



The development of a serious game to enhance digital well-being awareness

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Declaration

I, Given Mnisi, hereby declare that the dissertation entitled “The development of a serious game to enhance digital well-being awareness” is entirely my own original work and has not already been submitted to any other university or institution for examination.

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Abstract

Today, children are widely exposed to digital technologies, including smartphones, tablets, televisions, and video games, largely due to their accessibility within households. These technologies offer new modes of development and interaction, providing numerous benefits. However, they also present potential risks, as young children often lack the experience, maturity, and necessary knowledge to navigate digital environments safely, which is critical for maintaining positive digital well-being.

The primary aim of this study is to develop a serious game, guided by the digital well-being framework of Büchi, as an intervention to enhance digital well-being and cybersecurity awareness among preschool children. The game is designed as a collaborative tool for children and their caregivers, encouraging discussions and activities that extend beyond merely restricting technology use. The serious game implements optimal game elements, as well as elements tailored specifically for preschool children. A design science research approach was employed, and experts in the fields of preschool and primary education, caregivers, and academic researchers reviewed the game to validate the implemented elements and evaluate its effectiveness.

The findings revealed that experts perceive the game as a valuable potential tool for enhancing digital well-being and cybersecurity awareness, raising awareness among children and their caregivers, and promoting positive well-being and responsible technology use. Experts recommended the game as a resource for educators and caregivers working with young children. These findings led to an extension of Büchi's digital well-being framework in the context of preschool-aged children.

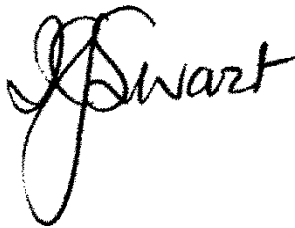
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This serves to confirm that I, Isabella Johanna Swart, registered with and accredited as professional translator by the South African Translators' Institute, registration number 1001128, language edited the following dissertation:

The development of a serious game to enhance digital well-being awareness

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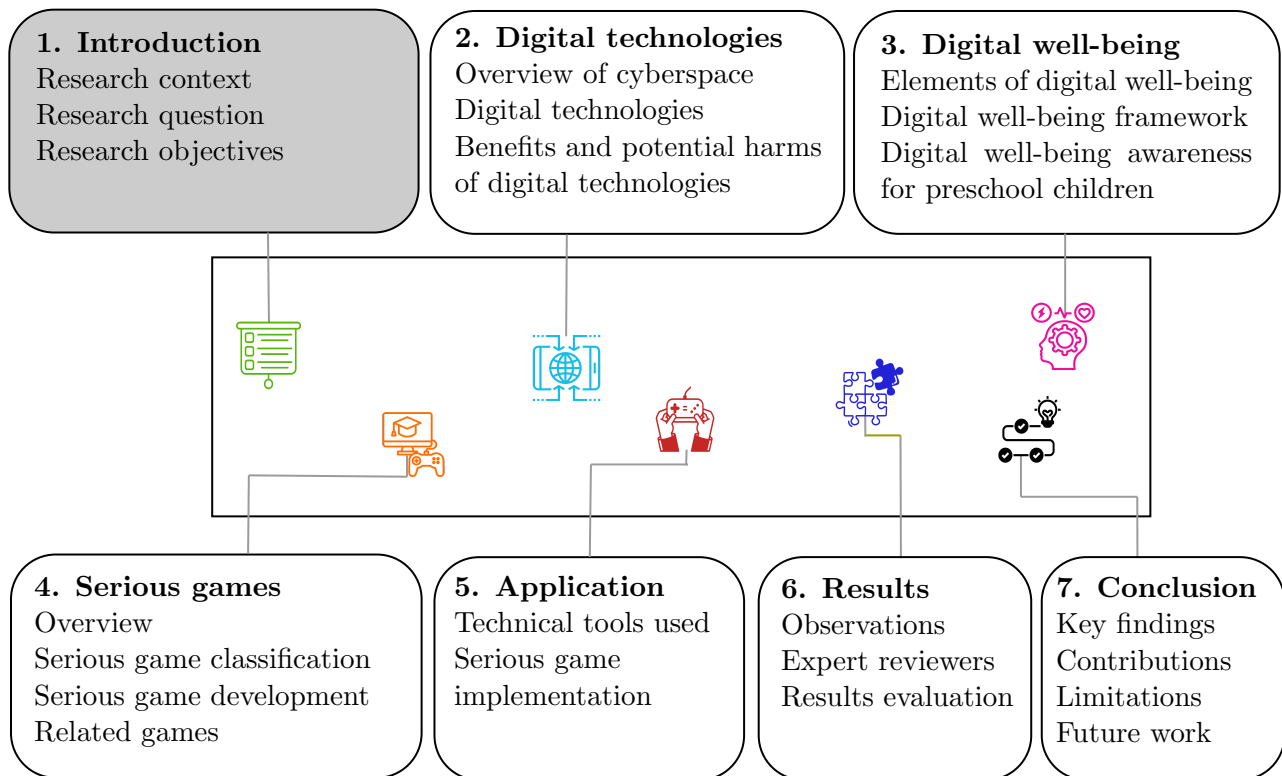
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Chapter 1

Introduction



1.1 Background

Today's children are born into a digital age, surrounded by various forms of digital technologies, such as smartphones, tablets, television, and video games. These digital technologies offer new avenues for children to interact and develop, making it challenging to protect them from their influence. Children's inherent need for attention is increasingly fulfilled through digital technologies rather than through interactions with their peers and caregivers.

Many children are introduced to digital technologies at an early age, with their first encounter with screen time occurring at as early as four months. This exposure allows them to connect with distant family members and become accustomed to screen time by the time they reach preschool age (Bacil et al., 2024; Swider-Cios et al., 2023). These digital technologies present various benefits, including fostering closeness, providing educational opportunities, offering entertainment, and supporting prosocial behaviour (Kabali et al., 2015; Ponti, 2023; Robidoux et al., 2019; Shortt et al., 2023; Yadav & Chakraborty, 2022). However, they also pose potential harms, such as problematic use, online vulnerabilities physiological and psychological impacts (Hill et al., 2016; Neumann, 2015; Nikkelen et al., 2014).

Digital technologies have transformed how children interact, shifting from traditional games, such as hide-and-seek, marbles, flying kites, and hopscotch to engaging with friends online through video games, sharing information, and watching videos on digital devices.

The COVID-19 pandemic accelerated this transition, making digital devices important tools for communication, entertainment, and learning. Lock-down measures significantly impacted families' and children's lives, leading to a substantial rise in screen time for both preschool and school-age children, as digital devices became the primary sources of entertainment and education (Emiroğlu İlvan & Ceylan, 2023).

From an early age, children today are immersed in the digital environment (von Solms & Fischer, 2017). Children are particularly vulnerable to unexpected risks linked to digital device usage because their innate curiosity leads them to explore independently. However, it is challenging for them to identify the risks and opportunities that come with digital device use, and they lack the knowledge and skills needed to protect themselves against cybersecurity threats (Esfandiari et al., 2025; Quayyum et al., 2021; von Solms & Fischer, 2017). Many parents are unaware of the online threats that their children face, and have limited experience with digital technologies. Additionally, educators are often unprepared to teach about cybersecurity, making it difficult to effectively support and protect children in cyberspace (Pons-Salvador et al., 2022; von Solms & Fischer, 2017).

Although the Internet provides children with numerous opportunities for development and well-being, it also presents risks, highlighting the importance of digital literacy and digital well-being, as these skills are essential in

the digital age.

Digital well-being refers to an individual's overall wellness when using digital technology (Büchi, 2024). It encompasses the capacity to recognise benefits and potential harms of digital spaces, to act responsibly, and to align digital and physical behaviour to ensure safety. Teaching children digital safety through play can yield significant benefits, as childhood experiences profoundly shape their development before primary school, fostering foundational skills and behaviours. Play comes naturally to children and is fundamental to their lives, offering numerous opportunities to hone their basic skills and discover new things (Etokabeka, 2024; Yogman et al., 2018).

Among various forms of digital media, video games are particularly prevalent among preschoolers and play a significant role in satisfying their psychological demands (Mnisi et al., 2025). The primary reason why preschoolers engage with digital devices is for gaming (Emiroğlu İlvan & Ceylan, 2023). Gaming is a favoured activity among children and benefits them in several ways, including creativity, social skills, relaxation, cognitive development, and learning opportunities (Scott et al., 2023). In addition, games have been found to be effective tools for raising awareness about digital well-being and cybersecurity (Esfandiari et al., 2025; Kritzinger, 2015; Panga et al., 2022; Quayyum & Jaccheri, 2025). They enable children to engage in meaningful, enjoyable and natural ways, offering opportunities to experiment, explore and learn at their own pace (Ebrahimi et al., 2025).

Although the primary aim of most video games is entertainment, a specific category, known as serious games, is created for educational purposes (Mnisi et al., 2024). Serious games aim to achieve objectives that extend beyond mere amusement (Pérez et al., 2023). They go beyond conventional teaching methods by integrating behaviour change theories, empowering users to proactively apply their knowledge, thus enhancing their ability to navigate the digital landscape safely (Chen et al., 2020).

Frameworks, such as those proposed by Büchi (2024) provide a structured approach to investigating the complex relationships between the use of digital practices that can ultimately impact the digital well-being of individuals. In this study, the digital well-being of Büchi (2024) will be used as a guide to analyse how the use of digital technologies impacts the digital well-being of preschool children, culminating in a serious game intervention designed to enhance their digital well-being and cybersecurity awareness.

1.2 Research question

A key focus of this study is to apply the digital well-being framework of Büchi (2024) to examine the impact of digital technologies on preschool children's digital well-being. This will culminate in the development of a serious game intervention aimed at enhancing their digital well-being and awareness. The existing theoretical framework is broad and simplified, lacking specificity regarding digital practices and measurable outcomes. Therefore, new research should aim to delineate the specific benefits and harms associated with different digital practices.

Consequently, the following research questions have been identified:

1. "How can the use of digital technologies be beneficial or potentially harmful to preschool children?"
2. "How can the use of digital technologies enhance the digital well-being of preschool children?"

1.3 Research objectives

The primary aim of this study is to develop a serious game, guided by the digital well-being framework of Büchi (2024), as an intervention to enhance the digital well-being and cybersecurity awareness among preschool children. The serious game is designed as a collaborative tool for children and their caregivers, encouraging discussions and activities that go beyond mere restrictions on technology use.

The following secondary objectives have been established to achieve the primary aim:

1. Conduct a literature review on the beneficial and potentially harmful impacts of the use of digital technologies among preschool children;
2. Conduct a literature review on the design principles for a serious game suitable for preschool children;
3. Develop a serious game to address the digital well-being and awareness of preschool children using identified design principles;
4. Use expert opinions to evaluate the implemented elements and assess the effectiveness of the serious game in enhancing the digital well-being of preschool children; and
5. Propose an extension of Büchi's framework to better understand the impacts of using digital technologies on the digital well-being of preschool children.

1.4 Research design and methodology

This study is conducted using the design science research (DSR) approach. Design science research aims to expand the understanding of humans by creating new artefacts and knowledge about their design (vom Brocke et al., 2020). Design science research consists of six steps (Alharahsheh & Pius, 2020), which guide this study:

1. Problem identification and justification - This phase consists of conducting a literature review to contextualise the problem and establish the motivation for the study (Chapter 1);
2. Establishing objectives for a solution - The second phase involves a comprehensive literature review of the relevant topics related to this study (Chapters 2, 3, and 4);
3. Designing and developing - This phase involves designing and developing the serious game using identified game design principles (Chapter 5);
4. Demonstration - After development, the game will be sent to experts for a pilot study to identify potential improvements (Chapter 5);
5. Evaluation - Following demonstration, the game will be sent to preschool and primary education, caregivers, and academic researchers, for final validation of the implemented elements and evaluate its effectiveness (Chapter 6); and
6. Communication - The final phase will communicate the findings of this study (Chapter 7).

Design science research consists of seven guidelines to ensure quality and rigour that should be followed throughout a study (March & Storey, 2008):

- Design as an artefact - Develop a valid instantiation, method, model, framework, or construct;
- Problem relevance - Develop technological solutions to address business challenges;
- Design evaluation - Illustrate the artefact's effectiveness, reliability, and utility;
- Research contributions - Must demonstrate clear and measurable contributions;
- Research rigour - A rigorous approach is necessary throughout the creation and assessment of the conceptual artefact;

- Design as a search process - Finding successful solutions using the available resources while adhering to the rules of the problem's context; and
- Communication of research - Present to both technology and management audiences.

1.5 Dissertation layout

This dissertation is structured as follows:

Chapter 1 established the foundation and justification for this study. It outlined the research aim, research questions, research objectives, research design, related publications and the overall structure of the study.

Chapter 2 provides background on cyberspace and digital technologies, including a description of cyberspace and various digital technologies relevant to this study. Furthermore, this chapter examines the benefits and potential harms of selected digital technologies for the digital well-being of preschool children.

Chapter 3 reviews the literature on digital well-being, exploring its key elements and presenting the digital well-being framework developed by Büchi (2024), which underpins this study. Furthermore, it provides digital well-being awareness for children and provides an overview of the book “Digital wellnests: Let us play in safe nests!” by Fischer and von Solms (2016), which serves as the existing and available content on which the game is based, as well as digital well-being in preschool education.

Chapter 4 discusses the literature on serious games, followed by the distinctions between game-based learning, game-based pedagogy, and gamification. Next, a classification of serious games is provided. This discussion is followed by the development of serious games, including design challenges and essential elements. Finally, related games developed to enhance digital well-being and cybersecurity awareness among children are presented.

Chapter 5 details the technology stack used for the development of the serious game and describes its implementation.

Chapter 6 presents the observational findings and expert review results, evaluating the effectiveness of the serious game intervention. Based on these results and insights, the chapter proposes an extension of Büchi's (2024) digital well-being framework, tailored for preschool children.

Chapter 7 concludes the dissertation by summarising how the research objectives were achieved, contributions, limitations, and future work.

1.6 Publications

During this study, a research output was produced: a full peer-reviewed conference paper titled “Lucky the Fish Teaches Children About Phishing.” This paper is listed as a Scopus output, is provided in Appendix G, and can be found at the following DOI: https://doi.org/10.1007/978-3-031-94924-1_11

1.7 Summary

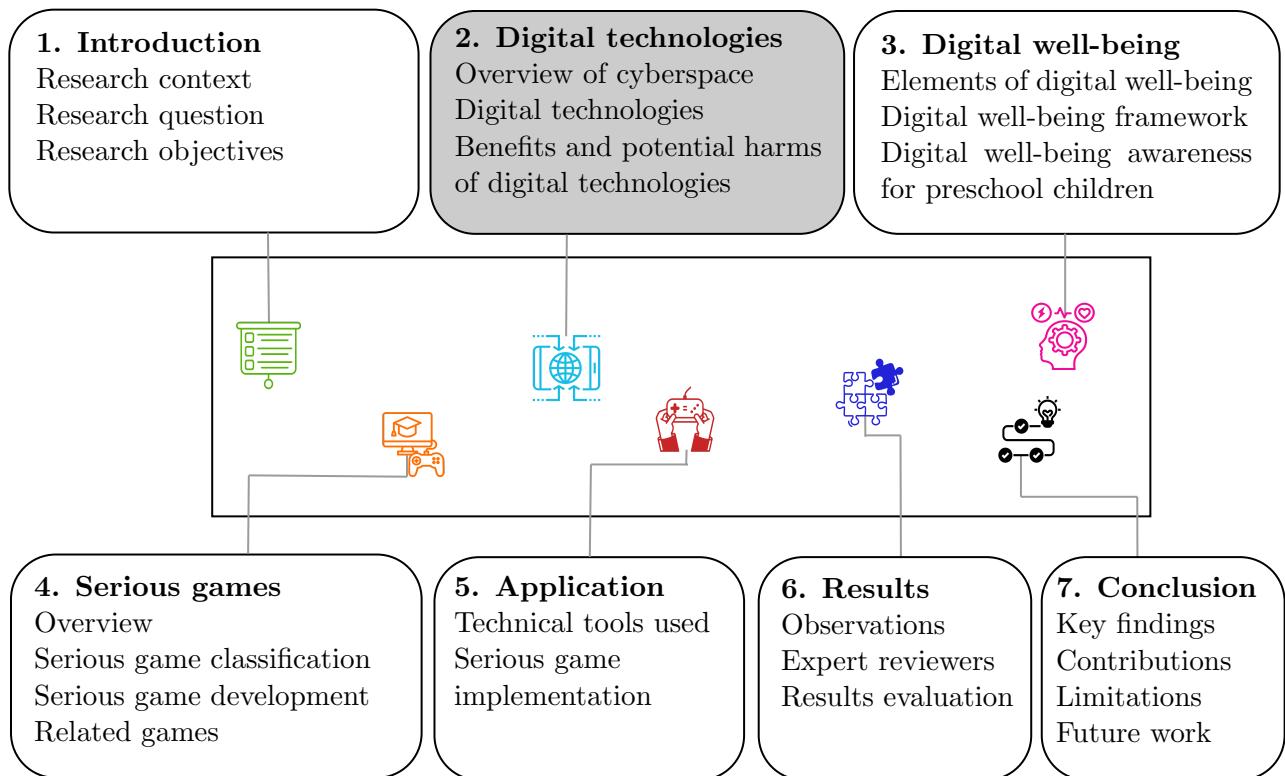
Digital technologies offer opportunities for children to learn and express creativity, but also expose them to online hazards due to limited digital well-being awareness. This study develops a serious game intervention to enhance digital well-being and cybersecurity awareness among preschool children, guided by the digital well-being framework of Büchi (2024).

In this chapter, the study’s foundation, including the background, research questions, objectives, design, structure, and publications is provided.

In the next chapter, the literature on cyberspace and digital technologies will be reviewed.

Chapter 2

Digital technologies



In this chapter, the background information on cyberspace and various digital technologies relevant to this study is discussed. In Section 2.1, the historical overview of cyberspace is presented, exploring its evolution over time. In Section 2.2, the prevalent digital technologies among children, such as mobile devices, television, and video games, are discussed, along with their beneficial and potentially harmful impacts on the digital well-being of preschool children.

