMITATIONS AND FUTURE WORK

This study made use of various fields of academia as well as studies of serious games and their design in order to answer the research question. The current limitations on answering this question centre around the amount of literature sourced. The fields (pedagogy, ludology, and gamification) discussed seem to be sufficient in terms of what literature can be used and as such it is the specific literature used that imposes limitations. There are many more instructional theories that could be considered and as such future research could delve into more theories and expand the supporting knowledge base. Another limitation comes from the case studies used. All of the main case studies discussed in this article had a focus on computer security to varying degrees. Due to this, future research could include case studies on the design, implementation, or development of serious games in other fields as the findings may not generalise to certain topics or domains. These design principles provide the possible foundation for a further framework that could be devised and used for serious game design in general as opposed to specifically for one type of game. The principles presented account for major sections of serious game design but lack specifics on the more intricate aspects.

In terms of future research, a more practical approach could include the development of a serious game on a topic based on one of the knowledge domains mentioned. This could include the development of an artefact for user testing, similarly to *Anti-phishing Phil* (Sheng *et al.*, 2007), based on the findings of this study or the designing of such an artefact more in line with the *Digital Wellnests* game (Allers *et al.*, 2021). Future research could also include looking at several types of games and how they could teach content in the different knowledge domains to build upon Kapp's (2012a) recommendations.

7. CONCLUSION

This study discussed the shift educational institutions are making towards including more technology in the teaching process. As such, research into how serious games can be used in an educational environment was conducted with a specific focus on the fields of pedagogy, ludology, and gamification in order to answer the question, what qualities are required for a serious game to be effectively used in an educational environment on assorted topics. Furthermore, several research papers were used as case studies to discover what design principles are typically followed in the development of serious games. This information was then used to identify what are the major qualities which a serious game should have in order to be effective in an educational environment as well as provide specific recommendations for various knowledge domains. The qualities identified were allowing for reflection, providing feedback, making use of story elements and a well thought out structuring of the game.

REFERENCES

- Ackoff, R. L. (1991). Teaching versus learning. *Systems practice*, 4(3), 179–180.
- Allers, J., Drevin, G., Snyman, D., Kruger, H., & Drevin, L. (2021). Children's awareness of digital wellness: A serious games approach. *IFIP World Conference on Information Security Education*, 95–110.

19th International Conference on Cognition and Exploratory Learning in Digital Age (CELDA 2022)

- Annetta, L. A. (2008). Video games in education: Why they should be used and how they are being used. *Theory into practice*, 47(3), 229–239.
- Burke, J. W., McNeill, M., Charles, D., Morrow, P., Crosbie, J., & McDonough, S. (2009). Serious games for upper limb rehabilitation following stroke. *2009 Conference in Games and Virtual Worlds for Serious Applications*, Washington DC, United States, 103–110.
- Callaghan, M. N., & Reich, S. M. (2018). Are educational preschool apps designed to teach? an analysis of the app market. *Learning, Media and Technology*, 43(3), 280–293.
- Costanza, R., Chichakly, K., Dale, V., Farber, S., Finnigan, D., Grigg, K., Heckbert, S., Kubiszewski, I., Lee, H., & Liu, S. (2014). Simulation games that integrate research, entertainment, and learning around ecosystem services. *Ecosystem Services*, 10, 195–201.
- De Gloria, A., Bellotti, F., & Berta, R. (2014). Serious games for education and training. *International Journal of Serious Games*, 1(1).
- Deshpande, A. A., & Huang, S. H. (2011). Simulation games in engineering education: A state-of-the-art review. *Computer applications in engineering education*, 19(3), 399–410.
- Dincelli, E., & Chengalur-Smith, I. (2020). Choose your own training adventure: Designing a gamified seta artefact for improving information security and privacy through interactive storytelling. *European Journal of Information Systems*, 29(6), 669–687.
- Fisch, D., Janicke, M., Kalkowski, E., & Sick, B. (2009). Learning by teaching versus learning by doing: Knowledge exchange in organic agent systems. *2009 IEEE Symposium on Intelligent Agents*, Nashville, TN, USA, 31–38.
- Frasca, G. (2013). Simulation versus narrative: Introduction to ludology. In *The video game theory reader*, pp. 221–235.
- Gibson, D., Aldrich, C., & Prensky, M. (2006). *Games and simulations in online learning: Research and development frameworks*. IGI Global.
- Helms, R. W., Barneveld, R., & Dalpiaz, F. (2015). A Method for the Design of Gamified Trainings. In *2015 Proceedings of the Pacific Asia Conference on Information Systems*, Singapore, 59.
- Huizinga, J., & Hull, R. F. C. (1949). *Homo ludens: a study of the play-element in culture*. [translated by rfc hull]
- Kalogiannakis, M., Papadakis, S., & Zourmpakis, A. I. (2021). Gamification in science education. A systematic review of the literature. *Education Sciences*, 11(1), 22.
- Kapp, K. M. (2012a). *The gamification of learning and instruction: Game-based methods and strategies for training and education*. John Wiley & Sons
- Kapp, K. M. (2012b). What is gamification. *The gamification of learning and instruction: gamebased methods and strategies for training and education*, 1–23.
- Keller, J. M. (1987). Development and use of the arcs model of instructional design. *Journal of instructional development*, 10(3), 2–10.
- Li, G. (2012). *Culturally contested pedagogy: Battles of literacy and schooling between mainstream teachers and asian immigrant parents*. Suny Press.
- Matthews, D., Lieven, E., & Tomasello, M. (2007). How toddlers and preschoolers learn to uniquely identify referents for others: A training study. *Child development*, 78(6), 1744–1759.
- Merrill, M. D. (2002). First principles of instruction. *Educational technology research and development*, 50(3), 43–59.
- Quinn, Clark. (2005). *Engaging Learning: Designing e-Learning Simulation Games*. John Wiley & Sons.
- Ranalli, J. (2008). Learning english with the sims: Exploiting authentic computer simulation games for l2 learning. *Computer Assisted Language Learning*, 21(5), 441–455.
- Reigeluth, C. M. (1996). A new paradigm of isd? *Educational technology*, 36(3), 13–20.
- Sheng, S., Magnien, B., Kumaraguru, P., Acquisti, A., Cranor, L. F., Hong, J., & Nunge, E. (2007). Anti-phishing phil: The design and evaluation of a game that teaches people not to fall for phish. *Proceedings of the 3rd symposium on Usable privacy and security*, Pittsburgh, Pennsylvania, USA, 88–99.
- Squire, K. (2003). Video games in education. *Int. J. Intell. Games & Simulation*, 2(1), 49–62.
- Tao, Y.-H., Cheng, C.-J., & Sun, S.-Y. (2009). What influences college students to continue using business simulation games? the taiwan experience. *Computers & Education*, 53(3), 929–939.
- Tirziu, A.-M., & Vrabie, C. (2015). Education 2.0: E-Learning Methods. *Procedia - Social and Behavioral Sciences*, 186, 376–380.
- Virvou, M., Katsionis, G., & Manos, K. (2005). Combining software games with education: Evaluation of its educational effectiveness. *Journal of Educational Technology & Society*, 8(2), 54–65.
- Zourmpakis, A. I., Papadakis, S., & Kalogiannakis, M. (2022). Education of preschool and elementary teachers on the use of adaptive gamification in science education. *International Journal of Technology Enhanced Learning*, 14(1), 1–16.

D Research Article 2

DESIGN CHOICES AMONG RECENT SECURITY RELATED SERIOUS GAMES

J. Esterhuizen¹, L. Drevin¹, G. Drevin¹, D. Snyman²

¹North-West University (SOUTH AFRICA)

²University of Cape Town (SOUTH AFRICA)

Abstract

Serious games provide a more fun and engaging manner of training and learning and are seeing use within the digital security field. These games are all designed differently with diverse target audiences in mind, a mix of design choices and frameworks utilised, various game types developed, and a vast array of topics covered in them. As such, there are bound to be similarities in these games as many of them use a similar design philosophy or focus on the same topic. From this, there are some key design choices made by the developers, albeit across many frameworks or taken from other fields of academia. As such, the most commonly used design factors used within this sect of serious games are identified in this paper through an extensive literature review. Furthermore, this paper can be used as a reference point for serious game designers, developers, and researchers to utilise when designing or developing a serious game, or a framework, as it provides information on different design choices utilised over the last five years within security-related serious games.

Keywords: Design Frameworks, Digital Security, Literature Review, Serious Games.

1 INTRODUCTION

Access to technology and personal devices is ubiquitous currently [1]. Due to this, users must be aware of the threats that come with this and how they can protect themselves from such threats. Additionally, professionals in various sectors of the technology industry, such as developers, must also be aware of and set measures in place to mitigate any threats. Due to the sheer number of threats and means they can be encountered, it is important that the aforementioned groups know what is happening in the world of security, which can be difficult as it is constantly changing.

One method that has seen success in training and teaching people about many topics, such as security, is that of serious games [2, 3]. These are games which are designed and developed for a purpose other than entertainment, such as instruction [4]. Serious games can also take on many different forms ranging from analogue games requiring physical items to a purely digital game played on a device.

From this overlap of serious games and security education, this paper aims to review the recent developments within serious games that focus on security-related topics and attempt to identify any common design choices which developers and researchers are trending towards. As such, the research question this paper aims to answer is, "*What are the most used design choices across security-related serious games over the last five years?*" From this question, this paper's contribution is that it will act as a collection of information on the design choices used for developing a security-focused serious game through an extensive literature review that can be used as a reference point for and give guidance to developers and researchers when developing a serious game. Additionally, focus is given to serious games from the last five years as it provides information on what the most recent design choices are when developing a serious game.

2 DEFINING TERMS

As this paper details serious games, the field of ludology is important. Ludology is the academic field of studying games, beginning with a focus on studying games through a cultural and social lens and how games interact with the "spirit of play" [5]. The field includes digital games and has a focus on examining the elements used to design games as well as developing models and ontologies to explain various mechanics and rules of games [4]. Serious games, both digital and analogue (or tabletop), then fall into this field and were introduced to be used as a means of training which was typically done using simulation type games [6].

Another field that is related to the use of games is gamification, which makes use of game-like mechanics, aesthetics, and thinking to create motivation, solve problems and produce a more suitable learning environment [7]. Gamification uses certain game elements, such as points, achievements, and leaderboards. Recently, gamification has been focused on from a technological viewpoint and could have an impact on how serious games are designed, albeit the outcome from this is typically a gamified digital environment [8]. A digital gamified environment is distinct from a serious game [7]. The use of game elements in a gamified environment is of interest when studying serious games as it provides a different understanding from a gamification viewpoint and may prove beneficial with an example being how gamification is able to scale the difficulty of tasks to a user's skill level [9].

The main difference between the two systems is that with serious games learning occurs in a more direct manner as the content of the game is what causes learning and in a gamified environment the learning happens indirectly [8].

3 METHODOLOGY

The main contribution of this paper comprises a structured literature review. Therefore, the first step in finding publications, and the subsequent games, was to conduct a keyword search on multiple databases, these being Google Scholar, EBSCO Host, IEEE Xplore, and ScienceDirect.

These searches resulted in a total of 22 serious games over 23 papers. Papers were excluded if they were not published in the last 5 years (i.e., 2018-2023) to identify what are the most recent trends within security-focused serious games. Additionally, the papers had to revolve around a serious game that focuses on a specific security topic or subfield.