2.1 Overview

The term “cyberspace” has been described using a variety of definitions and has been in the world’s concordance for more than two decades; yet, there is no universally accepted definition for it. The American philosopher, mathematician and computer scientist Norbert Wiener used the prefix “cyber” to define “cybernetics” in his first 1948 book, “Cybernetics: Or Control and Communication in the Animal and the Machine.” Wiener (2019, p. 11) defined cybernetics as “the study of control and communication in the animal and the machine.”

Wiener’s (2019) theory suggests that there is a resemblance between artificial and biological systems in terms of how they govern themselves and exchange information through feedback loops that can be social, cognitive, mechanical, or biological. Additionally, humans and machines can communicate, establishing a unique environment for interaction. Although Wiener (2019) did not use the term cyberspace directly, his ideas on communication served as the groundwork for the concept.

In the early 1980s, William Gibson, an American-Canadian speculative fiction writer, popularised the concept of “cyberspace” in his short story “Burning Chrome” and subsequently in his novel “Neuromancer.” In the novel, he stated:

Cyberspace. A consensual hallucination experienced daily by billions of legitimate operators, in every nation, by children being taught mathematical concepts ... A graphic representation of data abstracted from the banks of every computer in the human system. Unthinkable complexity. Lines of light ranged in the non-space of the mind, clusters and constellations of data. Like city lights, receding ... (Gibson, 1984, p. 59)

The first section of this definition discusses how humans can engage together to form a captivating virtual environment, using artificial realities that change their experiences. The last section highlights complexity as a key aspect of cyberspace. When Gibson (1984) developed this concept, he was making meaning out of his fictitious stories without any idea that it would evolve into a popular term (Fourkas, 2004; Ottis & Lorents, 2010).

This was the first formal definition of cyberspace that evolved into numerous other definitions. Fourkas (2002) stated that:

An artificial, computer-sustained, computer-accessed, and computer-generated, virtual space, in such a way so as to give people the potential (illusion, for others) of control, movement and access to information, and allowing them to interact with others, or with the computer-simulated worlds, at any time of day and night. (p. 5).

Fourkas's (2002) definition shows that cyberspace is an artificial world within computer systems that allows individuals to communicate and access information, similar to the physical world. According to Kritzinger (2020, p. 1), a modern definition of cyberspace includes "an environment in which users communicate and connect via a network with other users across the globe."

The term "cyberspace" has multiple definitions. However, the commonality according to these authors is characterised by a virtual environment where individuals interact with one another. Cyberspace encompasses all activities related to the Internet, such as sharing and communicating, among others (Bibak & Jafari, 2023). Essentially, people, technology, and information drive it. Similarly to the real world, cyberspace possesses both benefits and drawbacks, particularly for the younger generations born in an age when access to it is readily available, witnessing the rapid growth of artificial intelligence (AI). As artificial intelligence has grown more prevalent in recent years, the concept of cyberspace could evolve to incorporate it.

2.2 Digital technologies

Over the years, digital devices have become more accessible and affordable, making them more prevalent in households with children. In many of these households, when guardians or caregivers restrict their children's television use, they often replace it with tablets, smartphones, video games, or computers. In some cases, children may be introduced to digital devices before educational books, raising critical concerns about their safety and screen time (Vedechkina & Borgonovi, 2021). Screen time refers to the duration spent viewing or interacting with content on a screen, which may include mobile devices, video games, or computers (Konca, 2022).

In this study, digital technologies are defined as the devices or tools, such as video games, tablets, and computers used for recreational activities, including watching YouTube, playing games, shopping online, or for educational purposes, including sharing information and acquiring educational content (Panjeti-Madan & Ranganathan, 2023).

Research has shown that mobile devices, televisions, and video games are the most preferred digital technologies among children (Bacil et al., 2024;

Kabali et al., 2015; Konca, 2022; Neumann, 2015; Panjeti-Madan & Ranganathan, 2023; Vedeckina & Borgonovi, 2021). Given their widespread use, these devices serve as gateways to a variety of content found in cyberspace. In this study, mobile devices will be classified as tablets and smartphones, while video games include Nintendo Switch, Nintendo Wii, PlayStation, and Xbox.

2.2.1 Mobile devices

Children are increasingly using mobile devices for media consumption due to their interactive features, portability, streaming capabilities, and small screen sizes (Al Hosani et al., 2023). Around the age of two, some children begin to hold smartphones more confidently and explore their functions, such as tapping and sliding the screen. In addition, many preschoolers use drawing applications to write and sketch, typically with the assistance of their guardians (Yadav & Chakraborty, 2022).

Benefits associated with mobile devices

Mobile devices offer several benefits for children, including a sense of proximity, improved motor skills, enhanced creativity and imagination, entertainment, and educational opportunities, all of which will be described next.

Sense of proximity

The first screen time experience in which children engage using smartphones or tablets is typically video calls. Guardians generally have more positive perceptions of this activity than any other, as it maintains social connections, enhances family communication, and provides children with a sense of closeness to distant family members. Video calls offer a stronger sense of proximity than traditional calls, as they do not require advanced cognitive or verbal skills, allowing children to use gestures and facial expressions. Preschool children usually prefer video calling with familiar individuals who speak clearly and pay attention to them. However, they tend to be reserved and have limited attention spans during these calls (Swider-Cios et al., 2023; Yadav & Chakraborty, 2021, 2022).

Improved motor ability

Several studies indicate a significant association between fine motor skills and the use of touchscreen devices (Chaibal & Chaiyakul, 2022; Moon et al., 2019; Yadav & Chakraborty, 2022). Fine motor skills involve the precise coordination of muscles within the hands and fingers, which is essential for various tasks, such as handling, placing, and touching objects (Martzog et al., 2019). Children who actively use digital devices can enhance their fine

motor skills through activities, such as scrolling, flicking, dragging, playing drawing games, and frequently tapping the screen. As they continue to engage with these devices, their motor skills progressively improve.

Creativity and imagination

Drawing and writing are critical elements of children's development, as they foster creativity, imagination, fantasy, and the expression of their understanding of the world around them. Typically, most children start by drawing simple geometric shapes and progress to more detailed illustrations. While crayons and pencils are the most commonly used drawing tools on paper, many children now also use drawing applications on their mobile devices. These applications offer useful features, such as undo and eraser options, which assist in removing unwanted elements or reverting to an earlier version of a drawing. In addition, children can save their artwork and share it with their guardians or peers using these applications (Yadav & Chakraborty, 2021).

Entertainment

Guardians primarily allow children to use mobile devices to encourage eating during mealtimes, help them sleep, calm them down and distract them while working. Providing children with mobile devices as a reward fosters their frequent use, which can lead to distress when they are not given one. Caregivers may not realise the potential impact these devices can have on their children's digital well-being (Park & Park, 2021; Ponti, 2023). Mobile devices are preferred over other household devices for entertainment purposes. Among children, entertainment applications such as YouTube and Netflix, as well as educational applications, are the most popular. Children are captivated by videos featuring coordinated dance and harmonious music, as well as those with balloons, toys, cartoons, and games, prompting them to reach for the screen repeatedly (Kabali et al., 2015; Yadav & Chakraborty, 2021, 2022).

Educational opportunities

Mobile devices provide numerous opportunities for learning, including language acquisition, information gathering, and informal education. Children learn new vocabulary when their caregivers or parents use vocabulary applications with them and subsequently incorporate these words at home. Vocabulary applications are more effective than picture cards due to their interactive screens (Yadav & Chakraborty, 2021, 2022). Mobile applications like *Duolingo*, a beginner-friendly language learning tool, have been demonstrated to improve children's language learning abilities (Shortt et al., 2023).

Today, children frequently use voice assistants to search for information online, as they are typically not yet proficient in typing. Educational applications that teach basic arithmetic assist children in learning at home with parental support, helping them grasp complex concepts (Yadav & Chakraborty, 2021). Finally, early literacy can be promoted through “learn-to-read” applications and e-books that aid in word recognition, phonics, and story comprehension (Ponti, 2023).

Potential harms associated with mobile devices

Although there are numerous benefits to using mobile devices, they can also pose potential risks that can negatively affect individuals of all ages, including children, impacting their well-being and general health. These negative impacts include problematic smartphone use, caregiver-child interaction, artificial intelligence, and online vulnerabilities, which will be described next.

Problematic smartphone use

Excessive use of mobile devices, particularly smartphones, can lead to problematic smartphone use, commonly referred to as “smartphone addiction” or “nomophobia” (the fear of being without a mobile phone). This compulsive pattern of smartphone use, which exhibits dysfunction and symptoms similar to those of drug addiction, interferes with a user’s daily tasks. It is a non-chemical behavioural addiction linked to psychopathology rather than a psychological illness (Busch & McCarthy, 2021; Yang et al., 2020). Problematic smartphone use can be characterised by the following (Chaibal & Chaiyakul, 2022; Yang et al., 2020):

- Self-control failure: an intense drive to use a smartphone regardless of personal objectives set;
- Salience: giving smartphone use greater attention compared to other tasks; and
- Detrimental consequences: carrying on utilising smartphones despite detrimental effects, such as social, psychological and physical impacts.

Problematic smartphone use among children can have several adverse effects on their digital well-being, impacting both their psychological and physical health. It can lead to headaches and muscle pain, which may further disrupt sleep patterns and delay hormone release. Sleep is a crucial component of development for children, as it is essential for mood regulation. Disturbances in sleep can lead to anxiety, depression, and stress (Yang et al., 2020). Finally, excessive smartphone use can negatively impact children’s language development by reducing their social interactions with those around them (Moon et al., 2019; Park & Park, 2021).

Caregiver-child interaction

The majority of preschool children's daytime is spent with their caregivers (Park & Park, 2021). Bozzola et al. (2018) emphasise the importance of sufficient and healthy interactions between children and their caregivers, as these interactions play a significant role in neurocognitive and behavioural development. Parental use of digital technology strongly influences children's usage patterns, with children often imitating their parents' actions and viewing them as role models, including their use of digital technologies (Konca, 2022; Park & Park, 2021). When parents overuse mobile devices, it can result in reduced verbal and non-verbal communication with their children, increasing tension in their relationship (Bozzola et al., 2018). A study by Ochoa et al. (2021) found that caregivers who engaged in digital technologies were less likely to exhibit emotions, converse, and interact with their children. Children's screen time is affected by the following parenting styles (Panjeti-Madan & Ranganathan, 2023):

- Media-centric parenting: a significant proportion of children's daily activities involve the use of digital technologies;
- Media-moderate parenting: a balance is established between screen-free activities (such as outdoor play and drawing) and screen time activities, with supervision of the media consumed; and
- Media-light parenting: this style limits a child's interaction with digital technologies.

Online vulnerabilities

Children encounter various online risks when using mobile devices, including cyberbullying, phishing, malware, and viruses.

C. Zhu et al. (2021) define cyberbullying among children and adolescents as persistent and intentional harm inflicted in cyberspace through the use of smartphones and other devices by one or more peers. Cyberbullying can have serious consequences for children's mental health and privacy, and is often more harmful than traditional bullying because it is frequently disguised and can occur at any time.

Cyberbullying can have potentially harmful impacts on children, including (Yadav & Chakraborty, 2022; C. Zhu et al., 2021):

- Psychological effects: increased depression, anxiety, and low self-esteem;
- Physical effects: stress can cause sleep disturbances in children;
- Social isolation: loneliness and withdrawal from other children;

- Self-harm: higher likelihood of suicidal thoughts and self-harming actions; and
- Academic consequences: difficulty concentrating due to emotional distress.

Children are also vulnerable to phishing attacks when using mobile devices, which are often overlooked and regarded as issues affecting adults. Phishing attacks are deceptive attempts to obtain confidential information by sending messages or emails that appear to be from a trustworthy source. These attacks may be conducted for personal gain or to steal someone's identity (Collins & Muhammad, 2022; Ndulue et al., 2020).

Phishing typically involves four steps: (1) Establishing trust, where the attacker seeks to gain the victim's trust, encouraging actions such as responding to emails, replying to text messages, or clicking on links. Trust is often achieved through fake email addresses that mimic legitimate sources, deceptive websites, spoofed applications, and other misleading methods; (2) Redirection, an intermediary phase not present in all phishing attempts. In cases of spoofed emails, this may direct the victim to a fraudulent site via a hyperlink, where sensitive information is unknowingly provided; (3) Data collection, where the actual attack occurs and the attacker gathers crucial information either through the redirected website or from responses to spoofed emails; and (4) Execution, the final phase where the attacker implements identity theft or other fraudulent activities using the acquired information (Alkhalil et al., 2021).

There are numerous types of phishing attacks, including malware, browser extensions, pop-up phishing, man-in-the-middle, and vishing. However, clicking on hyperlinks is the most common among children, as they often lack the knowledge and experience to recognise legitimate websites (Collins & Muhammad, 2022).

Artificial Intelligence

AI has transformed the cyberspace landscape, making it easier to produce synthetic audio, video, and images with altered voices or facial features, commonly referred to as deepfakes. A popular form of deepfake is "deepfake videos", which create highly realistic videos of individuals doing or saying things they have never actually done (Ali et al., 2021; Murphy & Flynn, 2022).

Applications, such as FaceTune, FaceApp, and FakeApp enable users to manipulate media without requiring significant computational resources. Although deepfakes offer some potential benefits, such as translating educational resources into different languages or customising learning materials, they have primarily been used for malicious activities.

Deepfakes pose potentially harmful impacts on children in various ways

(Naffi et al., 2025; Westerlund, 2019):

- Child predators: deepfakes can be used to create misleading content, such as manipulating an adult’s face into that of a younger person’s face;
- Identity theft: manipulating children’s videos or images to create a fraudulent identity;
- Cyberbullying and harassment: perpetrators can create deepfake videos or images of children engaging in inappropriate behaviour, leading to cyberbullying and harassment;
- Educational implications: children may struggle to distinguish between real and fake information, affecting their ability to interact with media securely; and
- Psychological impact: deepfake videos containing disturbing content can cause children to experience trauma, fear, and confusion.

This form of online vulnerability affects not only children, but also society at large, with the impact varying based on the perpetrator’s motivations. Children are particularly at risk from deepfakes because they often lack the critical thinking skills and digital literacy needed to recognise such content.

While mobile devices offer numerous benefits, including communication, entertainment, and educational purposes, they also present harmful impacts, such as problematic usage, safety concerns, and a reduction in face-to-face communication. Nevertheless, mobile devices can be valuable learning tools for children and should not be taken away by parents. Instead, children should be taught to use them responsibly, enabling them to maintain a balanced lifestyle in cyberspace.

The second most preferred digital technology, television, will be discussed in the following sections.

2.2.2 Television

Television is a long-standing form of technology that significantly impacts the digital well-being of children, as most households own one (Panjeti-Madan & Ranganathan, 2023; Vedeckina & Borgonovi, 2021). Today, children are watching television more than they did a decade ago, largely due to its increasing accessibility, which raises concerns about their screen time. Preschoolers tend to watch more television than older children. Playing outdoors or participating in physical activities is becoming less popular among children, as they prefer to watch television (Brockmann et al., 2016; Lin et al., 2015). This early exposure to screens can shape children’s behaviours, which may persist into adulthood. At this stage, caregivers have greater control over their children’s screen usage, making it easier to limit their exposure (Ponti, 2023).

Benefits associated with television

Television can offer age-appropriate and well-designed educational content that can support early language learning, language skills, and entertainment, which will be described next.

Educational programming

Quality screen media that provides educational content aims to foster early literacy and language development in preschool-aged children. Prosocial television programmes that involve responsive interactions between caregivers and children can be particularly beneficial for learning when watched together, enhancing the bond between parent and child (Ponti, 2023; Robidoux et al., 2019).

Viewing age-appropriate educational television programmes, as shown in Table 2.1, while co-viewing with parents has been found to substantially enhance children's language acquisition, basic arithmetic, and cognitive skills (Neumann, 2015; Norris et al., 2013; Owen, 2008; Robidoux et al., 2019; Vedeckina & Borgonovi, 2021). These programmes are highly preferred by children; as preschoolers grow, they tend to gravitate towards programmes that feature real people interacting.

Furthermore, these programmes foster cognitive abilities such as memory, concentration, and reasoning by connecting content with real-world experiences, encouraging engagement, and preparing children for elementary school (Robidoux et al., 2019). Research conducted by Gottschalk (2019) found a positive relationship between watching educational television programmes and preschool achievement.

Although well-designed educational television shows offer high-quality content, research by Sundqvist et al. (2021) suggests that preschool children can develop fluency in language and vocabulary more effectively through live, engaging, and direct interactions with their caregivers. While television provides educational content for children, it can also include inappropriate material, about which caregivers should be vigilant.

Table 2.1: Examples of educational television programmes and their associated learning content for preschool children

Educational program	Content taught
Sesame Street ¹	- Early language acquisition - Reading and writing skills - Cultural diversity
Bob the Builder	- Teamwork - Problem-solving abilities - Importance of friends
Takalani Sesame ²	- Literacy and numeracy - Health and well-being - Intellectual and emotional development
Peppa Pig ³	- Daily routines - Language development - Problem-solving abilities
Timmy & Friends ⁴	- Social skills - Vocabulary expansion - Creativity and imagination
Masha and the Bear ⁵	- Friendship and support - Life skills - Cultivation of creativity
PAW Patrol ⁶	- Teamwork - Responsibility - Resilience

Potential harms associated with television

Although television offers several benefits among children, it can also present potential harmful impacts, such as psychological and physiological problems (Robidoux et al., 2019), which will be described next.

Development and health

Television has evolved into a “technological caregiver” for children. However, research by Lin et al. (2015), Reid Chassiakos et al. (2016), and Robidoux et al. (2019) suggests that excessive television viewing is associated with

¹<https://www.sesamestreet.org>

²<https://takalanisesame.org.za>

³<https://www.peppapig.com>

⁴<https://www.timmytime.tv>

⁵<https://mashabear.com>

⁶<https://www.pawpatrol.com>

various developmental problems, including physiological and psychological issues. Children who watch television excessively tend to spend insufficient time playing outdoors, which can hinder their overall development.

Research has found a positive correlation between excessive television viewing and a significant increase in body mass index among preschoolers (Hill et al., 2016; Neumann, 2015; Reid Chassiakos et al., 2016). Television viewing may contribute to obesity through various factors, including (1) exposure to unhealthy programming and advertisements promoting poor food choices (Strasburger, 2011), (2) inadequate sleep, which can disrupt food intake regulation by raising ghrelin levels, the “hunger hormone”, thereby raising energy intake and increasing the risk of positive energy balance and weight gain (Broussard & Klein, 2022), and (3) sedentary behaviour, which can lead to obesity in preschool-aged children (Hobbs et al., 2015).

Psychological impacts

The television viewing landscape has evolved to include more fast-paced and violent content, leading to a significant increase in attention deficit hyperactivity disorder (ADHD) among children and adolescents (Nikkelen et al., 2014). Previously considered a separate behaviour, ADHD is now recognised as a spectrum of behaviours (Nikkelen et al., 2014). This neurodevelopmental condition is characterised by symptoms of inattention, impulsivity, and hyperactivity, which can adversely impact a child’s social-emotional and cognitive development (Beyens & Valkenburg, 2022; Lissak, 2018). Beyens and Valkenburg (2022) outline the three symptoms in children as follows:

- Inattention: children struggle to maintain a focus on a task or activity or are easily sidetracked;
- Impulsivity: the inability of children to control their immediate actions, characterised by impatience; and
- Hyperactivity: excessive and energetic behaviour.

A study by Beyens et al. (2018) demonstrates that the correlation between screen media entertainment and ADHD is statistically small. However, there is a link between violent video games, television, and ADHD. This study identified two hypotheses on how violent and fast-paced content can impact ADHD-related behaviours in children and adolescents.

Exposure to violent content has been found to contribute to ADHD, as it leads to *violence-induced scripts* and *violence-induced arousal habituation*. *Violence-induced scripts* in children refer to the observation of violent or aggressive behaviours. These actions can influence how children respond to and perceive various situations, often resulting in a lack of self-control. *Violence-induced arousal-habituation* implies that overexposure to stimulating content can disrupt children’s arousal systems, potentially contributing

to ADHD-related behaviours. This excessive stimulation can lead to desensitisation and boredom, when viewed repeatedly, resulting in inattention, impulsivity, and hyperactivity.

In addition, the consumption of fast-paced content can lead to *scan-and-shift* and *fast-paced arousal habituation*. *Scan-and-shift* content is characterised by quick cutting and editing that encourages children to rapidly shift their attention from one activity to another. This can adversely affect tasks that require sustained attention, such as schoolwork. *Fast-paced arousal habituation*, a consequence of frequent attention changes induced by fast-paced activity, can stimulate children by causing them to continuously shift their focus, leading to increased levels of stimulation. Slower-paced activities may become boring, potentially impacting children's behaviour and ability to concentrate.

Increased television viewing is associated with social isolation due to its replacement of imaginative play and other high-quality interactions that improve cognitive function, rather than screen entertainment (Nikkelen et al., 2014; Ponti, 2023). Moreover, entertainment media focus on visual processing and use language more suited to adults, which hinders the development of children's language skills (Nikkelen et al., 2014). This may eventually have an impact on their academic performance (Shuai et al., 2021).

These potential health risks can affect children's well-being from childhood to adulthood. Therefore, instilling healthy habits, such as limiting prolonged television viewing and engaging in outdoor activities can benefit their overall health. The final preferred digital technology, video games, will be discussed in the following sections.

2.2.3 Video games

Video games, also known as computer games, have long been a popular recreational activity for children. These electronic games involve users manipulating images displayed on a screen (Kracht et al., 2020). In simple terms, video games are electronic games controlled by input devices such as keyboards, controllers, or other peripherals, which produce graphical output on a screen. The first video game to use a graphical display oscilloscope and an interactive analogue computer, featuring a bouncing dot and two dotted lines, was "Tennis for Two", developed by American physicist William Higinbotham in 1958 (Tretkoff, 2008).

This simple game marked the start of a new era for video games and led to the creation of gaming systems known as game consoles. Video games are more precisely defined as "digital games", as they are accessible on various devices, including mobile ones, and offer immersive gameplay through augmented and virtual reality (Kracht et al., 2020). Furthermore, video games have evolved from mere entertainment into valuable learning tools. Their interactive nature distinguishes them from other forms of technology (Granic

et al., 2014).

Benefits associated with video games

A myriad of video games have been intentionally developed for educational purposes, including cybersecurity, health, and academic reasons. In addition to providing entertainment, playing games has been shown to offer potential benefits for learning and improving problem-solving skills. It also serves as a motivational and emotional element and promotes prosocial creativity (Lérida-Ayala et al., 2022; Mondéjar et al., 2016; Nijhof et al., 2018; Yilmaz & Griffiths, 2023).

Learning and development

Playing games, specifically action games, has been demonstrated to enhance cognitive skills, such as knowledge acquisition, creativity, spatial skills, and problem-solving abilities (Lérida-Ayala et al., 2022), making it a valuable leisure activity. Research by Mondéjar et al. (2016) employed electroencephalogram (EEG) analysis, a method used for recording electrical activity in the human brain, to investigate the relationship between executive functioning and video game mechanics in children. The findings revealed a positive correlation between three game mechanics and executive functioning:

1. Timely action, which is associated with perception, problem solving, decision making, attention control and short-term memory;
2. Pattern learning, linked to controlled attention, response inhibition, and spatial perception; and
3. Planning and logical puzzles, related to short-term memory, information interpretation, problem solving, conceptualisation ability, and resilience to interference.

When children play games, their metacognitive skills are engaged, as they encounter scenarios that require them to analyse situations, gather information, and establish connections within the game, simulating real-life decision making processes (Dindar, 2018; Yilmaz & Griffiths, 2023). These abilities positively impact performance in various fields and can be transferred to contexts beyond video games (Nijhof et al., 2018). Engaging in role-playing games enhances children's practical competence, while strategic games, such as puzzles and matching games, can facilitate their development of problem-solving skills (Dindar, 2018).

A specific category of video games known as serious games will be discussed in Chapter 4. These games are designed with the intention of educational purposes while maintaining an element of entertainment (Pérez et al., 2023).

Motivational and emotional domain

Video games provide immediate feedback to players, which enhances their motivation and supports the concept of the “zone of proximal development” (Lérida-Ayala et al., 2022). This stage of development exists between the current level of problem-solving independence and their potential when guided by an adult (Irshad et al., 2021). In addition, video games present challenges that encourage players to work towards a common objective, instilling a sense of accomplishment upon completing a task, and thereby enhancing their overall mood.

Creativity and prosocial behaviour

Role-playing games provide a platform for children to express their creativity by developing character identities, pursuing objectives, and shaping game narratives. Video games, such as *Minecraft*⁷ have become an integral part of children’s media consumption (Mavoa et al., 2018). *Minecraft* allows children to build and explore virtual worlds without limitations, fostering creativity through block-based gameplay. In addition, it benefits preschoolers by helping them learn about shapes, colours, and collaborative world-building. Research by Ringland et al. (2017) indicates that children with autism spectrum disorders can also gain from playing on *Autcraft*⁸, a *Minecraft* server designed for them. This platform enables these children to express themselves and engage with peers while remaining anonymous, which reduces anxiety (Király et al., 2023).

Video games allow children to play in a self-directed manner, progressing in a way that is tailored to their learning preferences, thus maximising their learning potential. They help promote the development of social skills and prosocial behaviour by providing opportunities to participate in virtual communities (Lérida-Ayala et al., 2022).

Research by Harrington and O’Connell (2016) shows that prosocial games are significantly associated with positive prosocial behaviour. These games can foster cooperation, enhance social skills, and encourage empathy and helping behaviour among children. They also help cultivate positive relationships and a sense of belonging within peer groups and family members (Harrington & O’Connell, 2016; Lérida-Ayala et al., 2022).

Potential harms associated with video games

While video games offer opportunities for learning, development, creativity and prosocial behaviour, there are also potentially harmful impacts associated with playing video games. Specifically, gaming disorder is linked to negative consequences that can affect both physical and mental well-being.

⁷<https://www.minecraft.net/>

⁸<https://www.autcraft.com/>

In addition, playing violent games can contribute to the development of aggressive behaviour (Kracht et al., 2020; Limone & Toto, 2021).

Gaming disorder

Video games are rapidly becoming an integral part of children's lives; however, their potential for addiction can lead to gaming disorder, also known as video game disorder, game addiction, internet gaming disorder, or internet gaming addiction (Limone & Toto, 2021). Gaming disorder is characterised by persistent gaming behaviour that significantly impairs important areas of functioning (Darvesh et al., 2020). A study by Paulus et al. (2021) indicated that gaming disorder cannot be formally diagnosed in preschool children; however, early emotional dysregulation in this age group may serve as a significant predictor of gaming disorder symptoms later in childhood.

Huddleston (2016) identified certain signs of video game addiction, including the misuse of money on games. These diagnostic criteria and signs can be particularly harmful to preschool children, as they may become increasingly preoccupied with gaming instead of engaging in outdoor activities or essential tasks, such as schoolwork. This preoccupation can result in excessive screen time, disrupting their sleep, and potentially leading to obesity. In addition, these factors can negatively impact their mental well-being, causing anxiety, depression, concentration problems, social isolation, and academic struggles. The disorder may also lead to aggressive behaviour in children when caregivers restrict their gaming time. Therefore, it is crucial to balance gameplay with physical activities and to closely supervise and monitor their gaming habits.

Inappropriate influence

Children who play violent video games tend to demonstrate greater levels of aggressive affect, behaviour, and cognition (Lérida-Ayala et al., 2022; Yadav & Chakraborty, 2021). Similarly, racing games have been shown to promote reckless driving among children (Yadav & Chakraborty, 2022). In addition, children often mimic the actions depicted in video games, which can influence their personalities, potentially leading to academic underperformance, increased aggression, and physical altercations (Gupta et al., 2022; Panjeti-Madan & Ranganathan, 2023). These behaviours can ultimately inhibit children's creativity and impact their social lives.

A summary of the beneficial and potentially harmful impacts of digital technologies, such as mobile devices, television, and video games, on preschool-aged children is presented in Table 2.2. While digital technologies can enhance children's overall well-being, they also pose potential threats. Therefore, it is essential to supervise the use of these devices and encourage outdoor play.

Table 2.2: A summary of the beneficial and potentially harmful impacts of different digital technologies on preschool children

Digital technology	Beneficial impacts	Potential harmful impacts
Mobile devices	- Sense of closeness; - Improved motor skills; - Enhanced creativity and imagination; - Educational opportunities; and - Entertainment.	- Problematic usage; - Reduced caregiver-child interaction; - Online vulnerabilities; and - Exposure to deepfakes.
Television	- Educational content; and - Parent-child bonding.	- Physiological issues; and - Psychological impacts.
Video games	- Learning; - Motivational and emotional benefits; - Creativity; and - Prosocial behaviour.	- Gaming disorder; and - Inappropriate content influence.

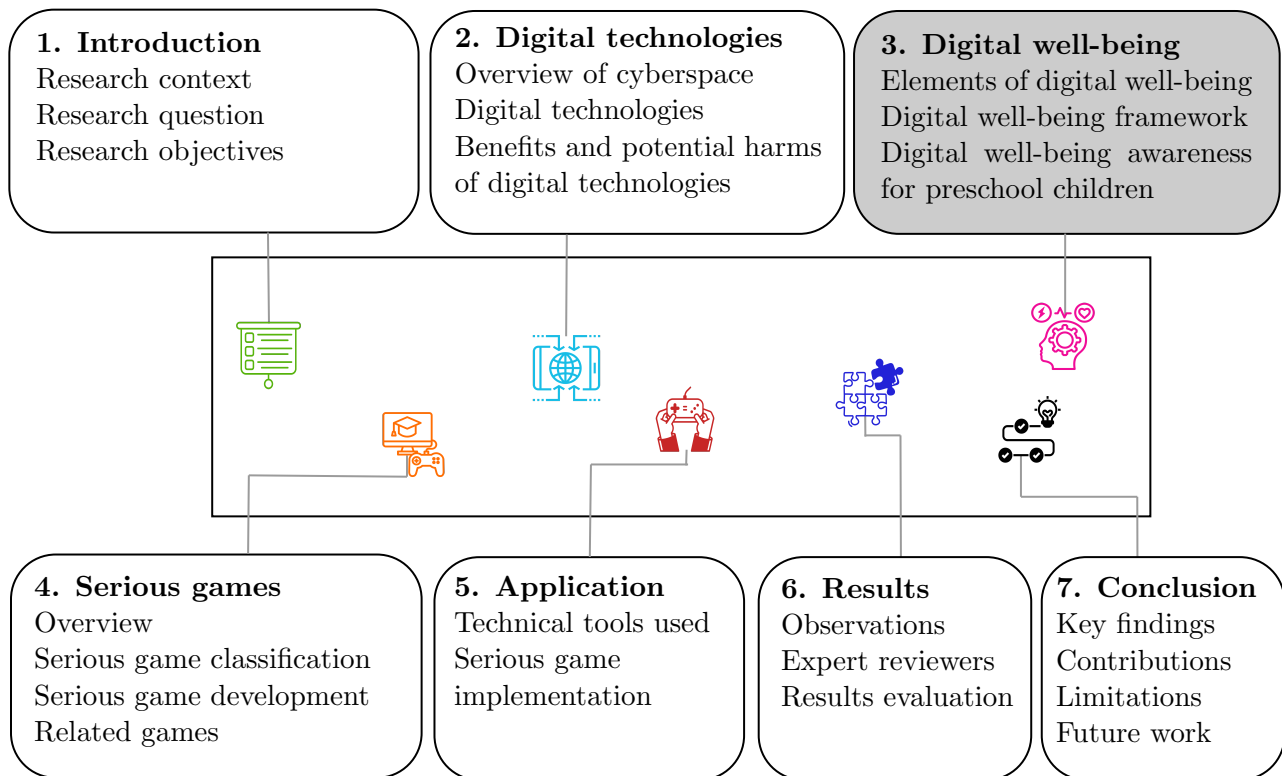
2.3 Summary

In this chapter, cyberspace was introduced. The relevant digital technologies prevalent among preschool children were discussed, including mobile devices such as tablets and smartphones, as well as television and video games. Children prefer mobile devices due to their interactive features and portability, while television is easily accessible to them. Finally, video games are favoured by children because of their interactive nature. The benefits of these digital technologies can enhance digital well-being, while potential harms can decrease it. This highlights the need to develop an intervention that will enhance children's digital well-being, which, in turn, will contribute to their overall well-being.

In the next chapter, a detailed literature review of digital well-being will be presented, including an exploration of its elements, the digital well-being framework, and approaches for enhancing digital well-being among preschool children.

Chapter 3

Digital well-being



In this chapter, the concept of digital well-being is discussed in detail to better understand how the use of digital technologies can impact children's digital well-being, with the aim of enhancing digital well-being and cybersecurity awareness among preschool children.

In Section 3.1, an introduction to digital well-being is presented. In Section 3.2, the elements of digital well-being are explored. Next, the digital well-being framework developed by Büchi (2024), which is the selected framework for this study is presented in Section 3.3.

In Section 3.4, two approaches that have been shown to successfully enhance digital well-being and cybersecurity awareness in children are discussed. In Section 3.5, a detailed overview of the “Digital wellnests” book by Fischer and von Solms (2016) is provided. This book is included as it is the existing content that focuses on the digital well-being of young children and serves as the basis for the serious game.

Finally, the stakeholders involved in digital well-being and cybersecurity awareness, along with the approaches through which children learn are presented in Section 3.6.

3.1 Overview

Today, children grow up in a technological environment where digital technologies are used daily for various purposes, including learning, acquiring information, and entertainment. However, it is important to recognise that these technologies can have both positive and potentially harmful impacts. Young children, more than others, are susceptible to the dangers linked with digital technology and may lack awareness of these dangers (Cao & Li, 2023; Mnisi et al., 2024).

Just as maintaining a healthy lifestyle in the physical world is important, it is also vital to uphold well-being while navigating the digital realm, which is known as digital well-being. As in the case of cyberspace, digital well-being lacks a consensus definition, with various studies proposing different interpretations.

Gui et al. (2017) defined digital well-being as follows:

We define digital well-being as a state where subjective well-being is maintained in an environment characterized by digital communication overabundance. Within a condition of digital well-being, individuals are able to channel digital media usage towards a sense of comfort, safety, satisfaction and fulfilment. As we have seen above, this condition is favoured both by specific individuals' skills and by the socio-cultural context they live in. (p. 166)

When evaluating this definition, Gui et al. (2017) describe it as a state

of an individual's well-being that is balanced in cyberspace. In this state, individuals can use digital technologies constructively while considering advantages and potential negative consequences, as well as their surrounding environment.

Vanden Abeele (2021) defined digital well-being as:

Digital well-being is a subjective individual experience of optimal balance between the benefits and drawbacks obtained from mobile connectivity. This experiential state is comprised of affective and cognitive appraisals of the integration of digital connectivity into ordinary life. People achieve digital well-being when experiencing maximal controlled pleasure and functional support, together with minimal loss of control and functional impairment. (p. 938)

This definition also emphasises the importance of balancing the benefits and drawbacks of being connected to cyberspace. It involves using digital technology to enhance quality of life while minimising potential risks.

Recently, Büchi (2024) described digital well-being as follows:

Digital well-being concerns individuals' affect (e.g., positive emotions), domain satisfaction (e.g., one's relationships or job), and overall life satisfaction in a social environment characterized by the constant abundance of digital media use options. (p. 3)

Büchi (2024) defines digital well-being as an individual's overall wellness when engaging with digital technology and the online environment. This concept encompasses the influence of technology on all aspects of a person's life, including personal and professional relationships, in a digitally dominant world. These authors argue that digital well-being involves maintaining a balance in cyberspace while utilising digital technologies. In addition, it encompasses the impact of these technologies on an individual's wellness. In this study, digital well-being is concerned with the impact of digital technologies on one's overall wellness; it involves using technology responsibly and maintaining a balance between its advantages and drawbacks.