The process of finding papers was done as follows:

- 1 Conducting a keyword search on the databases,
- 2 Screening a paper based on the title,
- 3 Identifying and removing any duplicate papers,
- 4 Additional screening based on skimming of the papers, and
- 5 The remaining papers were studied, and certain ones removed due to heavy focus on previous works from the same authors.

For the database searches, the keywords "Serious Game", "Game", "Security", "Cyber Security", "Digital Security" and "Information Security" were used in different combinations resulting in roughly 180 papers, reduced to 60, based on title and abstract screening, and further down to 23 after getting a general overview of the papers, or skimming. Most papers used were gathered from Google Scholar as it was searched first and multiple of the already collected papers appeared in the subsequent database searches.

4 RESULTS

This paper, as mentioned, considers 22 serious games within the security field. Table 1 provides a list of what these are with the name of the serious game, the type of game, and the topics covered (if the information was provided by the papers). Of note is that the games *Persuaded* [10] and *Protect* [11] are listed under one entry as these shared design choices and corresponding authors. Additionally, *CATS* [12, 13] was developed over multiple research papers.

4.1 Design ontologies and methodologies used

Regarding the design of these serious games, only the design of the game itself is considered here. As such, design frameworks or models relating to the content of these games are not considered. An example of this is how *Riskio* [20] uses constructivism learning theory to design the game and adopts the STRIDE threat taxonomy [33] for the division of cards, where this paper will look at the use of the learning theory only. Another example is that of the *CSRAG* [32], where the use of the Firesmith Ontology [34] was used to map similar security concepts to the same content. Additionally, where possible, reference is made to the source of the design principles and frameworks.

Table 1. List of Games

<i>Game Name</i>	<i>Game Type</i>	<i>Topic Handled</i>	<i>Source</i>
"Persuaded," "Protect"	Digital (Card)	Social Engineering	[10, 11]
Unnamed	Digital	Passwords	[14]
Unnamed	Analogue (Card)	Privacy	[15]
CyberSecurity Challenges	Digital	Secure Coding (Awareness)	[16]
InfoSecure	Digital (Quiz)	Multiple IS Topics	[17]
Crypto Go	Analogue (Card)	Cryptography	[18]
Cyberspace Odyssey	Digital (Team-based, Puzzle)	Computer Network Security	[19]
Riskio	Analogue (Board, Card)	Cyber Security Education	[20]
SherLOCKED	Digital (Puzzle, Quiz)	Cyber Security Education	[21]
Passworld	Digital	Passwords	[22]
PickMail	Digital (Quiz)	Phishing	[23]
Cyber Secured	Digital (Quiz)	Multiple IS Topics	[24]
Data-Driven Security Game	Digital	Information Security	[25]
PenQuest	Analogue (Board)	Cyber Attack Awareness	[26]
Phish Phinder	Digital	Phishing	[27]
CEBT Game	Digital	Blockchain Security	[28]
Unnamed	Analogue (TTRPG)	Social Engineering	[29]
SCIPS	Digital (Team-based)	Cyber Security Education	[30]
Unnamed	Digital	Cyber Security Education	[31]
CSRAG	Analogue (Card)	Software Security Awareness	[32]
CATS	Digital (Board)	Cloud Security Awareness	[12, 13]

For *Persuaded* [10], and thus *Protect* [11], the defence mechanisms from the field of social psychology were used. The main design choices are to have the game be easy to learn and then play which resulted in a low level of complexity and little preparation needed to play the game. Additionally, the game's replay value and player's role were considered when it was made a single-player game where the player is attacked. Another aspect of the design mentioned was that of the user interface, where Don Norman's design principles for UI were used. The first of these, *Visibility*, deals with making the controls clearly visible to a user so that they can identify what they can do at a given point. *Feedback* in this set of principles links to visibility by referring to sending information back to users based on their actions via audio, visual, verbal, or tactile cues. *Constraints* refer to restricting certain elements to the user under certain conditions. *Mapping* is linked to the controls a user has access to, where input from the user would have some effect. *Consistency* relates to having interfaces being similar throughout and using similar elements and can extend to having certain controls always having the same affect. Lastly, *Affordance* refers to giving users "clues" of how interfaces work as these are learned conventions from one system to the next [35].

InfoSecure [17] discussed several design frameworks or philosophies but ultimately used the one described in [36]. This conceptual framework comprises the elements of *Capability*, *Instructional content*, *intended learning outcomes*, *game attributes*, *Learning activity*, *Reflection*, *Game genre*, *Game mechanics*, and *Game achievement*. From this framework, the following principles can be seen *feedback*, *challenge* to keep engagement, good *usability* to keep the learning process moving forward, *reflection* allowing the learner to absorb the information and *rewards* to again keep interest and engagement with the game.

Cyberspace Odyssey [19] was designed using feedback from the target audience, being undergraduate students, and the set learning outcomes with a focus on competitiveness and fun. Regarding

competitiveness and fun, a scoring system is in place to reward players and discourage repetitive gameplay by providing diminishing returns and moving the game forward. This letter system thus applies some form of constraint on the player, urging them forward. Additionally, the MDA (Mechanics, Dynamics, Aesthetics) framework [37] was used in the design of the game.

Riskio [20] was designed based on the principles of constructive learning theory, which states that building knowledge through experiences is effective. Simulated authentic learning, active learning, collaborative learning, and interactive learning are also incorporated through making real-world scenarios, having a role-playing aspect, interactions between other players and a Game Master (GM) guiding players and providing feedback, respectively. A focus was also put on reflection, simplicity and having the game be adaptable to diverse needs. Additionally, a story or narrative was included.

Passworld [22] refers to the Experiential Gaming model, which aims to combine an optimal flow experience with experiential learning and feedback [38]. A similar “learn and reflect” methodology was followed, which focused on a simple interface, learning tips and timely feedback [22]. In addition to this, *Passworld* used Bloom's taxonomy [39], which comprises six elements or levels. The ones mentioned in the paper are *Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation* [22]. *Passworld* achieves all these throughout the game, from the initial explanation to the quiz at the end [22]. The last design inclusion mentioned is that of the conceptual-procedural principle, which states that to understand a process or set of rules properly, it is important to know why they are being implemented and what the context behind them is [7].