3.2 Elements of digital well-being

The elements of digital well-being are complex concepts that have been studied by various scholars from different perspectives. McMahon and Aiken (2015) identified three digital well-being elements: physiological, behavioural, and psychological. JISC (2019) identified three elements of digital well-being using different terminology: mental, physical, and emotional health.

Johnson (2021) included physiological, behavioural, and emotional aspects as levels of digital well-being. Most recently, Tiwari et al. (2024) identified three factors constituting elements of digital well-being: psychological, physical, and social aspects. Collectively, these studies indicate that digital well-being encompasses physiological, behavioural, and psychological elements, which will be discussed in the following sections.

3.2.1 Physiological well-being

The physiological aspect (also known as physical well-being) of digital well-being refers to an individual's physical health while engaging with digital technology. According to McMahon and Aiken (2015), this component comprises two classifications: screen time and technostress.

Screen time

The digitisation of technology has made screen time an unavoidable aspect of childhood, resulting in a decrease in outdoor activities (Gupta et al., 2022). As children get older, their daily screen time tends to increase significantly (Swider-Cios et al., 2023). Gupta et al. (2022) identified three categories that influence the duration of children's use of screens. These categories include:

1. Child-related - sedentary behaviours (playing video games, using mobile devices), the age at which children are introduced to screens, and consumption of fast food while using screens;
2. Parents and caregivers - views and opinions regarding screen time; and
3. Demographic and environment - encompassing aspects, such as working from home, socio-economic status, lockdown measures and the availability of devices within the household.

These factors are interconnected and collectively influence the duration of screen time in which children engage. Furthermore, these digital devices can have detrimental effects on children, leading to postural problems and visual disturbances.

Konca (2022) identified three strategies that impact the screen time of children:

1. Active mediation - involves a collaborative approach between parents and children in determining the content viewed while using digital technology;
2. Co-viewing - parents interact closely with their children throughout screen time, remaining present and using digital technologies alongside them; and

3. Restrictive strategy - parents establish guidelines for the use of digital technologies, including where to use them and how long they should be used.

These strategies may vary among parents; some may have no expectations for their children or no specific rules. To promote responsible screen time usage among children, various countries and organisations, including, Australia (Hinkley et al., 2020), Canada (Tremblay et al., 2016), South Africa (Draper et al., 2020) and the World Health Organisation (WHO) (Willumsen & Bull, 2020), have developed guidelines recommending that screen time be limited to one hour a day. These guidelines support a healthy lifestyle and foster children's development. Restricting screen usage can positively impact children's overall health and digital well-being, which includes limiting screen time during mealtimes and bedtime, supervising their screen use, and encouraging them to engage in more physical activities.

Technostress

In a world where cyberspace and digital technologies dominate, individuals benefit from enhanced convenience in communication, information exchange and learning, ultimately improving their quality of life. However, the use of this information and communication technologies can significantly affect stress levels (Salo et al., 2022). This stress is classified as technostress. Ragu-Nathan et al. (2008) described technostress as the stress encountered by end users when interacting with digital technologies.

Technostress comprises five key constructs that contribute to stress: constant connectivity (commonly known as techno-invasion), information overload (or techno-overload), novel technologies (also referred to as techno-complexity), job insecurity (or techno-insecurity), and lack of experience (also known as techno-uncertainty) (Nastjuk et al., 2024).

While technostress primarily occurs in professional workspaces, it can also significantly impact children, particularly through techno-overload. Children may experience symptoms similar to traditional stress, including physical, psychological, behavioural, cognitive, and social symptoms (La Torre et al., 2019; Nastjuk et al., 2024). Caregivers and parents must be aware of these symptoms related to digital technology's impact on their children's well-being and should promote healthy digital habits and digital literacy among them.

3.2.2 Behavioural well-being

The behavioural aspect refers to the patterns, practices, and actions that individuals exhibit when interacting with digital technologies. This aspect focuses on an individual's conduct during their engagement with technology, their online activities, and their reactions to specific information in

cyberspace. Behavioural well-being includes problematic internet use and media multitasking (McMahon & Aiken, 2015).

Problematic internet use

Problematic internet use is the excessive and disruptive behaviour related to internet usage (Restrepo et al., 2020). It is considered an addictive behaviour due to its symptoms, which include increased tolerance over time, impaired functioning, and withdrawal (Dib et al., 2021). This condition is known by several names, including problematic use of the internet, pathological use of the internet, internet overuse, problematic media use, compulsive internet use, and internet addiction (Moretta & Buodo, 2020). These terms fall under the broader category of problematic technology use, as they encompass any form of technology.

Problematic internet use is classified into two categories: generalised problematic internet use, which encompasses overall internet usage behaviour, and specific problematic internet use, which refers to particular online activities, such as gaming and social media. These categories are distinguished by their different interventions and mechanisms (Ruckwongpatr et al., 2022).

Children who excessively use the internet are prone to experience academic challenges, aggressive behaviour, sleep disturbances, attention problems, impaired self-regulation skills, and decreased emotional and social abilities (Rega et al., 2023). Király et al. (2020) provided practical recommendations for mitigating children's problematic internet usage. These include parental involvement in monitoring online activities, supervising behaviour, and using digital well-being applications that can promote self-control and awareness.

Screen media multitasking

Today, children have unprecedented access to multimedia content due to the widespread availability of digital technologies in households. As a result, there has been a significant increase in media multitasking. Media multitasking refers to the simultaneous use of two or more media platforms or the integration of media with non-media activities (Zhou & Deng, 2023). While media multitasking occurs in all age groups, young people tend to multitask more frequently (Beuckels et al., 2021). As children grow older, they become increasingly inclined to engage in media multitasking (Soldatova et al., 2019; Srisinghasongkram et al., 2021). Previous studies indicate that media multitasking can negatively impact children and adolescents, leading to a shorter attention span, impaired cognitive functioning, behavioural problems, decreased prosocial behaviour, and increased anxiety and depression (Primack et al., 2017; Soldatova et al., 2019; Srisinghasongkram et al., 2021). Positive parenting styles have been found to play a crucial role in mediating these

effects (Srisinghasongkram et al., 2021).

3.2.3 Psychological well-being

The psychological aspect (also known as mental well-being) of digital well-being pertains to an individual's emotional, social, and cognitive well-being when interacting with digital technologies. This aspect includes online security and the online disinhibition effect (McMahon & Aiken, 2015).

Online security

Many of children's online activities can pose security and privacy risks. Due to their limited understanding of online security, children may be vulnerable to various online threats and cyberattacks. The use of technologies, such as predictive analytics and artificial intelligence raises concerns regarding the potential misuse of children's data for profiling purposes, which may undermine their fundamental rights (Jang & Ko, 2023).

Livingstone and Stoilova (2021) identified four Cs for recognising online risks among children using digital technologies. These include exposure to age-inappropriate content that contains harmful, violent, or gory material (content risk); involvement in harmful interactions, such as grooming, hateful behaviour, stalking and cyberbullying (contact risk); engaging in or witnessing harmful situations, whether as a victim or perpetrator (conduct risk); and exposure to inappropriate advertisements and the misuse of personal information, such as identity theft and phishing (contract risk).

These online risks can have psychological impacts on children, leading to depression and triggering emotions, such as social withdrawal, despair, and a loss of interest in previously enjoyed activities. In addition, they can contribute to increased anxiety and stress, which ultimately affects children's mental health (AlShabibi & Al-Suqri, 2021). While children's online safety is important, digital technologies should not be prohibited, as they can potentially significantly enhance children's lives and offer numerous learning opportunities (Jang & Ko, 2023). One fundamental defence against these online risks is to foster early awareness interventions among children, emphasising the importance of open communication with their parents regarding their online activities.

Online disinhibition effect

The online disinhibition effect, a term introduced by the cyberpsychologist John Suler, is an individual's inclination to show greater openness and self-disclosure in cyberspace compared to the physical world (Suler, 2004). In layman's terms, online disinhibition can be defined as a psychological state in which individuals behave or communicate online in ways they would not in face-to-face interactions (Cheung et al., 2021). This definition, established

by Suler, remains unchanged and has been adopted in various studies (Cheung et al., 2021; Hayes et al., 2022; Wang et al., 2024). Online disinhibition manifests in two different ways (Suler, 2004). Benign disinhibition occurs when individuals express kindness, fears, emotions, and desires in the online environment, while toxic disinhibition involves the use of threats and offensive language that individuals would typically avoid in the real world (Cheung et al., 2021).

Six factors contribute to online disinhibition: dissociative anonymity (individuals separating their online actions from offline actions, leading to a feeling of being less restricted in self-expression), invisibility (the assumption that one is not physically seen by others online), asynchronicity (the time delay in online communication, which minimises its direct impact on behaviour), solipsistic introjection (the extent to which individuals mentally perceive others' images or voices in cyberspace), dissociative imagination (online communication fosters creativity and fantasy that are not disconnected from the real world), and minimisation of authority (individuals perceive the reduction in or less influence of authority in the real world) (Suler, 2004).

Studies conducted by Cheung et al. (2021) and Wang et al. (2024) have revealed that online disinhibition is linked to cyberbullying. Anonymity may influence cyberbullying since it can be done online and anonymously. Invisibility allows perpetrators to send harmful remarks with the assumption of not being seen (Wang et al., 2024).

3.3 Digital well-being framework

The primary aim of this study is to develop a serious game, guided by the digital well-being framework of Büchi (2024), as an intervention to enhance the digital well-being and cybersecurity awareness among preschool children. This framework serves as a guide for developing specific theories regarding how a digital practice can lead to particular outcomes. In this context, it examines the opportunities and challenges associated with preschool children's use of digital technologies, ultimately facilitating the development of a targeted intervention.

According to Büchi (2024), the digital well-being framework examines how an individual's use of technology can yield both advantages and harms that often co-occur, resulting in an impact on subjective well-being. In layman's terms, an individual's digital practices, such as their daily use of digital media or technology, can lead to various benefits and risks, ultimately affecting their subjective well-being (Büchi, 2020). This framework consists of three interconnected components that are fundamental, suggesting that these practices can be influenced by other variables. These factors include (1) digital practice, (2) associated benefits and risks, and (3) subjective well-being.

Digital practice is the first component of the digital well-being framework and encompasses the behaviours through which individuals use and interact with digital technologies. Users who engage with digital media daily often struggle with information overload, interpersonal relationships, and time management, which can significantly impact their well-being and quality of life (Büchi, 2020, 2024; Cano-Gillis, 2023; Isaks et al., 2023).

The second component involves analysing the proximal outcomes that arise from digital practices, including the benefits and harms which may occur simultaneously. This component highlights the importance of considering additional factors that could influence the connection between digital practices and well-being, such as situation and personality (Cano-Gillis, 2023).

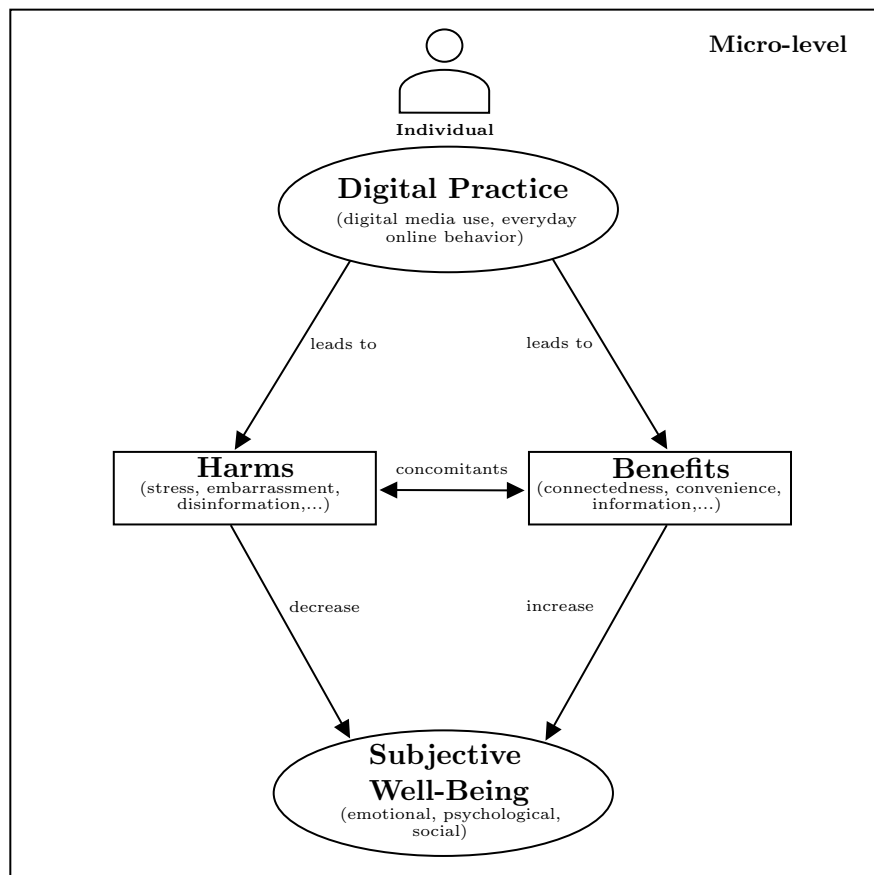


Figure 3.1: Digital well-being framework (Büchi, 2024). An individual's digital practices can lead to both benefits and harms that often co-occur, thereby impacting overall digital well-being

Finally, subjective well-being constitutes the last component of the framework. Subjective well-being refers to an individual's introspection of their quality of life (Isaks et al., 2023). Digital well-being is a specific aspect of subjective well-being that focuses on an environment where digital

media and technologies are omnipresent. Benefits contribute to improving an individual's digital well-being, while harms typically have a negative effect. These processes, including digital practice, benefits and harms, and well-being, may be influenced by additional factors, such as personality, demographics, and situational differences (Büchi, 2024; Isaks et al., 2023).

This framework acknowledges that both individual (micro) and societal (macro) influences can impact an individual's actions and overall well-being (Büchi, 2024). The micro-level of digital well-being relevant to this study is presented in Figure 6.6, which excludes the macro-level and its interconnected components.

The digital well-being framework proposed by Büchi (2024) has been used to gain a deeper understanding of specific digital practices and their impact on digital well-being through empirical research. This includes a longitudinal study by Wang et al. (2025), which investigates the relationship between social activities, peer relationship problems, and children's well-being, suggesting interventions aimed at enhancing their psychological well-being. Badri et al. (2025) employed this framework to analyse the effects of digital transformation on the well-being of younger generations, recommending that policymakers develop strategies to prepare children for the digital age. Isaks et al. (2023) used the digital well-being model as a theoretical framework to investigate the impacts of social media usage on the digital well-being of university students, thereby expanding on this model in the context of university students. Finally, Shu et al. (2025) utilised the digital well-being framework to analyse how different social media sharing behaviours (school-related, social-related, and work-related) among college students impact their psychological well-being.

This framework was selected for its structured and comprehensive approach to examining the influence of digital practices on individual digital well-being. It considers moderating factors, such as personality, which shape how individuals experience the benefits and potential harms of digital technologies. Moreover, this framework clearly differentiates between digital practices, their proximal impacts, and overall well-being. It aims to develop specific theories regarding how particular digital practices can ultimately affect an individual's digital well-being. In this study, it facilitates a thorough understanding of how digital technologies impact the digital well-being of preschool children. This analysis can lead to tailored interventions designed to enhance children's awareness of digital well-being and cybersecurity, equipping them with the essential knowledge and skills necessary to maintain positive well-being while using digital technologies.

3.4 Digital well-being awareness for children

Two approaches have been shown to be successful in enhancing children’s digital well-being and cybersecurity awareness: digital applications and early intervention campaigns (Cao & Li, 2023). The digital applications and early intervention resources discussed in this section were selected based on the age group they target and their specific focus on digital well-being and cybersecurity topics.

3.4.1 Digital applications

Anti-Phishing Phil, developed by Sheng et al. (2007), is an interactive game that immerses players in the role of “Phil”, a young fish who distinguishes between real and fake worms with the guidance of his experienced father. The game aims to achieve three fundamental objectives: detecting fraudulent links, recognising browser cues, and identifying trustworthy websites. While *Anti-Phishing Phil* is a valuable tool for teaching digital well-being and cybersecurity awareness, it has limitations in cognitive development, as children may find it difficult to identify URLs, a task that can also be complex for adults. It lacks contextual learning, making the connection between the scenarios presented in the game and real life. It does not include a level selector, which could help structure the challenge based on player age and skill level.

CyberAware, a digital application developed by Giannakas et al. (2015), teaches preschoolers about cybersecurity. It covers various topics, including email spam filters, security updates and patches, antivirus software, and firewalls, using simulations, interactive lessons, and quizzes. However, *CyberAware* lacks a level selector functionality, which could benefit players who find certain levels too easy or too difficult. In addition, the mini-games do not incorporate real-life scenarios; they primarily focus on recognising cybersecurity technologies.

CyberFamily is a game designed for family participation that teaches cybersecurity topics in an engaging and collaborative way. These topics include phishing, cyberbullying, password management, social media privacy, digital well-being, and basic internet etiquette. The game encourages players to engage with their families and promotes discussions about digital safety and conduct between guardians and their children (Quayyum & Jaccheri, 2025). However, while *CyberFamily* encourages family participation, it lacks a guide for parents who may not be familiar with these concepts, which could hinder their ability to guide their children effectively. It assumes that players have a foundational understanding of these topics, which may not resonate with all players. In addition, its delayed feedback mechanism may not be efficient for children.

*Interland*⁹, a game developed by Google, aims to teach children about digital well-being in cyberspace and how to make informed decisions in a fun and interactive way. It imparts key principles, such as thoughtful sharing of information, respect for others, protection of personal belongings, and transparency in interactions. While *Interland* is an effective tool for educating young users on these topics, it has limitations. Caregiver participation is essential to reinforce the lessons learned, and the game is designed for a broad audience. This general approach may make it challenging for some children, who have specific needs, to fully grasp the content presented.

Internet Hero, developed by Kayali et al. (2014), offers an immersive gaming experience where players navigate a fictional virtual world. The game addresses four key aspects of internet usage: types of connection, social networks, malicious programs, and emails. To succeed in the mini-games, players must understand the foundational concepts behind each aspect. While engaging, *Internet Hero*, also lacks a level selector to accommodate children's varying abilities.

*Spoofy*¹⁰ is a cybersecurity game designed to teach children about online behaviour, cybersecurity risks, and related topics. It features four worlds where players navigate and complete various missions that cover cybersecurity and digital well-being themes. While *Spoofy* is a valuable learning tool, its heavy reliance on text may be less appealing to children.

Finally, *Tanzanite Collector*, developed by Panga et al. (2022), is a mobile game created with African contexts in mind, specifically Tanzania. In this game, players control the Tanzanite Collector, gathering genuine tanzanite stones while avoiding fake ones. The game incorporates various phishing concepts, including email, phone calls, and message-based attacks. Similar to the other games, it lacks a difficulty selector and does not include caregiver engagement, which is critical for child development.

Although these games have demonstrated effectiveness in promoting digital well-being and cybersecurity among children, they have their own limitations, particularly for preschool-aged children, as discussed above. However, they provide a foundation for digital well-being and cybersecurity awareness, and offer potential for improvement through simplified gameplay, engaging visuals, and age-appropriate language.

3.4.2 Early intervention campaigns

Designing early intervention programmes that involve parents, caregivers, and children to cultivate healthy habits are beneficial and promotes digital literacy. This includes implementing a school curriculum that uses digital comics, interactive storytelling, and educational videos, thereby incorporating educational resources about digital well-being and cybersecurity

⁹<https://beinternetawesome.interland>

¹⁰<https://spoofy.ee/en>

(Quayyum et al., 2021).

According to Snyman et al. (2021), several key components are essential for fostering early intervention campaigns aimed at enhancing children’s digital well-being and cybersecurity awareness. These components include consistency, simplicity, engaging content, and appropriateness. Some resources specifically designed for children include an interactive educational e-book titled “Cyberheroes”¹¹ by Zhang-Kennedy et al. (2017), which educates children about online privacy. This e-book addresses topics, such as online anonymity, not talking to strangers, password security, cyberbullying, and location sharing. It introduces two superhero characters, *Ally* and *Bobby*, who guide readers through 14 interactive screens. Through a haptic touch interface, children can fully engage with the story through animations, music, and voice audio. This e-book serves as a valuable tool for fostering active discussions about online privacy between parents and children. In addition, it includes a discussion guide specifically designed for parents.

“The Savvy Cyber Kids” Book Series, written by Halpert and Southerland (2014), consists of three flip books featuring two superheroes, *Tony* and *Emma*. The primary goal of this resource is to educate children and educators about cybersecurity concepts that children may encounter when using digital technologies, including online privacy, balancing screen time with outdoor play, and cyberbullying. These books are accompanied by relevant activities and lesson plans.

“Chicken Clicking”, a children’s book by Willis (2015), explores the topic of online safety. The story follows a young chick that discovers a farmer’s laptop and ventures into the world of cyberspace. Driven by curiosity, the chick unknowingly begins online shopping for the entire farm and eventually befriends someone on the internet. However, when the chick shares personal information and arranges a meeting, the friend turns out to be different than expected.

Thomson and Gcaza (2025) contribute to the area of raising digital well-being and cybersecurity awareness among preschool children and Grade R (ages 5–6) learners by incorporating cyber safety skills into the curriculum. This is achieved through “The CyberSmart Squad,” which features animated characters based on South Africa’s Big Five animals, each having superpowers essential for safe online interactions and good digital citizenship. The characters include Lethu the Lion (Courage), Esihle the Elephant (Kindness), Lily the Leopard (Safety), Ryno the Rhino (Respect), and Babalo the Buffalo (Honesty). The aim of “The CyberSmart Squad” is to teach age-appropriate cyber safety and digital well-being content, using worksheets and animated videos in an interactive and fun way. This is designed to bridge the gap in early education on responsible and safe online behaviour and build lifelong digital literacy.

Prior and Ophoff (2024) conducted a study with young children about

¹¹<https://www.leahzhangkenedy.com/cyberheroes>

phishing, using CyberSprinters UK government resources. The study focuses on raising awareness and teaching children how to recognise online scams, and phishing attempts. The authors emphasise that effective cybersecurity education involves various stakeholders, including children, teachers and parents. By engaging these groups, children's digital well-being and cybersecurity awareness can be significantly enhanced.

“Digital wellnests: Let us play in safe nests!” by Fischer and von Solms (2016), is a book designed to enhance digital well-being and cybersecurity awareness among preschoolers. It features 14 poems with animal characters, each containing a moral lesson, and questions for children to ask their caregivers. This resource is the primary focus of this study and stands out from other instructional materials by addressing various topics related to digital well-being and cybersecurity, including phishing, hacking, cyberbullying, and password safety.

3.5 Digital wellnests: Let us play in safe nests!

To promote a culture of cyber safety among children, a book titled “Digital wellnests: Let us play in safe nests!”¹² by Fischer and von Solms (2016) is available for free download in both black and white and full colour. This makes it a cost-effective option for educational institutions and a fun colouring exercise for children. The book introduces new concepts with clear explanations and uses simple language suitable for all readers, including non-native English speakers (von Solms & Fischer, 2017).

The book features illustrations on each page to capture children's attention, portraying everyday digital challenges faced by both adults and children in cyberspace. It provides clear explanations to introduce new concepts. The events take place in a fictional animal world, which follows familiar African animals, including fish, cats, snails, and sheep, using various digital technologies. The book was positively received during a localisation workshop in Nairobi, Kenya, where stakeholders appreciated its simple and clear approach, as well as culturally recognisable characters (von Solms & Fischer, 2017).

The book is divided into four distinct parts. The first serves as a foreword for guardians, teachers, and parents. The second section explains technology-related terminology. The third presents poems featuring animal characters that teach lessons about online safety, each poem accompanied by a concise moral. The final section includes 14 short messages designed for children to memorise (von Solms & Fischer, 2017).

¹²<https://www.up.ac.za/african-centre-of-excellence-for-information-ethics/article/2109737/digital-wellness-toolkit>

3.5.1 Concepts

The book was developed with the understanding that cybersecurity is a new concept for everyone. For this reason, it aims to provide explanations of each of the nine technical concepts:

1. Camera: Device that captures images;
2. Cell phone: Portable device used for communication with others (either through emails, text, or phone calls);
3. Kindle: Portable device that enables the reading of electronic books;
4. Email: Communication method involving the exchange of electronic messages between people;
5. Computer: Electronic device designed for storing, organising, and sharing data;
6. Mouse: Electronic device used in conjunction with a computer to control and navigate the screen and its contents;
7. Signal Tower: Device that functions as a central hub for sending and receiving signals;
8. Social Media: Term used to describe online platforms and applications that enable users to generate, share and exchange information within an online social environment on the internet; and
9. Tablet: Portable electronic device that combines the functions of a personal computer, a mobile phone, and an electronic book reader. It features a touch-screen interface and falls in size between a cell phone and a computer.

3.5.2 Poems

The book primarily contains 14 poems, each accompanied by a unique story and concluding with a moral lesson focused on digital well-being and cybersecurity. Each short moral lesson includes one or two questions that guardians or caregivers can ask the child (or that the child can ask them). The following are the titles of the poems, along with their corresponding topics and moral lessons.

The safety of nests

The first poem is about a small bird that frequently uses its phone to browse the internet and shop online. The bird openly communicates with its teachers and guardians about its online activities and experiences. Its parents provide guidance on online safety. The moral of the story is that it is essential to maintain honesty and integrity while using the internet.

Safety Snail's e-mails

A Snail named Jenny receives an email from an unknown individual. Rather than opening and reading it, she chooses to delete the message. The moral of the story is to avoid opening mysterious or questionable emails from an unknown sender.

Lucky the Fish

A mobile message informed Lucky the fish that he had won a reward. Although he knew he had not entered any competition, he considered clicking on the dubious link provided. However, his buddy Sunny persuaded him to delete it instead, warning that it might be a trick. Lucky agreed with Sunny and deleted the message to avoid any potential risks. The moral of the story is to refrain from opening or responding to unknown or unclear messages.

Rabbit with the tablet

While using her tablet, a tiny Rabbit and his Monkey friends visited harmful websites, which frightened her. She realised the several risks present online and that she needs to be cautious. The moral of the story is to be responsible and careful when engaging in online activities or browsing the internet.

Elephant and his shoe

Rabbit helps his friend Elephant tie his shoelaces using the internet, as Rabbit is skilled with gadgets. However, Rabbit encourages Elephant to go outside and play. The moral of the story is that while the internet can be helpful, it is important to engage in outdoor activities with friends. Balancing screen time with outdoor activities is essential for a healthy lifestyle.

Sheepish Shelly

Shelly, a sheep, accepted a friend request from someone she did not know. She disclosed highly confidential information about herself and was subsequently stalked by a wolf with a fraudulent profile. Before the wolf could harm Shelly, a policeman spotted it and captured it, leading to its imprisonment. The moral of the story is to accept friend requests solely from individuals you know and to avoid sharing sensitive information online.

Wolf, Hyena and Fox

A wolf and his two friends, Hyena and Fox, are discussing the importance of setting strong passwords and the necessity of keeping them private. They emphasise the use of combinations of special characters, numbers, and capital

letters to make passwords harder to guess. The moral of the story is to ensure that your passwords are robust and not easily guessed.

Healthy Bear

A bear named Buddy had his computer infected with a virus because he did not update his anti-virus software. He reached out to his father for help, and his father explained that anti-virus programs protect his computer. Buddy realised that just as vitamins keep his body strong and healthy, anti-virus programs act like medicine for his computer, defending it against threats. He also learned that viruses can come from all over the internet. The moral of the story is to keep your digital devices safe by regularly updating your anti-virus programs.

Happy Hippo

A hippo named Henry received mean text messages, but hesitated to report them since there was no physical harm. However, Ron, his rhino friend, explained that cyberbullying is just as serious as any other form of bullying, and they should inform Teacher Owl. They approached the teacher, and the bullying eventually stopped. The moral of the story is that if you experience or witness bullying, you should reach out to a trusted person for support and assistance.

Buffy the Bully

A buffalo named Buffy enjoys spending time on his computer, forming online connections instead of engaging with people in real life. However, Buffy soon starts to feel lonely and depressed. In response, he begins sending harsh remarks to his online peers. His peers report him to their teacher, Owl. The teacher advises Buffy to talk about his feelings, emphasising that bullying is not the answer. The moral of the story is that if you witness someone engaging in bullying behaviour, it is important to report it to a trusted adult.

Identity Cricket

A young cricketer, feeling lonely, decides to make friends by sharing all his personal details online. However, his plan backfires, attracting dangerous strangers to his home. The moral of the story is to avoid sharing personal information online, as it can be accessed by anyone.

Cyber Cat

A cat named Cyber Cat used the internet to play and became skilled with computers. Eventually, he started stealing large sums of money and sending it to his friends and family by typing a few lines of code to gain unauthorised access everywhere. Ultimately, he was caught and sent to jail. The moral of the story is that hacking is illegal and has consequences. This story encourages users to avoid engaging in illegal activities.

Cannot see Chameleon

King Lion organised a tournament to select the healthiest animal in the realm. Teacher Owl points out the chameleon, since it shields its identity from predators and uses camouflage to protect itself from revealing personal information while navigating the online world. The moral of the story is to take precautions when connecting to and using the internet.

Zebra and his stripes

Zebra lines remind us to look both ways when crossing the street for safety. Similarly, when we are online, we should think of zebra stripes: pause and think before posting in order to remain safe. The moral of the story is to think twice before sharing anything on social media.

3.5.3 Short messages

The 14 brief messages at the end of the book are primarily designed for children to memorise. They aim to be entertaining while simultaneously imparting essential lessons. These teachings closely align with the lessons found in the stories and poems throughout the book. An example of messages from one of the stories in the book is as follows (Fischer & von Solms, 2016):

I never give personal information to anyone I don't know. I don't tell them my name, address or where I go. This information is private and remains alone mine. A real friend will not ask personal questions online. (p. 37)

3.5.4 Digital well-being for preschool children

From the stories and their digital well-being and cybersecurity-related concepts, the following four digital well-being elements for children have been identified:

The first element is the problematic use of the internet and digital technologies, defined as excessive use that can lead to various situations. This is illustrated in stories, such as “Safety of nests”, “Rabbit with the tablet”, “Elephant and his shoe”, and “Cyber Cat.”

Online security and privacy are the most prevalent digital well-being elements, as many stories address privacy and protection in cyberspace. This is evident in the following stories: “Safety Snail’s emails”, “Lucky the Fish”, “Rabbit with the tablet”, “Sheepish Shelly”, “Wolf, Hyena and Fox”, “Healthy Bear”, “Identity Cricket”, “Cyber Cat”, “Cannot see Chameleon”, and “Zebra and his stripes.”

Screen time is addressed in “Elephant and his shoe”, which emphasises maintaining a balance between digital technology and outdoor play.

Finally, online disinhibition, particularly toxic disinhibition, is depicted in the stories, “Happy Hippo” and “Buffy the Bully”, where mean words lead to cyberbullying.

The content of this book, including morals and short messages from the animals, can be generally summarised as follows:

- Avoid suspicious websites;
- Do not disclose sensitive information when using the internet, and be honest online;
- Report online harassment to a teacher or parent;
- Remove requests for friends and messages from unfamiliar and suspicious parties;
- Maintain a balance between screen time and outdoor play;
- Create secure passwords and do not share them with anyone;
- Always keep and use your anti-virus programs and utilities up to date;
- Avoid engaging in illicit acts when utilising electronic devices or the web; and
- Refrain from meeting strangers in person whom you engaged with online without parental guidance and approval.

3.6 Digital well-being in preschool education

For the two approaches, digital applications and early intervention campaigns, to be successful, it is essential to have involvement and support from various stakeholders to ensure their effectiveness. According to von Solms and von Solms (2014), this includes:

- Government: setting up systems that promote and assist a secure online environment;
- Law: establishing legislation to protect children from cybercrime;

- Schools: conducting and creating initiatives centred upon digital well-being awareness;
- Teachers: being well-equipped when it comes to digital well-being and cybersecurity education;
- Caregivers: supervising their children when they use the internet, as they have a direct impact on how they use it; and
- Peers: motivating and assisting their friends.

While this is feasible, it requires a significant amount of time, as well as commitment, especially in developing countries where resources are scarce. In addition, it must be translated into multiple languages, and many caregivers and teachers are inadequately prepared in the fields of digital well-being and cybersecurity education.

3.6.1 Play as a medium for learning and development

To promote digital well-being and cybersecurity awareness among children, it is essential to understand their learning preferences and optimal approaches. Children learn in various ways, with play being a central component of their early childhood development (Mnisi et al., 2025). Play is a multifaceted concept observed not only in humans, but also in various species, allowing individuals to hone their skills (Pellis & Pellis, 2013; Yogman et al., 2018). Huizinga (1938) defined play in his book, “Homo ludens”, as a voluntary activity composed of rules and order, which elicits a sense of happiness and excitement. It differs from ordinary activities and should not be dismissed as frivolous behaviour, as it is a crucial aspect of brain development (Pellis & Pellis, 2013; Sutton-Smith, 1997). In addition, play allows children to test boundaries, experiment, and take risks (Yogman et al., 2018).

Caillois (2001) expanded upon Huizinga’s definition by categorising play into four fundamental forms: *agôn* (competition), *alea* (chance), *mimicry* (simulation or role play), and *ilinx* (vertigo or balance). Competition involves players competing against each other; chance involves outcomes determined by luck rather than skill; simulation allows players to experience imaginative realities; and vertigo refers to a feeling of dizziness, often caused by physical sensations. These categories provide a holistic viewpoint for understanding the various manifestations of play in both animals and humans.

These works emphasise the importance of play in promoting the physical, emotional, social, and cognitive development in children. Play not only provides opportunities for skill acquisition but also helps children develop a sense of identity (Yogman et al., 2018). Through play, children can explore, observe, and make sense of their surroundings. Some of the ways in which children learn include (UNICEF & The LEGO Foundation, 2018):

- Hands-on experience: actively engaging with people and objects;

- Trial and error: through playful interactions using problem-solving skills, creativity and imagination to tackle obstacles and learn from mistakes;
- Social interaction: communicating with friends and guardians;
- Parental involvement: when parents are actively involved, children benefit from enriched play experiences; and
- Self-directed: giving children the freedom to guide their play, which promotes attentiveness, self-assurance and reliance.

Additional learning methods may include inquisitiveness and auditory learning (Snyman et al., 2021). It is important to note that children learn in different ways; some may learn through listening, while others may learn through hands-on activities or require assistance from their caregivers. Play is a multifaceted component that promotes holistic growth in children, providing opportunities to acquire new skills that nurture their well-being, development, and learning. Integrating these elements into a game can be a beneficial and engaging approach that enhances children's overall learning experiences and helps achieve the desired objective.