PickMail [23] mentions a few main design choices, with the first being that the feedback provided is immediate on any answer selection. The difficulty of the game also increases as the player progresses. Factors from Extrinsic motivation were utilised, which is motivation coming from an outside source such as rewards. Experiential learning is also used in the form of simulating the real world. Lastly, it is also mentioned that the game uses a narrative.

Data-Driven Security Game [25] made use of surveys directed at the target audience to determine the focus in the design of the game. This resulted in a focus on fun, intuitive gameplay, and real-world educational content.

Phish Phinder [27] used a theoretical model that focused on self-efficacy for users through the Conceptual-procedural principle [40] in addition to several persuasive design principles and a focus group for additional design components. These additional components included adding a narrative, a reward system, a progress checker, and seamless interaction.

The CEBT Game [28] made use of a narrative and feedback. Additionally, the mechanics of the game should be constant throughout, having the game act as a sandbox where the player can go anywhere and propose the inclusion of adaptive responses from in-game characters.

The game presented in [29] followed a design resembling another serious game [41] but with some differences. As such, the design choices in that game focused on the goals of keeping the game simple, making it entertaining, providing context-specific content, and being based on existing social engineering research [41].

SCIPS [30] made use of a conceptual framework focused on cyber security called Conceptual Framework for e-Learning and Training (COFELET) [42]. This ontology describes the high-level design elements and how they can be combined to form scenarios [42].

The game presented in [31] used a framework that describes the development lifecycle of a serious game for cyber security [43]. This includes the *Preliminary Analysis, Design, Development, Game Assessment, Deployment* and *Player Assessment* steps, with some of the steps referring to other frameworks and ontologies, such as the Design, Play, Experience (DPE) Framework [44] in the first two steps. Furthermore, this framework mentions the design principles of *clear objectives* and *progressive difficulty* [43].

The CSRAG [32] included a narrative and several elements from gamification: badges, limited resources, clear goals, challenge, fantasy, fellowship, and discovery, which were extracted from [45]. Additionally, the learning techniques of inquiry and team-based learning and learning through play were utilised in the design.

As for the remaining games, the one presented in [15] made use of a “playcentric” framework presented in [46]. *Crypto Go* [18] and *Cyber Secured* [24] were both based on existing games named *Sushi Go* and *Spent* respectively. *PenQuest* [26] mentions the use of gamification and concepts from role-playing and strategy games. Lastly, *CATS* [12, 13] mentioned using design science. The game presented in

[14], while not explicitly stated, makes use of leaderboards and competitiveness as the game takes on the form of a Royale, where one hundred players compete against each other and one winner takes all. SherLOCKED [21] used gamification principles (and goal setting) and, as such, includes a narrative, feedback, progress reporting and competition through leader boards.

4.2 Analysis

A sizeable portion of these games was developed as analogue games [15, 18, 20, 26, 29, 32]. The reasoning for this was that it increased the players' engagement with the game and, as such, would be more effective as a learning tool. These games likely take more advantage of experiential learning practices due to the increased engagement. Quiz-based games [17, 21, 23, 24] were the most common digital game type. This is likely because assessment is a norm within traditional teaching, where students take part in written tests or multiple-choice quizzes.

Table 2. Caption for the table.

<i>Design Principle</i>	<i>Times Used</i>	<i>Used by</i>
Feedback	9	[10, 11, 17, 20-23, 27, 28]
Ease of use/Usability/Simplicity	6	[10, 11, 17, 20, 22, 29]
Story/Narrative	5	[20, 21, 23, 27, 28]
Rewards	5	[17, 19, 23, 27, 32]
Challenge	4	[17, 23, 31, 32]
Constraints	4	[10, 11, 19, 32]
Reflection	3	[17, 20, 22]
"Fun"	3	[19, 25, 29]
Competitiveness/Competition	3	[14, 19, 21]
Consistency	3	[10, 11, 28]
Adaptability	2	[20, 28]
Conceptual-Procedural Principle	2	[22, 27]
Real-World Content	2	[23, 25]
Clear Objectives/Goals	2	[31, 32]
Visibility	2	[10, 11]
Mapping	2	[10, 11]
Affordance	2	[10, 11]
Intuitive Gameplay	1	[25]
Seamless Interaction	1	[27]
Context-Specific Content	1	[29]
Teamwork/Fellowship	1	[32]

Regarding the design choices on the ontologies and frameworks made use of, there is a divide between distinct principles to follow, such as the concept of increasing difficulty seen in [23], and more abstract or subjective ones, such as implementing it so that the game is fun. The latter is often up to the discretion of the game developer or who the game is targeted at, as they may find certain gameplay elements more engaging than others. Within this section, there is also the use of more than one source of design principles or a design framework that used various sources for its formulation. However, there are still certain aspects that are more common than others. Table 2 shows a breakdown of all main design choices discussed above while ignoring the development cycles presented by some. From this, it is clear which design choices are the most used. Certain design choices were placed in the table under different names; these are a progress report [21] or checker [27] being placed under feedback,

progressive difficulty [23] being placed under challenge, entertainment [29] under fun, and limited resources [32] under constraints.

In terms of the research question set forth, these games used different design frameworks, and some opted for a security-specific framework. There is seemingly a need for a common framework to use. However, the reason literature shows the use of various frameworks is that each game requires a different set of guidelines. In the paper for *InfoSecure* [17], the authors review multiple serious game models and exclude several for being “too general” or “too basic” or only including the serious game evaluation and not design. As for the specific design principles and choices, the most used one across all games is *feedback* followed by some form of *simplicity*, *a narrative or story*, *a reward system*, and *challenge*. The design principles of rewards and challenge were mostly mentioned alongside keeping and increasing player engagement and motivation respectively. As such, these principles are a common means to keep players interested in playing the game. Similarly, the inclusion of a narrative also accomplishes this. However, it does have a major drawback, which is apparent in *Riskio* [20] where the employees of the test group found the game fun and effective while the target audience (students) did not; they could not relate to the scenario being set in an office environment. As such, the target audience of a serious game must be considered before any narrative design takes place and to cater towards that group to avoid this.

In terms of what game types used which principles, the most prevalent game type was a card game (in five of the reviewed games). They mostly made use of feedback, simplicity, and constraints two games using these principles. The other principles used in one game, being narrative, rewards, consistency, reflection, adaptability, clear goals visibility, mapping, affordance, and teamwork.

For the second most common type of game developed, being a quiz-based game, feedback is the most used as seen in three out of four games. This is followed by narrative, rewards, and challenge in two games and simplicity and reflection in one. While a sample size of five and four is not enough to draw any concrete conclusions, these smaller subsets of the reviewed games also seemingly follow the overall trend of using *feedback*, followed by some combination of the more common principles of *simplicity*, *narrative*, *rewards*, *challenge*, etc.

4.3 Design choice descriptions

As most design choices are not the focus of the papers, this section will attempt to provide definitions and descriptions for the most used ones. This will be done by consolidating the information from the papers where the specific design choice was used with other literature if needed. As for the design choices not discussed in this section, they are either typically useful within certain types of games, such as with competitiveness being used in a multiplayer-type game, or underrepresented in the papers used and should typically have more of an impact, e.g., “Fun” where without its inclusion users might feel forced to play instead of playing because it is enjoyable [47]. As for the most common design choices, they are:

- Feedback – The game responds in some way to player input or actions,
- Simplicity – The game is easy to use with a simplistic design,
- Narrative – There is a story within the game,
- Rewards – Players are rewarded for their successes in the game, and
- Challenge – The difficulty is increased or decreased based on player performance.

Feedback can be presented to a user in many ways in the context of a game through different audio, visual or tactile cues [35]. Some examples of more general game feedback are points, health status in the game or controller vibration [36]. More important, however, is that of relaying to a user how they are progressing within a game. In a serious game, this can be done in several ways. As presented above, this can be done through a progress report or providing information after a choice is selected in a quiz. The framework presented in [36], details four basic sequences through which feedback can be provided. These are fixed ratio, variable ratio, fixed interval, and variable interval. The former two sequences deal with providing feedback depending on a ratio of correct and wrong answers or actions taken by a user. Alternatively, where the feedback is fixed, i.e., not based on a ratio, will happen every n^{th} response, or can happen intermittently at random [36]. The fixed and variable interval sequences deal with providing a response after a set or random time spent playing the game, or after a response is given. These sequences can be easily applied to games where accepting a response from the user is typical, such as with a quiz-type game, but can still be implemented in others with an end-of-level or section score or other tracked metrics, screen.

Simplicity refers to the myriad of descriptors above, such as having the game be easy to learn with little preparation [10, 11] or using a simple interface [22]. This design choice comes down to having the game be designed so that learning how to play the game is not a hindrance to the overall learning experience.

Narrative refers to the inclusion of some story elements, such as the real-world content used in *Riskio* [20] or the various scenarios the other games put a user in. A game should allow for a narrative to take place during the teaching process and can be done either contextually, be the focus or make use of some agent to guide a user through the game [48]. Furthermore, the use of a story-based agent can be utilised to guide the user through the game, which falls under the “Learner Guidance” point in the First Principles discussed in [49], which is a set of principles and corollaries founded in pedagogy.

Rewards are used to keep a user engaged and interested in the game [17, 23] and to have users play a certain way [19]. This can be done by presenting users with points, levels, leaderboards, achievements, or badges in the game [50]. Rewards in a game aim to drive a user's intrinsic motivation by presenting them with something to work towards, which is also typically the type of motivation that arises when playing games for entertainment [50, 51].

Challenge is a means to keep users engaged with the game [17] and can be done through progressive changes to difficulty [31]. This can be achieved by increasing the difficulty as the game progresses or increasing the difficulty as the user successfully completes tasks and lowering it when they begin to struggle and fail to complete tasks [48]. Alternatively, suppose the game involves other aspects apart from questions. In that case, the difficulty can also be adjusted to a user's skill level by increasing health or decreasing the damage taken [52] if it is a part of the game. Additionally, this could include a system to set the difficulty for users dynamically. This system is discussed in [52], where various metrics about the player and the game are changed depending on skill level.

4.4 Other Notable Findings

Most of the games presented reported that the evaluation found them to be effective learning tools with feedback on some having a more critical response to certain aspects such as complexity or gameplay.

One of the bigger drawbacks of serious games is the sheer investment needed to design and develop one in terms of time, as seen with *CATS* [12, 13] being developed over two papers. In the case of a security-focused game, it is vital that they be kept up to date as the field expands. The *Data-Driven Security Game* [25] circumvents this as it can automatically update with new scenarios as it gathers information for these from a regularly updated database and has algorithms in place to generate new scenarios based on the information. In a similar vein, some of the serious games were developed to include means for easier inclusion of new scenarios [16, 11] which would still require human interventions to add them but is a quicker means as the game is already developed.

5 CONCLUSION AND FUTURE WORK

This paper set forth the question of, “*What are the most used design choices across security-related serious games over the last five years?*” To this effect, twenty-two serious games were identified from literature and analysed. Various design methodologies and frameworks are used in the design of serious games with overlapping choices between them. From this, *feedback* is identified as the most used design principle or choice included in developing a serious game. The principles of *simplicity*, *narrative*, *challenge*, and *reward system* following behind it. As for the remaining design choices, most are useful only to specific types of games. In terms of what future work could stem from this paper, a similar approach could be taken to a different field that uses serious games such as serious games for behavioural change, physical rehabilitation, or healthcare in general. As this paper presents various design choices used across multiple serious games another possibility of future work is to develop a framework based on the major choices presented and make use of literature from pedagogy to add additional educational context to the design choices.