3.7 Summary

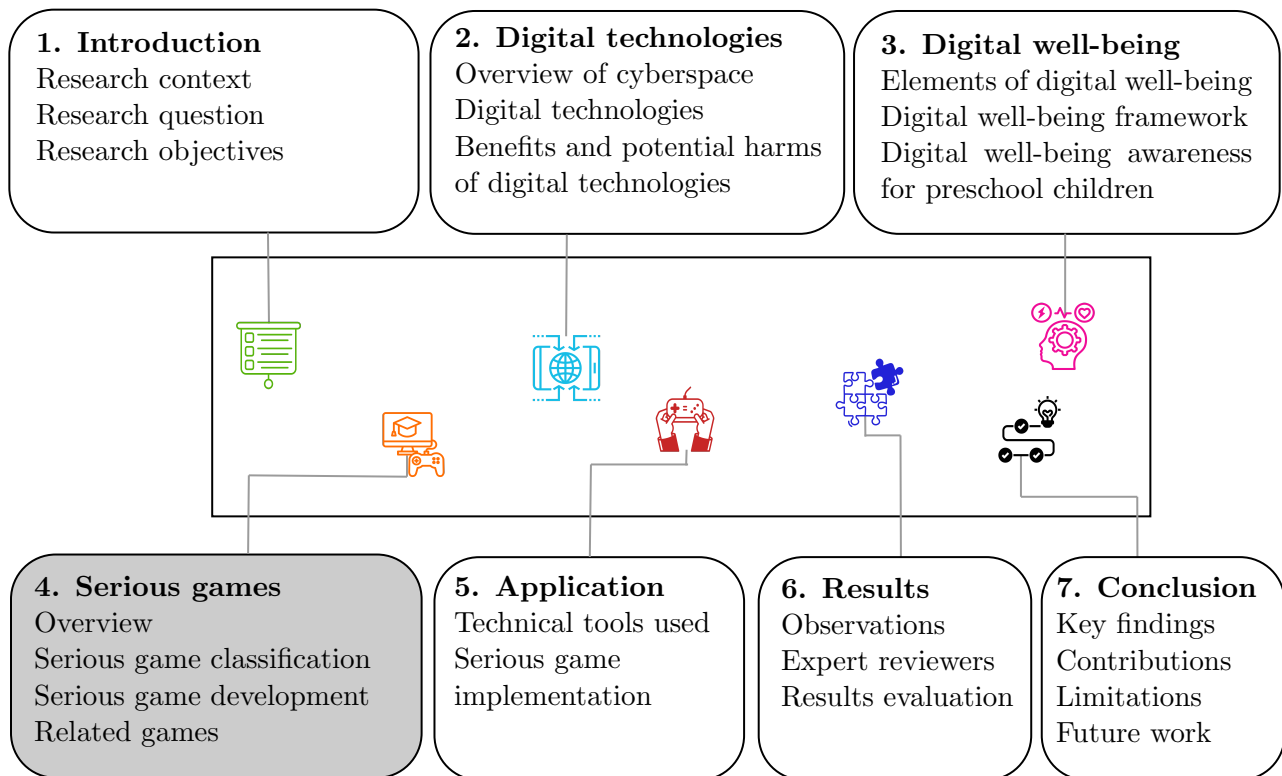
In this chapter, the topic of digital well-being was discussed, focusing on its three key aspects: physiological, behavioural, and psychological well-being. Following this, Büchi's (2024) digital well-being framework was introduced as a theoretical lens for this study, emphasising the micro-level, as this study focuses on children as individuals.

Next, two approaches that have been shown to be successful in enhancing digital well-being and cybersecurity awareness were presented, including digital applications and early intervention programmes, along with relevant examples. The fifth section focused on the book "Digital wellnests", summarising the stories and their morals. Finally, the various role players involved in ensuring the effectiveness of the two methods were discussed, along with the different ways children learn.

In the next chapter, the concept of serious games will be discussed.

Chapter 4

Serious games



In this chapter, the concept of serious games is discussed. In Section 4.1, an overview of serious games is presented, as well as the three different approaches that share similarities with them. The G/P/S model for classifying serious games, clarifying what is considered a serious game, is provided in Section 4.2. In Section 4.3, the factors contributing to the failure of serious games and the design principles for their optimal development, are discussed. Finally, the serious game elements tailored for preschool children, aligned with their unique cognitive abilities and related games are presented in Section 4.4.

4.1 Overview

Games have long been a popular recreational pursuit across generations. A game is defined as a competition, whether mental or physical, played according to predetermined guidelines for the purpose of entertaining the player (Laamarti et al., 2014). Most games feature narrative stories with characters that involve players in a constructed competitive environment with clear objectives and rewards. These elements challenge the player while offering immersive sensory experiences through haptic feedback, audio, dynamic animations, graphics and text (Schrader, 2023). Games come in various formats, including physical, online, video, card, and board games.

Video games, also known as computer games, are a specific type of game that involves users manipulating images displayed on a screen (Kracht et al., 2020). In simple terms, video games are electronic games controlled by input devices, such as keyboards, controllers, or other peripherals, which generate graphical output on a screen. These games are governed by specific objectives that players must achieve to win, with the primary aim of providing entertainment.

However, there are also games referred to as serious games, which serve a “serious goal”. The term “serious games” was coined by the American researcher Abt (1970), who defined them as follows:

We are concerned with serious games in the sense that these games have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement. This does not mean that serious games are not or should not be, entertaining. (p. 9)

Abt’s (1970) definition of serious games emphasises that these games prioritise educational value while also incorporating an element of entertainment. Ntoa et al. (2024) describe serious games as a type of video game where the main objective extends beyond mere amusement. The primary aim of serious games is to engage users in ways that are both entertaining and effective in achieving desired learning or behavioural change outcomes.

Serious games can take various forms, including educational games, role-playing games, and simulations. They are designed to achieve specific objectives, which may include promoting health, providing training, facilitating education, and raising awareness (Damaševičius et al., 2023).

Beyond serious games, there are several approaches that share similarities with them, but have distinct differences. These include game-based learning, game-based pedagogy, and gamification, which will be discussed next for a better understanding.

Game-based learning

Game-based learning is an educational approach that uses video games to achieve specific learning goals, such as acquiring knowledge and skills (Becker, 2021; Liu et al., 2020). The digital games used in this approach do not necessarily have to be serious; they can include any games employed for educational purposes. This type of learning typically takes place in a classroom setting with an educator, where learners develop innovative skills, apply their existing knowledge and abilities, and acquire new information on crucial topics while balancing educational content with enjoyment (Schrader, 2023). While it shares some similarities with serious games, game-based learning focuses on using games as a process rather than being a game in itself.

Game-based pedagogy

In contrast to game-based learning, game-based pedagogy focuses on the study and application of games for educational purposes. Although both concepts share similarities, game-based learning centres on learning through games from the learner's perspective, whereas game-based pedagogy emphasises teaching with games from the teacher's perspective (Becker, 2021).

Gamification

Gamification is the practice of applying game mechanics and elements in non-game contexts, such as healthcare, business, and education. The main objective is to improve user motivation, engagement, and involvement in various tasks. This approach integrates features, such as leaderboards, badges, points, and feedback systems. The ultimate goal of gamification is to improve health, productivity, or learning outcomes (Damaševičius et al., 2023). Unlike game-based learning and pedagogy, gamification incorporates game-like elements into everyday activities to encourage participation (Plass et al., 2015).

A serious game has been chosen in this research to enhance digital well-being and cybersecurity awareness among preschool children because of its serious nature. The game aims to facilitate active participation between

preschool children and their caregivers, creating an environment where they can learn from their mistakes without facing real-life consequences, all while remaining entertained.

4.2 Classification of serious games

To support researchers, developers, and designers in understanding serious games across various domains, including game elements, educational objectives, target audience, and platform, it is crucial to establish a taxonomy to classify these games. Such taxonomies are valuable tools for evaluating the effectiveness of serious games in achieving their intended outcomes for the target audience (Pelser-Carstens & Matthew, 2023).

A comprehensive study by De Lope and Medina-Medina (2017) focused on the various taxonomies of serious games. The initial classification served as a widely accepted standard for video games, while three studies concentrated on specific application areas, disregarding other genres.

Alvarez and Djaouti (2011) emphasised that the current classification primarily focuses on specific applications. Therefore, they proposed a classification that highlights both the serious and the game dimensions of a game, guiding in the broader field of serious game development known as the G/P/S model. This model centres on Gameplay, Purpose, and Scope.

Uskov and Sekar (2014) built upon the work of Alvarez and Djaouti (2011) by extending it with more detailed criteria while retaining the original G/P/S model. The G/P/S model is applicable in the current study, as it considers both the serious and game dimensions, and several studies have used it as a solid foundation for serious games.

4.2.1 Gameplay criterion

The gameplay criterion describes the type of gaming employed. It provides information about the game, including its structure and rules. It distinguishes between game-based gameplay, which involves clear objectives, and play-based gameplay, which lacks defined goals (Djaouti et al., 2011).

4.2.2 Purpose criterion

The purpose component of the G/P/S model refers to the intended use of the game alongside its recreational aspects. This may include sharing data, training users, and conveying messages through education, information, persuasion, and subjectivity (Alvarez & Djaouti, 2011).

4.2.3 Scope criterion

The final criterion is the sector, which refers to the intended audience of the game, encompassing both the market and the general public. The market encompasses sectors, such as the military, education, healthcare, and scientific research. The public may consist of students, professionals, or the general population (Djaouti et al., 2011).

The serious game to be developed will adhere to this model. It will feature game-based gameplay with clear and concise objectives. Its purpose should be educational and informative, aiming to enhance the digital well-being of preschool children, as the target audience falls within the education market, which serves as the scope criterion.

4.3 Serious game development

Developing serious games can be challenging, as it requires the integration of various game design principles to ensure their success (Pelser-Carstens & Matthew, 2023). Several factors can influence a game's effectiveness, which will be discussed below.

4.3.1 Design challenges in serious games

Pelser-Carstens and Matthew (2023) identified four factors that present challenges in the development of serious games, including:

- Learning and entertainment: Striking a balance between learning and entertainment is crucial in developing an engaging and enjoyable game while effectively conveying the required educational objective;
- Technical complexity: The development of serious games often requires a high level of technical expertise. This can be particularly challenging for educators who lack a background in programming or game development;
- Content: For a serious game to be effective, the designer must possess a solid understanding of the subject matter, and the ability to transform complex concepts into engaging and captivating gaming experiences; and
- Evaluation and feedback: To ensure the effectiveness of a serious game, it is essential to establish efficient evaluation and feedback mechanisms. This requires careful consideration of how to assess learning objectives within the context of the game and provide players with meaningful feedback.

4.3.2 Design principles for games

The fundamental principle of developing an optimal serious game is to ensure it is both entertaining and educational. Various design principles or elements contribute to the overall quality of a serious game, distinguishing it from other types of games. Numerous studies have examined optimal design principles (Adams, 2010; Bazid et al., 2022; Charsky, 2010; Drevin et al., 2023; Esterhuizen et al., 2023; Garriss et al., 2002; Lamerass et al., 2017; Malone, 1981; Maqsood, 2020; Mildner et al., 2015; Reynolds & Martin, 1988), as shown in Table 4.1.

Table 4.1: Optimal design elements of game development

Author name	Paper title	Design elements identified
Malone (1981)	Toward a Theory of Intrinsic Instruction	- Challenge; - Fantasy; and - Curiosity.
Reynolds and Martin (1988)	Designing an Educational Computer Game: Guidelines that Work	- Educational objectives; - Game interactions; - Player control; - Challenge, fantasy and curiosity; - Graphics and sound; - Feedback and error correction; and - Positive reinforcement.
Garris et al. (2002)	Games, motivation, and learning: A research and practice model	- Fantasy; - Rules/Goals; - Sensory Stimuli; - Challenge; - Mystery; and - Control.
Adams (2010)	Fundamentals of Game Design	- Gameplay; - Aesthetics; - Harmony; - Storytelling; - Risks and rewards; - Novelty; - Learning; and - Socialising.
Continued on the following page		

Table 4.1: Continued from previous page.

Author name	Paper title	Design elements identified
Charsky (2010)	From Edutainment to Serious Games: A Change in the Use of Game Characteristics	- Competition and goals; - Rules; - Choice; - Challenges; and - Fantasy.
Mildner et al. (2015)	From Game Characteristics to Effective Learning Games Evaluation of a Component-based Quiz Game	- Competition and goals; - Rules; - Choice; - Challenge; - Fantasy; and - Aesthetics/graphics.
Lameras et al. (2017)	Essential features of serious games design in higher education: Linking learning attributes to game mechanics	- Competition and goals; - Rules; - Choices; and - Fantasy.
Maqsood (2020)	The Design, Development and Evaluation of a Digital Literacy Game for Preteens	- Motivation; - Challenge; - Content; - Feedback; and - Narrative.
Bazid et al. (2022)	A Conceptual Frame-work Supporting Obesity Awareness in Serious Game	- Goals; - Interactions; - Challenge; - Points; - Feedback; and - Rules.
Esterhuizen et al. (2023)	Design choices among recent security-related serious games	- Feedback; - Simplicity; - Narrative; - Rewards; and - Challenge.
Drevin et al. (2023)	The Story of Safety Snail and Her e-Mail: A Digital Wellness and Cybersecurity Serious Game for Pre-School Children	- Challenge; - Fantasy; - Choice; - Rules; - Competition and goals; - Aesthetics; - Feedback; - Game characters; and - Reflection opportunities.

The game design principles applied are those proposed by Drevin et al. (2023), Esterhuizen et al. (2023), and Mildner et al. (2015). Drevin et al. (2023) examined the guiding principles for creating educational games for preschool children, which aligns with the aim of this study. Esterhuizen et al. (2023) analysed the commonly used design principles in twenty-two serious games, providing valuable insights for researchers, developers, and designers focused on security-centred serious games. Mildner et al. (2015) conducted a comprehensive examination of game characteristics crucial for creating effective games. The following is a list of the applicable game design elements, with brief descriptions:

Competition and goals

Competition and goals are two critical, interconnected principles present in every game. According to Drevin et al. (2023), competition refers to the challenges that must be overcome to achieve a goal, which represents the winning conditions of a game. In some cases, competition and goals involve players competing against each other or the computer. Implementing competition in games helps keep players motivated to complete activities as they strive for victory (Charsky, 2010).

Rules

Rules are crucial for distinguishing one game from another, as they provide instructions for fair and proper gameplay (Bazid et al., 2022; Mildner et al., 2015). They impose constraints that limit the actions a player can take, and they cannot be changed or broken since they are typically fixed (Charsky, 2010). According to Garriss et al. (2002), clear and specific goals lead to improved performance. The authors categorised rules into three different types: (1) system rules, which define how the game operates; (2) procedural rules, which specify the actions players can take within the game, such as accumulating certain information to advance to the next level; and (3) imported rules drawn from the real world, which enable gameplay and establish implied standards that govern general behaviour based on common sense. An example of this would be not walking through walls or cheating.

Choice

Choice allows players to select from a variety of options both before and after the game. There are three types of choice: (1) expressive choice, which involves selecting or designing a character; (2) strategic choice, which pertains to game configurations that directly impact gameplay, such as the difficulty level; and (3) tactical choices, which are the decisions made by the player during the game (Drevin et al., 2023; Mildner et al., 2015).

Challenge

Challenge is an important element that involves tasks and activities requiring players to engage in problem solving. Challenges maintain player engagement by progressively adjusting difficulty levels. It is crucial to ensure the levels are neither too easy nor too difficult, as this can lead to player frustration (Bazid et al., 2022; Esterhuizen et al., 2023; Mildner et al., 2015). In the context of serious games, challenges should be strategically designed to achieve defined learning outcomes (Charsky, 2010).

Fantasy

Fantasy contributes to an exciting and engaging gameplay experience by providing a unique backstory and subject matter for each game (Mildner et al., 2015). Games typically feature fictional worlds that do not impact the real world, allowing players to engage in actions they would not pursue in real life without facing any consequences. Fantasy can be classified into two types: (1) exogenous, which enhances the player's skills through imagination and exists separately from the content being taught, making it potentially engaging for children; and (2) endogenous, which is directly involved in the content being taught.

Aesthetics

Aesthetics refers to the overall design of a game, encompassing both auditory and visual elements, as well as their display. These elements enhance visual appeal, capture players' attention, promote enjoyment, and increase motivation, fostering deeper immersion in the game. An aesthetically pleasing game can attract players and encourage engagement (Bazid et al., 2022; Drevin et al., 2023; Mildner et al., 2015).

Simplicity

Simplicity ensures that the game is easy to play and features a user-friendly interface (Esterhuizen et al., 2023). This includes large buttons for players, intuitive navigation, and the avoidance of excessive elements that could distract from the actual content.

Feedback and rewards

Feedback encourages players to continue playing and can be provided through points, haptic feedback, auditory cues, or visual cues. Rewards offer players motivation, encouragement, and additional details about their performance. These rewards can include badges, achievements, levels, and points (Bazid et al., 2022; Esterhuizen et al., 2023).

Game characters

Game characters, also known as story-based agents, should be used to contextualise learning and facilitate the educational process. These characters can be cartoon-like or realistic and play a crucial role in storytelling (Dincelli & Chengalur-Smith, 2020; Drevin et al., 2023). In addition, players can identify with these characters, making the game resonate with them and creating a deeper connection.

The success of a serious game, as well as the effective delivery of the intended message by designers, developers, and researchers, can be achieved by applying serious game design principles.

4.4 Serious games for preschool children

When creating a game for preschool children, it is crucial to implement design elements that align with their unique cognitive abilities, as they process information differently than older individuals. Since their cognitive memory is still developing, preschool children typically have shorter attention spans and limited visual processing capabilities. By implementing these elements, the game can leverage children's natural enjoyment of play, creating an effective medium for their learning experience (Callaghan & Reich, 2018).

The following game design elements have been identified in the literature as suitable for preschool children (Callaghan and Reich, 2018; 2020; Drevin et al., 2023):

Clear and simple goals

Since children are still developing their cognitive processing skills, it is important that games have clear and straightforward instructions. These instructions or objectives should explicitly state what players are supposed to do and how to do it. In addition, games can reinforce or repeat instructions when the player pauses the game (Callaghan & Reich, 2018).

Engaging visuals

Implementing visually appealing elements that capture the attention of preschoolers without overwhelming them is crucial. While familiar characters, vibrant colours, and animations can help maintain their focus, developers and designers must be cautious of excessive visual distractions, which may divert attention from the educational content (Drevin et al., 2023).

Quality feedback mechanisms and reward system

Providing consistent visual feedback to children is crucial to helping them understand their progress and identify areas for improvement. High-quality

feedback should offer detailed explanations of instructional material and support children throughout their learning journey. When children receive positive feedback for their correct answers, they experience a sense of accomplishment and gain confidence. Conversely, negative feedback can help prevent the development of misconceptions and encourage them to attempt the same task again. Immediate feedback has the potential to enhance children's working memory, and the quality of feedback provided can significantly influence the knowledge they acquire. Implementing meaningful rewards, such as badges upon completion of tasks, can effectively boost children's motivation and foster ongoing engagement in the learning process (Callaghan & Reich, 2018; Drevin et al., 2023).