REFERENCES

- [1] M. H. Nguyen, “Managing social media use in an always-on society: Exploring digital wellbeing strategies that people use to disconnect,” *Mass Communication and Society*, vol. 24, no. 6, pp. 795-817, 2021.

- [2] E. Dincelli and I. Chengalur-Smith, "Choose your own training adventure: designing a gamified SETA artefact for improving information security and privacy through interactive storytelling," *European Journal of Information Systems*, vol. 29, no. 6, pp. 669-687, 2020.
- [3] S. Sheng, B. Magnien, P. Kumaraguru, A. Acquisti, L. F. Cranor, J. Hong, and E. Nunge, "Anti-phishing phil: the design and evaluation of a game that teaches people not to fall for phish," in *Proceedings of the 3rd symposium on Usable privacy and security*, pp. 88-99, 2007.
- [4] G. Frasca, "Simulation versus narrative: Introduction to ludology," in *The video game theory reader*, pp. 221-235, Routledge, 2013.
- [5] J. Huizinga, *Homo Ludens. A Study of the Play-element in Culture*. [Translated by RFC Hull.]. London: Routledge & Kegan Paul, 1949.
- [6] A. De Gloria, F. Bellotti, and R. Berta, "Serious games for education and training," *International Journal of Serious Games*, vol. 1, no. 1, 2014.
- [7] K. M. Kapp, *The gamification of learning and instruction: game-based methods and strategies for training and education*. John Wiley & Sons, 2012.
- [8] M. Kalogiannakis, S. Papadakis, and A.I. Zourmpakis, "Gamification in science education. A systematic review of the literature," *Education Sciences*, vol. 11, no. 1, 2021.
- [9] A. I. Zourmpakis, S. Papadakis, and M. Kalogiannakis, "Education of preschool and elementary teachers on the use of adaptive gamification in science education," *International Journal of Technology Enhanced Learning*, vol. 14, 01 2022.
- [10] D. Aladawy, K. Beckers, and S. Pape, "Persuaded: fighting social engineering attacks with a serious game," in *Trust, Privacy and Security in Digital Business: Proceedings of the 15th International Conference, TrustBus 2018, Regensburg, Germany, September 5-6, 2018*, pp. 103-118, Springer, 2018.
- [11] L. Goeke, A. Quintanar, K. Beckers, and S. Pape, "Protect-an easy configurable serious game to train employees against social engineering attacks," in *Computer Security: ESORICS 2019 International Workshops, IOSec, MStEC, and FINSEC, Luxembourg City, Luxembourg, September 26-27, 2019, Revised Selected Papers 2*, pp. 156-171, Springer, 2020.
- [12] T. Zhao, T. E. Gasiba, U. Lechner, and M. Pinto-Albuquerque, "Exploring a board game to improve cloud security training in industry," in *International Computer Programming Education Conference*, 2021.
- [13] T. Zhao, U. Lechner, M. Pinto-Albuquerque, E. Ata, and T. Gasiba, "CATS: A serious game in industry towards stronger cloud security," in *Ubiquitous Security: Second International Conference, UbiSec 2022, Zhangjiajie, China, December 28-31, 2022, Revised Selected Papers*, pp. 64-82, Springer, 2023.
- [14] G. Delnevo, L. Deluigi, D. Evangelisti, and S. Magnani, "On increasing password security awareness using a serious game," in *2022 IEEE 19th Annual Consumer Communications & Networking Conference (CCNC)*, pp. 82-87, 2022.
- [15] R. Fatima, A. Yasin, L. Liu, J. Wang, W. Afzal, and A. Yasin, "Sharing information online rationally: An observation of user privacy concerns and awareness using serious game," *Journal of Information Security and Applications*, vol. 48, p. 102351, 2019.
- [16] T. E. Gasiba, U. Lechner, and M. Pinto-Albuquerque, "Cybersecurity challenges: Serious games for awareness training in industrial environments," *CoRR*, vol. abs/2102.10432, 2021.
- [17] A. Ghazvini and Z. Shukur, "A serious game for healthcare industry: Information security awareness training program for hospital universiti kebangsaan Malaysia," *International Journal of Advanced Computer Science and Applications*, vol. 9, no. 9, 2018.
- [18] A. I. González-Tablas, M. I. González Vasco, I. Cascos, and A. Planet Palomino, "Shuffle, cut, and learn: Crypto go, a card game for teaching cryptography," *Mathematics*, vol. 8, no. 11, 2020.
- [19] K. Graham, J. Anderson, C. Rife, B. Heitmeyer, P. R. Patel, S. Nykl, A. C. Lin, and L. D. Merkle, "Cyberspace odyssey: A competitive team-oriented serious game in computer networking," *IEEE Transactions on Learning Technologies*, vol. 13, no. 3, pp. 502-515, 2020.

- [20] S. Hart, A. Margheri, F. Paci, and V. Sassone, "Riskio: A serious game for cyber security awareness and education," *Comput. Secur.*, vol. 95, p. 101827, 2020.
- [21] A. Jaffray, C. Finn, and J. R. C. Nurse, "SherLOCKED: A detective-themed serious game for cyber security education," in *Human Aspects of Information Security and Assurance*, pp. 35-45, Springer International Publishing, 2021.
- [22] G. C. Jayakrishnan, G. R. Sirigireddy, S. Vaddepalli, V. Banahatti, S. P. Lodha, and S. S. Pandit, "Passworld: A serious game to promote password awareness and diversity in an enterprise," in *Proceedings of the Sixteenth USENIX Conference on Usable Privacy and Security, SOUPS'20, (USA)*, USENIX Association, 2020.
- [23] G. C. Jayakrishnan, V. Banahatti, and S. Lodha, "Pickmail: A serious game for email phishing awareness training," in *Usable Security and Privacy (USEC)*, 2022.
- [24] D. Kletenik, A. Butbul, D. Chan, D. Kwok, and M. LaSpina, "Game on: Teaching cybersecurity to novices through the use of a serious game," *J. Comput. Sci. Coll.*, vol. 36, p. 11-21, Apr 2021.
- [25] D. E. H. Løvgren, J. Li, and T. D. Oyetyan, "A data-driven security game to facilitate information security education," in *2019 IEEE/ACM 41st International Conference on Software Engineering: Companion Proceedings (ICSE-Companion)*, pp. 256-257, 2019.
- [26] R. Luh, M. Temper, S. Tjoa, S. Schrittwieser, and H. Janicke, "Penquest: a gamified attacker/defender meta model for cyber security assessment and education," *Journal of Computer Virology and Hacking Techniques*, vol. 16, pp. 19-61, 2019.
- [27] G. Misra, N. A. G. Arachchilage, and S. Berkovsky, "Phish phinder: A game design approach to enhance user confidence in mitigating phishing attacks," 2017.
- [28] Mittal, M. Gupta, M. Chaturvedi, S. R. Chansarkar, and S. Gupta, "Cybersecurity enhancement through blockchain training (CEBT) - a serious game approach," *International Journal of Information Management Data Insights*, vol. 1, no. 1, p. 100001, 2021.
- [29] F. Muhly, P. Leo, and S. Caneppele, "A serious game for social engineering awareness creation," *Journal of Cybersecurity Education, Research and Practice*, vol. 2022, no. 1, p. 5, 2021.
- [30] S. O'Connor, S. Hasshu, J. Bielby, S. Colreavy-Donnelly, S. Kuhn, F. Caraffini, and R. Smith, "SCIPS: A serious game using a guidance mechanic to scaffold effective training for cyber security," *Information Sciences*, vol. 580, pp. 524-540, 2021.
- [31] M. M. Yamin, B. Katt, and M. Nowostawski, "Serious games as a tool to model attack and defense scenarios for cyber-security exercises," *Computers & Security*, vol. 110, p. 102450, 2021.
- [32] A. Yasin, L. Liu, T. Li, R. Fatima, and J. Wang, "Improving software security awareness using a serious game," *IET Softw.*, vol. 13, pp. 159-169, 2019.
- [33] B. Potter, "Microsoft SDL threat modelling tool," *Network Security*, vol. 2009, no. 1, pp. 15-18, 2009.
- [34] D. Firesmith, "Specifying reusable security requirements," *Journal of Object Technology*, vol. 3, pp. 61-75, Jan 2004.
- [35] J. Preece, H. Sharp, and Y. Rogers, *Interaction design: beyond human-computer interaction*. John Wiley & Sons, 2002.
- [36] A. Yusoff, A conceptual framework for serious games and its validation. PhD thesis, University of Southampton, 2010.
- [37] R. Hunicke, M. LeBlanc, R. Zubek, et al., "MDA: A Formal Approach to Game Design and Game Research," in *Proceedings of the AAAI Workshop on Challenges in Game AI*, vol. 4, (San Jose, CA), AAAI, 2004.
- [38] K. Kiili, "Digital game-based learning: Towards an experiential gaming model," *The Internet and higher education*, vol. 8, no. 1, pp. 13-24, 2005.
- [39] B. S. Bloom, M. D. Engelhart, E. Furst, W. H. Hill, and D. R. Krathwohl, Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain. Longmans, Green & Co., 1956.

- [40] N. A. G. Arachchilage and S. Love, "A game design framework for avoiding phishing attacks," *Computers in Human Behavior*, vol. 29, no. 3, pp. 706-714, 2013.
- [41] K. Beckers and S. Pape, "A serious game for eliciting social engineering security requirements," in *2016 IEEE 24th International Requirements Engineering Conference (RE)*, pp. 16-25, 2016.
- [42] M. Katsantonis and I. Mavridis, "Ontology-based modelling for cyber security e-learning and training," in *Advances in Web-Based Learning - ICWL 2019* (M. A. Herzog, Z. Kubincová, P. Han, and M. Temperini, eds.), (Cham), pp. 15-27, Springer International Publishing, 2019.
- [43] A. Le Compte, D. Elizondo, and T. Watson, "A renewed approach to serious games for cyber security," in *2015 7th International Conference on Cyber Conflict: Architectures in Cyberspace*, pp. 203-216, 2015.
- [44] B. M. Winn, "The design, play, and experience framework," in *Handbook of research on effective electronic gaming in education*, vol. 3, pp. 1010-1024, IGI Global, 2009.
- [45] S. Deterding, D. Dixon, R. Khaled, and L. Nacke, "From game design elements to gamefulness: Defining "gamification"," in *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments*, MindTrek '11, (New York, NY, USA), p. 9-15, Association for Computing Machinery, 2011.
- [46] T. Fullerton, *Game Design Workshop: A Playcentric Approach to Creating Innovative Games*. CRC Press, 4th ed., 2018.
- [47] G. Drevin, D. P. Snyman, L. Drevin, H. A. Kruger, and J. Allers., "The story of safety snail and her e-mail: A digital wellness and cybersecurity serious game for pre-school children," in *Proceedings of the 9th International Conference on Information Systems Security and Privacy - ICISSP*, pp. 519-527, INSTICC, SciTePress, 2023.
- [48] J. Esterhuizen, G. Drevin, D. P. Snyman, and L. Drevin, "Linking gamification, ludology and pedagogy: Principles to design a serious game," in *Proceedings of the 19th International Conference on Cognition and Exploratory Learning in Digital Age (CELDA 2022)*, (Lisbon, Portugal), pp. 57-65, Nov. 2022.
- [49] M. D. Merrill, "First principles of instruction," *Educational technology research and development*, vol. 50, no. 3, pp. 43-59, 2002.
- [50] S. Nicholson, *Gamification in Education and Business*, Ch. 1 A recipe for meaningful gamification, pp. 1-20. Springer, 2015.
- [51] G. Richter, D. R. Raban, and S. Rafaeli, *Gamification in Education and Business*, Ch. 2 Studying gamification: The effect of rewards and incentives on motivation, pp. 21-46. Springer, 2015.
- [52] R. Hunicke, "The case for dynamic difficulty adjustment in games," in *IFAC Symposium on Advances in Control Education*, 2005.