Structured challenge

Scaffolding enables children to develop abilities that exceed what they could achieve independently. This is achieved by gradually reducing guidance and introducing increasingly challenging tasks as their skills advance. Games should present obstacles that are appropriately scaffolded to support children's growth. As children's knowledge improves, the level of challenge should be steadily increased to sustain their motivation and interest. This process promotes the development of higher executive functioning (Callaghan and Reich, 2018; 2020; Drevin et al., 2023).

Physical interactions

Developing a game that promotes physical interaction among children can effectively enhance motor skills and make the learning process more engaging. However, it is crucial to ensure that these interactions remain simple. Examples of such interactions include tapping and sliding. Additionally, implementing larger buttons into the game's interface would cater to the needs of younger users (Callaghan & Reich, 2018).

Balanced simplicity and complexity

Developers and designers should maintain a balance between the simplicity and complexity of a game. It is important to consider the capabilities of children, as overlooking them can result in lost interest. Creating an excessively easy game may fail to engage their attention (Drevin et al., 2023).

Appropriate interface

An appropriate interface is essential for children, as it directly influences learning outcomes, engagement, and accessibility. Interfaces should be intuitive, age-appropriate, and visually clear to support children's development.

They must facilitate smooth navigation without overwhelming users (Drevin et al., 2023).

Short playtime

Children have shorter attention spans due to their developing cognitive abilities, so a game should include short playtime, along with engaging visuals and sounds to capture their attention (Drevin et al., 2023).

Balanced seriousness and play

Serious games aim to disseminate behaviour change theories and educational content while also being fun. However, many prioritise education at the expense of enjoyment, leading to a gaming experience where children feel compelled to play without truly enjoying the game. When designing and developing a serious game, developers must strike a balance between education and enjoyment to create an engaging and effective experience (Drevin et al., 2023).

Quality interactions

A game should include high-quality interactions between the player and the environment, as this is a critical factor in determining the overall quality of a game. Therefore, effective and concise communication is essential (Drevin et al., 2023).

The elements mentioned above align with the objectives outlined in Section 1.3, which aim to develop a game specifically designed for preschool children, implementing optimal game development features (Drevin et al., 2023). These elements will be implemented into the serious game, as they have the potential to effectively meet the needs of preschool-age children.

4.4.1 Traditional serious game elements inappropriate for preschool children

While serious games are designed to educate, many traditional features commonly found in games for older children and adults are not suitable for preschool-aged children. These aspects can impact engagement, accessibility, and developmental appropriateness for young learners. Key features that should be avoided include (Cong & Zhang, 2019; Y. Zhu et al., 2024):

- Text-heavy instructions and interfaces: Preschool children have limited verbal memory and may find it difficult to understand or recall complex terms and lengthy instructions;
- Abstract visual elements: Young children are drawn to figurative graphics with bright colours and familiar shapes. Traditional serious

games often use abstract visuals focused on educational content, which may fail to capture preschoolers' interest;

- Complex controls and interfaces: Sophisticated menu systems, intricate navigation, and complicated user interfaces can overwhelm preschool children, whose cognitive and motor skills are still developing;
- Extended playtimes: Long gaming sessions exceed the natural attention span of preschoolers, which typically lasts only 5 to 10 minutes;
- Unengaging design: Professional colour palettes and designs may not appeal to young children. At this stage, children are stimulated by vibrant colours, but designers must balance stimulation to avoid overwhelming them; and
- Delayed feedback and minimal rewards: Preschoolers require immediate feedback and frequent rewards to maintain motivation and engagement. Traditional games often focus on assessment rather than positive reinforcement, which can reduce interest.

By intentionally avoiding these traditional features, developers can create serious games that are accessible, enjoyable, and developmentally appropriate for preschool children.

4.4.2 Related games

A list of serious games in Table 4.2 is designed to promote digital well-being and cybersecurity awareness. Although these games are primarily developed for children, they target an international audience and highlight a gap in resources specifically targeted at African audiences. Developing a serious game to address this gap could make these games accessible to a broader range of individuals.

Band Runner's content is primarily designed within the context of the United Kingdom government, which may not resonate with children from other countries. Developed by the United Kingdom's Child Exploitation and Online Protection command (CEOP), the scenarios and cultural references reflect situations specific to the UK. This may present challenges for children from other countries who may find these references unfamiliar. In addition, its text-based scenarios may limit engagement for children who are not proficient in reading. While it encourages parental participation, it does not adequately equip parents with the necessary concepts to effectively guide their children, especially if they have limited knowledge.

Table 4.2: Serious games developed to enhance digital well-being and cybersecurity awareness among children

Game name	Description
Band Runner ¹³	Band Runner is an interactive endless runner game that educates children on how to stay safe online when facing risks. The game presents various scenarios that children may encounter online and covers important topics, such as: - Online safety; - Recognising online and fraudulent websites; - Cyberbullying awareness; and - Password safety.
Cloud Chaos ¹⁴	Cloud Chaos is one of the games in the NetSmartzKids series, which takes place in a fictional world where the player must protect the Internet from various online threats. The game covers important topics, such as: - Recognising online threats; - Password security; - Responsible online behaviour; and - Privacy protection.
CyberKids (Pérez et al., 2020)	CyberKids focuses on cybersecurity awareness. The player must navigate through missions to safeguard their virtual home from cyber threats in a fun and engaging manner. The game covers crucial topics, such as: - Creating strong passwords; and - Identifying potential vulnerabilities.
Digital Compass ¹⁵	Digital Compass is a Common Sense Education game designed to teach children about digital citizenship and the consequences of their online behaviour. The game covers crucial topics, such as: - Recognising and addressing cyberbullying; - Password security; - Avoiding phishing scams; and - Protecting personal information.

Although Cloud Chaos is engaging, it lacks a feedback mechanism to assess children's understanding. CyberKids aims to promote cybersecurity and digital well-being; however, its content is also specific to a particular country and lacks engaging visuals, which could cause children to lose interest

¹³<https://www.ceopeducation.co.uk/8.10/about/>

¹⁴<https://www.netsmartzkids.org/games/>

¹⁵<https://www.digitalcompass.org/>

and thereby limit its overall effectiveness. Digital Compass offers contextual learning, but falls short in providing sufficient choices for players. Moreover, its long playtime, combined with a predominantly text-based format, may restrict engagement for children who have not yet developed reading skills. While these games are primarily developed for children, they target an international audience and highlight a gap in resources specifically targeted at African audiences. Developing a serious game to address this gap could make these games accessible to a wider range of individuals.

4.5 Summary

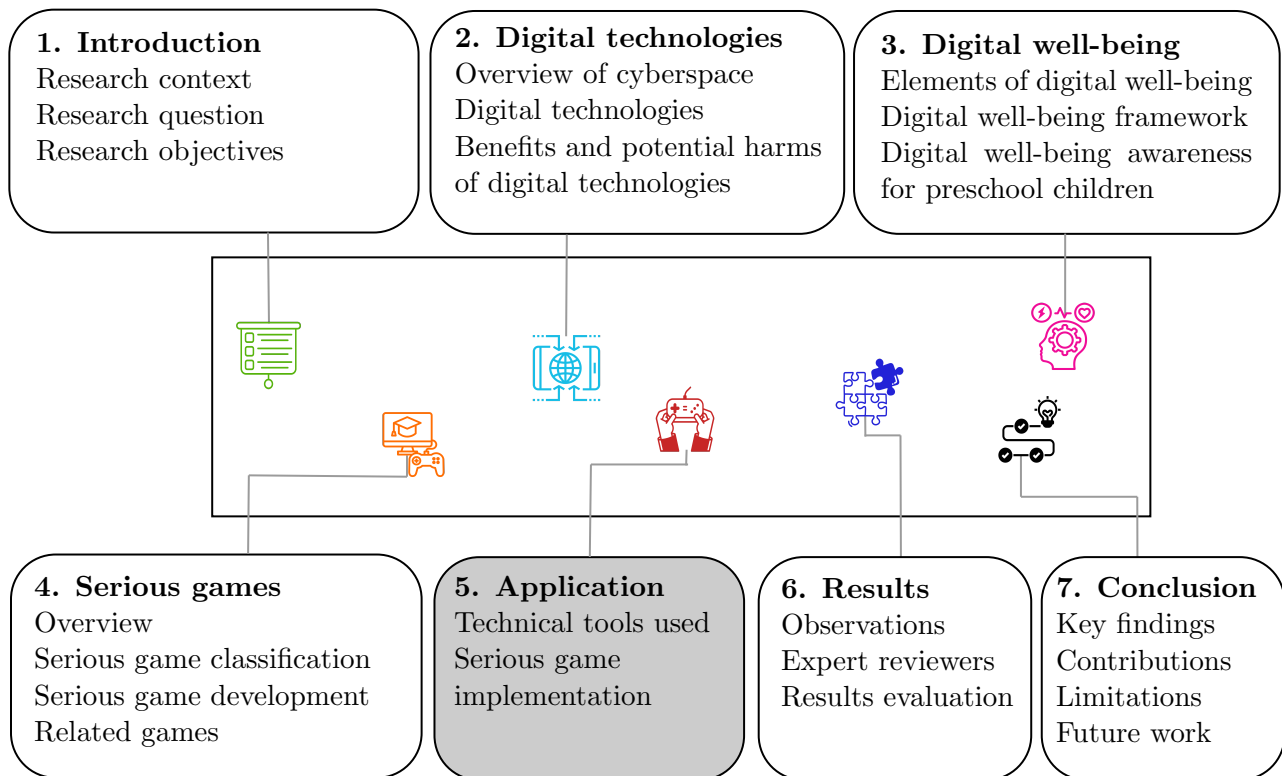
In this chapter, an overview of games was discussed, focusing specifically on the concept of serious games. Following this, the different approaches that share similarities with serious games were discussed, such as game-based learning, game-based pedagogy, and gamification. Next, the classification of serious games using the widely recognised Gameplay, Purpose, and Scope (G/P/S) model, which offers a solid foundation for classifying serious games, was discussed.

The third section of this chapter focused on serious game development, addressing factors that often lead to failure in serious games. The different design principles that make a game successful were compared from different studies, and the most optimal ones were discussed. Finally, the last section presented ten design principles for developing serious games for preschool children, along with existing serious games aimed at promoting digital well-being and cybersecurity awareness.

In the next chapter, the technical tools used to develop the serious game will be discussed, followed by its implementation and the design process.

Chapter 5

Application overview



In this chapter, the technical implementation of the game is detailed. In Section 5.1, the design of the game is presented, outlining the crucial elements for developing an optimal serious game for preschool children. The technical tools used to develop the game are provided in Section 5.2, along with the rationale for each selection. In Section 5.3, the developed serious game is presented, and its functionality, followed by the implementation of game elements identified in the literature. Finally, the design process followed for optimal game development is discussed in Section 5.4.

5.1 Design of the game

The primary aim of this study is to develop a serious game, guided by the digital well-being framework of Büchi (2024), as an intervention to enhance the digital well-being and cybersecurity awareness among preschool children. The game should incorporate elements such as age-appropriate content and interactive participation to ensure optimal effectiveness, while balancing serious and fun aspects. It should function as a collaborative tool for children and their caregivers to promote digital health. To meet the above-mentioned objectives, the following have been identified in Chapters 3 and 4:

1. Elements for fostering early intervention campaigns (Section 3.4.2, p. 36):
 - Simplicity;
 - Consistency;
 - Engaging content; and
 - Appropriateness.
2. Elements the game should allow children to engage in (Section 3.6.1, p. 44):
 - Hands-on experience;
 - Trial and error;
 - Social interaction;
 - Parental involvement; and
 - Self-directed learning.
3. Elements of a serious game, the G/P/S model (Section 4.2, p. 49):
 - Gameplay criterion: Game-based with clear and concise objectives;
 - Purpose criterion: Educational and informative; and
 - Scope criterion: Enhance the digital well-being and cybersecurity awareness of preschool children within the educational market.

4. Elements for developing an effective, engaging and enjoyable game (Section 4.3.2, p. 51):
 - Competition and goals;
 - Rules;
 - Choice;
 - Challenge;
 - Fantasy;
 - Aesthetics;
 - Simplicity;
 - Feedback and rewards; and
 - Game characters.
5. Elements of serious games for preschool children (Section 4.4, p. 55):
 - Clear and simple goals;
 - Engaging visuals;
 - Quality feedback mechanisms and reward system;
 - Structured challenge;
 - Balanced simplicity and complexity;
 - Short playtime;
 - Balanced seriousness and play;
 - Appropriate interface; and
 - Quality interactions.

During the development of the serious game, the elements that will be directly implemented are listed under categories 1, 4, and 5. The elements of criteria 2 and 3 are not implemented directly for the following reasons:

- The elements in criteria 2 will be embedded in the gameplay rather than as single elements. The game encourages active participation, providing children with a hands-on experience. Its mechanics promote trial and error, allowing children to make mistakes without consequences and to learn from those experiences. Although the game is designed for single-player use, it offers parental involvement to supervise them, making it a collaborative tool. Finally, it supports self-directed learning by allowing children to progress at their own pace; and
- The elements in criteria 3 are part of the G/P/S model, which characterises a serious game. These aspects are implemented into the design to ensure the game has clear and simple goals that will be understood by the target audience. While the game remains engaging, it is also structured to be educational and informative.

The specific elements that will be implemented into the game to enhance its effectiveness, engagement, appropriateness, and enjoyment for preschool-age children include competition and goals, rules, choice, structured challenge, fantasy, aesthetics, simplicity, clear and simple goals, engaging visuals, quality feedback and rewards, game characters, an appropriate interface, and quality interactions.

The game will be presented to expert reviewers to validate its effectiveness, the game elements and its impact on the digital well-being of preschool children. This evaluation will serve as a basis for proposing an extension to Büchi's (2024) digital well-being framework.

5.2 Technical tools used

In this section, the technology stack used to develop the serious game is discussed. It is divided into four parts: game engine, scripting language, version control, and visual editing.

5.2.1 Game engine

The Godot game engine¹⁶ is the chosen development platform for this application. It is a free and open-source platform that supports multiple operating systems. The engine enables the creation of video games that can be deployed and exported to various platforms, including HTML5, Android, iOS, Microsoft Windows, macOS, and Linux.

The selection of the Godot game engine as a development platform was based on the following considerations:

- Extensive documentation and an active community. There is comprehensive documentation available to assist developers in their learning process, along with a community that provides tutorials, forums, and resources.
- Node system. In Godot, a scene consists of a hierarchical structure of nodes. Each node functions as a self-contained object that can inherit from other nodes, provided they share a common root node.
- Lightweight. The Godot game engine is portable, executable software that can be used without installation. It is not resource-intensive, making it accessible to low-end and high-end devices, including both 2D and 3D capabilities.
- Window management and in-game editing. With an embedded game window, developers can preview their games directly within the editor without the need to open a separate window. In addition, in-game

¹⁶<https://godotengine.org/>

editing enables developers to debug the game while it is paused or running.

Although the Godot game engine has been chosen, it has its drawbacks. Its debugging tool, particularly for nested code, can be challenging to use. In addition, it lacks certain advanced features, such as low-level rendering access, advanced animation systems, and visual scripting, which are commonly found in other engines. This may make it less appealing to developers seeking high-end graphics. Lastly, compatibility issues may arise when upgrading from one version to another, as certain features may not be supported in newer releases.

5.2.2 Scripting language

The game is developed using Godot's built-in scripting language, GDScript. GDScript is a dynamically typed, high-level, object-oriented programming language that resembles Python syntax. It also supports C# and GDNative, a technology that enables interactions with other programming languages. Officially, C++ and C are the supported languages for GDNative, while the community has developed and maintains bindings for Rust, Python, Nim, Kotlin, and D.

GDScript was selected as the scripting language for the game due to the following considerations:

- Beginner-friendly syntax. Syntax-wise, it is similar to Python, making it easier for new and existing developers to learn and understand.
- Seamless integration with Godot. GDScript features are designed to blend perfectly with the game engine, ensuring optimal performance. Developers can operate effortlessly without the need for external tools, eliminating unnecessary complications.
- Performance. No compilation stack is required, allowing games to run immediately in the editor for enhanced productivity. In addition, the code can be modified while the game is running.
- Built-in functions. GDScript offers a range of built-in functions that greatly enhance development. These functions facilitate code reusability, removing the need for external libraries. Comprehensive documentation for these built-in functions is readily available within the game engine.

While GDScript is not as performant as C#, it integrates well with the game engine. However, its automatic memory management can lead to inefficient memory usage in larger projects. In addition, although GDScript has built-in functions, it lacks advanced features, such as typed dictionaries and structs, which may limit developers.

5.2.3 Version control

GitHub¹⁷ was used as a platform to store, manage, and track code changes for the game. It employs a version control system called Git, which is free, open-source and designed to monitor code changes. GitHub allows developers to access their projects across multiple devices and test different features while preserving the original version.

GitHub was selected as the version control system for the following considerations:

- Easy to use. GitHub provides a user-friendly interface that enables novice users to store their code repositories effortlessly. In addition, it serves as a reliable backup system for code.
- Version control. Allows developers to save and manage different versions of a project file. If changes are made that cause the project to malfunction, developers can revert to a previous working version of the code.
- Branches. GitHub comprises branches that allow users to experiment safely by creating new features and bug fixes without modifying the default files of the project.
- Integration. GitHub seamlessly integrates with a wide range of development tools, such as Visual Studio, Godot, Google Cloud, and Microsoft Azure, resulting in enhanced developer productivity.

While GitHub offers numerous benefits, there is a learning curve associated with features, such as pull requests, push requests, and merging, which can be overwhelming for beginners.

5.2.4 Visual editing

The graphical elements of the game were edited using two software programs and one web-based program, namely: Paint.NET¹⁸; and Synfig Studio¹⁹.

Paint.NET

Paint.NET is a lightweight and free image editing software. It features an intuitive, user-friendly interface that simplifies the manipulation and layering of images using various tools. In addition, this software supports multiple plugins, enabling the extension of its functionality based on specific needs. It allows for the export of files in a wide range of formats, such as .mp4, .gif, .png, and .bmp.