E Ethical Clearance



Private Bag X1290, Potchefstroom
South Africa 2520

Tel: 018 299-1111/2222
Fax: 018 299-4910
Web: <http://www.nwu.ac.za>

Senate Committee for Research Ethics
Tel: 016 910 3446
Email: Feziwe.Mseleni@nwu.ac.za

ETHICS APPROVAL LETTER OF STUDY

Based on approval by the **Faculty of Natural and Agricultural Sciences Ethics Committee (FNAS-REC)**, the Faculty of Natural and Agricultural Sciences Ethics Committee hereby **approves** your study as indicated below. This implies that the North-West University Senate Committee for Research Ethics (NWU-SCRE) grants its permission that, provided the special conditions specified below are met and pending any other authorisation that may be necessary, the study may be initiated, using the ethics number below.

Study title: Designing and Developing a Serious Game to Teach Digital Wellbeing															
Study Leader/Supervisor: Dr D Snyman															
Student: J Esterhuizen															
Ethics number:	N	W	U	-	0	1	3	6	3	-	2	2	-	A	9
	Institution				Study Number					Year			Status		
<i>Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation</i>															
Application type: Single				Risk Category:				Minimal							
Commencement date: 01/02/2022															
Expiry date: 31/01/2025															
Approval of the study is initially provided for a year, after which continuation of the study is dependent on receipt and review of the annual (or as otherwise stipulated) monitoring report and the concomitant issuing of a letter of continuation.															

Special in process conditions of the research for approval (if applicable):

- The following documentation are archived by FNASREC and should be complete and kept up to date:
 - Research proposal
 - Signed approval from the scientific committee indicating the proposed risk category
- All researchers involved in the study should submit signed NWU code of conduct statements annually.
- All researchers of low risk studies should submit proof of relevant ethics training every two years.
- All researchers that take part in activities that pose a safety and security threat to the researchers or the environment should submit a risk assessment form annually.
- All research involving human interaction should follow best ethical practise and keep documents as proof. This includes informed consent, questionnaires, incorporation of risk-benefit, and responsible data management.
- Any research at governmental or private institutions, permission must still be obtained from relevant authorities and provided to the FNASREC. Ethics approval is required BEFORE approval can be obtained from these authorities.

General conditions:

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, the following general terms and conditions will apply:

- *The study leader/supervisor (principle investigator)/researcher must report in the prescribed format to the FNASREC:
 - *annually (or as otherwise requested) on the monitoring of the study, whereby a letter of continuation will be provided, and upon completion of the study; and*
 - *without any delay in case of any adverse event or incident (or any matter that interrupts sound ethical principles) during the course of the study.**
- *The approval applies strictly to the proposal as stipulated in the application form. Should any amendments to the proposal be deemed necessary during the course of the study, the study leader/researcher must apply for approval of these amendments at the FNASREC, prior to implementation. Should there be any deviations from the study proposal without the necessary approval of such amendments, the ethics approval is immediately and automatically forfeited.*
- *Annually a number of studies may be randomly selected for an external audit.*
- *The date of approval indicates the first date that the study may be started.*
- *In the interest of ethical responsibility, the NWU-SCRE and FNASREC reserves the right to:
 - *request access to any information or data at any time during the course or after completion of the study;*
 - *to ask further questions, seek additional information, require further modification or monitor the conduct of your research or the informed consent process;*
 - *withdraw or postpone approval if:
 - * *any unethical principles or practices of the study are revealed or suspected;*
 - * *it becomes apparent that any relevant information was withheld from the FNASREC or that information has been false or misrepresented;*
 - * *submission of the annual (or otherwise stipulated) monitoring report, the required amendments, or reporting of adverse events or incidents was not done in a timely manner and accurately; and / or*
 - * *new institutional rules, national legislation or international conventions deem it.***
- *FNAS-REC can be contacted for further information or any report templates via Roelof.Burger@nwu.ac.za 018 299 4269*

The FNASREC would like to remain at your service as scientist and researcher, and wishes you well with your study. Please do not hesitate to contact the FNASREC or the NWU-SCRE for any further enquiries or requests for assistance.

Yours sincerely,



Prof Roelof Burger
Chairperson Faculty of Natural and Agricultural Sciences Ethics Committee (FNASREC)

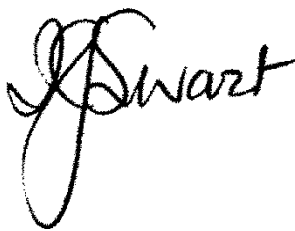
F Language Editing Certificate

This serves to confirm that I, Isabella Johanna Swart, registered with and accredited as professional translator by the South African Translators' Institute, registration number 1001128, language edited the following dissertation:

Designing and Developing a Serious Game to Teach Digital Wellbeing

by

Joshua Esterhuizen



Dr Isabel J Swart

Date: 19 March 2024

23 Poinsettia Close
Van der Stel Park
Dormehlsdrift
GEORGE
6529
Tel: (044) 873 0111
Cell: 082 718 4210
e-mail: isaswart@telkomsa.net