¹⁷<https://github.com/>

¹⁸<https://getpaint.net/>

¹⁹<https://www.synfig.org/>

Synfig Studio

Synfig Studio (referred to as Synfig) is free and open-source software designed to animate 2D vector graphics. This tool allows for the scaling of images without any loss of original quality. It offers a wide range of simple and complex tools, including skeletal-based animation, vector-based animation, and traditional animation techniques, enabling the creation of intricate animations. In addition, Synfig facilitates seamless transitions through automated tweening and simulated shading.

5.3 Serious game overview

The resulting game will implement the elements identified in Section 5.1 and will aim to enhance the digital well-being and cybersecurity awareness of preschool children. In this section, the game will be presented and explained, showing how the identified elements were implemented.

5.3.1 Game flow

The structure of the game is shown in Figure 5.1, consisting of four main scenes: the main menu, poem, quiz, and game scene.

The main menu serves as the initial interface, allowing users to select a poem. Each poem is paired with a corresponding quiz and game. Upon selecting a poem, users advance to the poem scene, where the chosen poem is presented. Upon completing the quiz, users will be presented with reflection questions related to the poem. In addition, a game will be presented to users as a reward for successfully completing both the poem and the quiz.

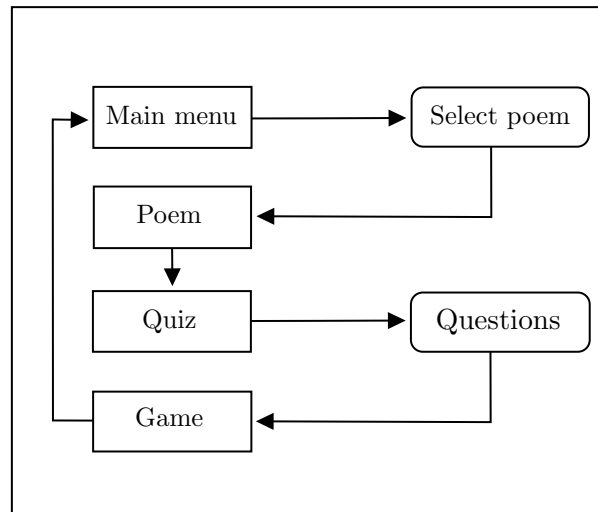


Figure 5.1: Flowchart of the game

5.3.2 Main menu

The main menu is the first screen that players encounter. In this scene, players can select a poem, along with its corresponding quiz and game. A screenshot of the main menu is shown in Figure 5.2.



Figure 5.2: Main menu scene for game selection, including navigation arrows to navigate through different games, a settings button, and an exit button

When the game begins, the poems are animated to capture the child's attention. Below is a numbered list of the various elements depicted in the figure above:

1. Left arrow button - This button is used to navigate between the various poems in the main menu. Clicking it selects the previous poem in an anti-clockwise direction.
2. Right arrow button - This button is used to navigate between the various poems in the main menu. Clicking it selects the next poem in a clockwise direction.
3. Settings button - This button displays the game's settings, which include sound configurations (master, music, and sound effects), controls, assets, and credits. Additional settings will be implemented in future versions of the game.
4. Instructions - This component displays the instructions for the game.

5. Selected poem title - The component shows the title of the currently selected poem.
6. Exit button - This component provides the player with exit options.
7. Selected poem - This component shows the actively selected poem. When clicked, the corresponding poem will be displayed in the poem scene. This poem has been implemented by Mnisi et al. (2025).
8. Poems (8–12) - The different poems with their various poem scenes, quizzes, and games. Poem number 8, titled “Safety Snail e-mails,” has been implemented by Drevin et al. (2023). Poem number 9, titled “Cyber Cat,” has been implemented by Mnisi et al. (2024). Poem number 10, titled “Happy Hippo,” has been implemented by Allers et al. (2021). Finally, poem number 11, titled “Wolf, Hyena, and Fox,” has been implemented by Snyman et al. (2021).

In Table 5.1, the essential elements of the game to develop an effective and enjoyable serious game for preschool-age children, as identified in Sections 4.1 and 4.4, are presented along with their implementation into the main menu scene.

Table 5.1: Implemented game design elements into the main menu scene

Game element	Implementation
Competition and goals	Competition and goals design elements are not implemented in the main menu scene.
Rules	The main menu scene presents clearly defined rules through valid inputs to ensure a coherent user experience. System rules are facilitated by the navigation arrows, settings, an exit option, and instructions, enabling the player to navigate the game seamlessly.
Choice	The choice component is evident in the main menu through the selection of various poems (expressive choice). In addition, the player can adjust the game settings or exit the game (strategic choice).
Structured challenge	Structured challenge element is not implemented in the main menu scene.
Fantasy	The fantasy design element is implemented in the main menu scene through animal characters that reside in a fictional jungle world, accompanied by jungle music, making it unique.
Aesthetics	The aesthetic element is evident through the vibrant visuals, appropriate background music, and engaging graphics.
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Table 5.1: Continued from previous page

Game element	Implementation
Simplicity	The simplicity element is reinforced by the user-friendly interface, which ensures players can navigate the game easily.
Clear and simple goals	The clear and simple goals are well-defined to select a story that is presented both audibly and visually.
Engaging visuals	Engaging visuals are evident in the colourful and child-friendly design, further enhanced by animated characters and a jungle-themed background.
Quality feedback and rewards	Quality feedback is delivered through both audio and visual elements. Clicking the buttons activates audio feedback, while visual feedback is triggered when the player hovers over the buttons.
Game characters	The game characters element is reinforced in the main menu scene by allowing players to select different stories with different characters.
Appropriate interface	The game features large buttons and icons that simplify navigation, allowing players to click easily without feeling overwhelmed.
Quality interactions	The quality of the interaction element is reinforced by using large buttons, which can improve motor skills.

5.3.3 Poem

Upon selecting a poem from the main menu, players are directed to the poem scene, where the chosen poem is presented both visually and audibly, as it is read to the player.

The primary objective of this scene is to raise awareness of the risks present in cyberspace while enhancing digital well-being in an engaging and entertaining manner. The specific poem presented in Figure 5.3 addresses the topic of phishing.

A fish named Lucky receives a message informing it that it has won a prize and should click on a link to claim it, despite knowing that it has not entered any competition. However, its friend Sunny advises it to delete the message, warning that it might be a trick. A key takeaway from this story, as noted by Fischer and von Solms (2016, p. 37), is that “If somebody tries to give you a prize. It might be a trick to fool you to click. Before I click a link, I stop and think.”

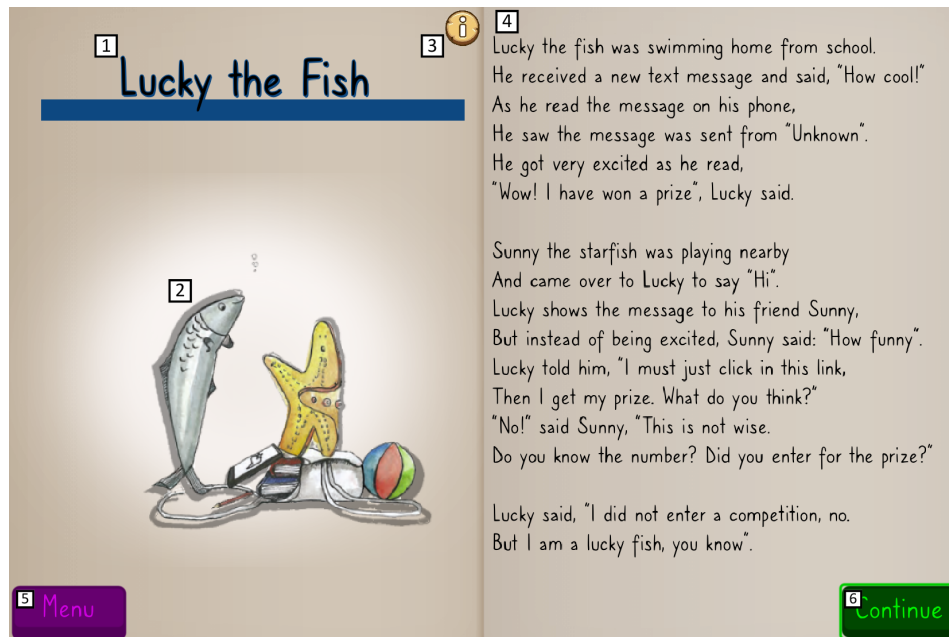


Figure 5.3: Poem scene presented visually and audibly

Below is a numbered list of the various elements depicted in the figure above:

1. Title of the poem - This component presents the title of the poem that is read at the moment.
2. Animation of the story - The animation components serve to visually represent a segment of the poem. These animations update dynamically with the narration of each new paragraph or page.
3. Poem instruction - This component shows the instructions that players should follow.
4. Text of the poem - This component presents the poem's content and moral lesson, alongside questions designed to encourage discussion between peers and caregivers.
5. Menu button - This button enables players to return to the main menu.
6. Continue button - This button allows players to progress to the next paragraphs or pages.

In Table 5.2, the essential elements of the game to develop an effective and enjoyable serious game for preschool-age children, as identified in Sections 4.1 and 4.4, are presented along with their implementation into the poem scene.

Table 5.2: Implemented game design elements into the poem scene

Game element	Implementation
Competition and goals	The competition component is not directly implemented in the poem scene; however, the subsequent scene is influenced by it and presents a few questions based on the understanding of the poem. The goal of this scene is to raise awareness about a specific topic, providing players with a sense of direction and purpose, as the topic can be further discussed among individuals.
Rules	The poem scene includes clearly defined rules, supported by an information button that offers instructions when hovered over.
Choice	The choice element in the poem scene is evident through the use of two buttons: the Menu and Continue buttons. These options enable players to make strategic choices.
Structured challenge	The poem scene does not present a structured challenge, but it provides all the necessary information for the upcoming scene that creates the challenge.
Fantasy	The poem scene reinforces fantasy by presenting information to the player in an engaging manner, using animations and auditory feedback.
Aesthetics	Aesthetics are reinforced through animations and background music.
Simplicity	The simplicity element is reinforced by a straightforward interface that minimises distractions, allowing players to engage with the poem by clicking the continue button and either reading or listening to it.
Clear and simple goals	The clear and simple goals in this scene are conveyed through the large Continue button. When clicked, it displays the poem, allowing the player to read or listen to it. In addition, hovering over the Info button provides clear instructions.
Engaging visuals	The animation for each poem is displayed alongside the text, making it engaging and helping children understand the poem's dialogue, as both elements complement each other.
Quality feedback and rewards	Feedback is delivered through both audio and visual elements. The animations and sound that accompany the reading of the poem enhance the experience. When a page is turned, a sound effect mimics the feel of a real book, while distinct animations are used for each paragraph read.
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Table 5.2: Continued from previous page

Game element	Implementation
Game characters	The poem scene reinforces the game characters by implementing them with the accompanying text. Each story features different characters, allowing players to contextualise and engage with complex scenarios through relatable animal figures.
Appropriate interface	The poem scene provides a user-friendly interface that presents information clearly and concisely, without overwhelming the player.
Quality interactions	The poem scene offers seamless interaction by allowing players to click anywhere on the screen to display the next paragraph or page.

5.3.4 Quiz

The quiz scene is the third encounter for the player, following the poem scene. Its objective is to assess the player's understanding of the issue presented in the poem by presenting four randomly selected topic-related questions to them, thereby introducing an element of replayability.

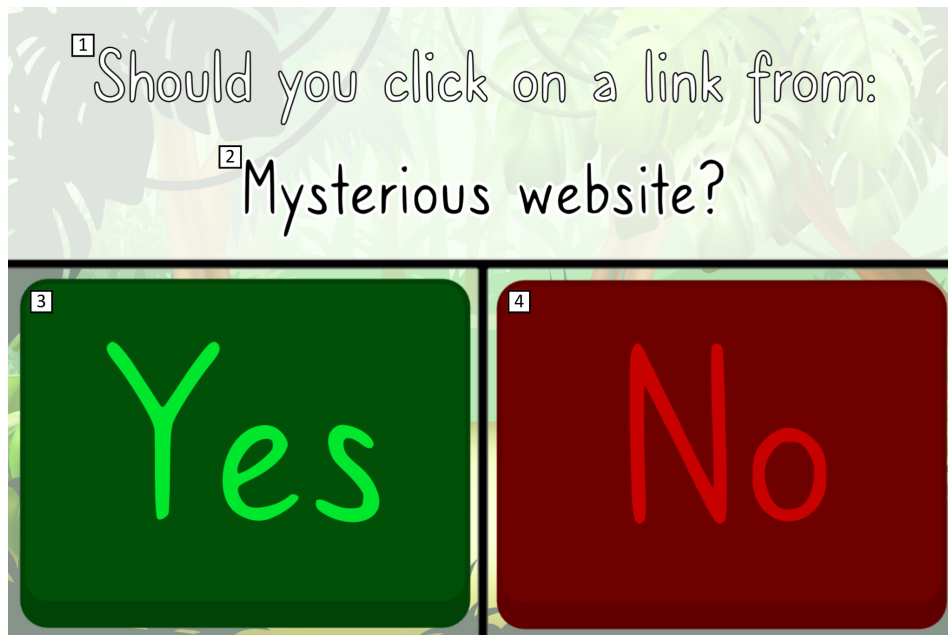


Figure 5.4: Quiz scene presenting four random questions based on the poem scene

The game's progress is not dependent on the player's performance; even if the player achieves suboptimal results, they will still advance to the next

scene. This scene aims to raise awareness of a specific topic in an engaging way, rather than offering formal education. It can also serve as a collaborative tool for children and their guardians. A screenshot of the main menu scene is shown in Figure 5.4.

Below is a numbered list of the various elements depicted in the figure above:

1. Question text - This component shows the active quiz question.
2. Possible answers - This component presents four randomly selected answers to the player, which are then read aloud.
3. Yes button - Click this button to respond to the positively asked question. A green check mark indicates a correct response, while a red cross will be displayed if it is incorrect, accompanied by the corresponding sound effects for each response.
4. No button - Click this button to respond to the negatively asked question. A green check mark indicates a correct response, while a red cross will be displayed if it is incorrect, accompanied by the corresponding sound effects for each response.



Figure 5.5: Quiz outcome displaying the number of correct answers using four silhouettes of the poem's characters, with each correct answer filling one silhouette

5. Quiz results - This component displays the number of correct answers

out of four, providing visual feedback. For example, as shown in Figure 5.5, a player answered three out of four questions correctly.

6. Badge outcome - This badge element serves as a reward and feedback for the player. Each silhouetted character features a unique random badge, accompanied by a sound effect to encourage the player.
7. Try again button - This button appears only after the quiz is completed. If the player is dissatisfied with their results, clicking the button will enable them to replay the quiz.
8. Continue button - This button appears only upon completion of the quiz. When clicked, it will take the player to the game scene.

In Table 5.3, the essential elements of the game to develop an effective and enjoyable serious game for preschool-age children, as identified in Sections 4.1 and 4.4, along with their implementation into the quiz scene, are presented.

Table 5.3: Implemented game design elements into the quiz scene

Game element	Implementation
Competition and goals	The goal element is reinforced in the quiz scene by challenging players to test the knowledge they gained in the poem scene. In addition, players are motivated to improve by competing against their previous scores.
Rules	The rules are clearly indicated by the two buttons labelled, “Yes” and “No”. Correct answers contribute to the player’s score, while incorrect answers have no impact. In addition, the quiz scene features a straightforward rule presented as a question that players must answer.
Choice	The quiz scene enables players to make tactical choices when answering questions. After finishing the quiz, players can choose to replay it or continue with the game.
Structured challenge	The structured challenge is not implemented in the quiz scene because the game’s target audience is preschool children. This challenge may be developed further in future versions to appeal to a broader audience.
Fantasy	In the quiz scene, fantasy is less prominent due to its seriousness, as it aims to assess the player’s understanding of the content presented in the poem scene.
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Table 5.3: Continued from previous page

Game element	Implementation
Aesthetics	The aesthetic element is not prominent; the quiz scene conveys a sense of seriousness, featuring only colourful buttons.
Simplicity	The element of simplicity is achieved through a straightforward colour palette, a minimalistic background, large buttons, and clearly legible text for the player.
Clear and simple goals	The goal of the quiz poem is clear and simple: players must respond to a question or statement with either a “Yes” or “No”.
Engaging visuals	Engaging visuals are not implemented in the quiz scene.
Quality feedback and rewards	Quality feedback is provided when the player completes the quiz. Throughout the quiz, players receive visual feedback indicated by a green check mark for correct answers and a red cross mark for incorrect answers. In addition, audio feedback is given through sound effects.
Game characters	Game characters are not implemented in the quiz scene.
Appropriate interface	The quiz scene features a user-friendly interface that clearly presents information through large buttons, enhancing usability for the player.
Quality interactions	The quiz scene features seamless interaction through large buttons that use vibrant colours and clear text, ensuring optimal visibility for the player.

5.3.5 Game

The game scene is the final encounter for the player. Each poem is paired with a unique game that serves as a reward for the player upon completing the poem and quiz. In Figure 5.6, a screenshot of the game menu is displayed and read aloud to the player.



Figure 5.6: Game instructions

In Figure 5.7, the first game presented is the “Lucky the Fish” game. The primary goal of this game is to raise awareness when it comes to distinguishing between safe emails, indicated by a green checkmark and safety signs, and unsafe emails, represented by caution and phishing signs, as they appear from the bottom of the screen. The player must collect twenty safe emails to achieve victory; however, clicking on three unsafe emails results in a loss. The game enhances hand-eye coordination, thereby improving fine motor skills. In addition, it educates players on the importance of identifying secure and malicious messages, promoting awareness and digital well-being. The inclusion of a level slider encourages players to replay the game to improve their skills.

In Figure 5.8, the second game presented is “Elephant and his shoe”. In this game, the player takes on the role of a rabbit. The objective is to navigate through a series of obstacles, such as thorns and cacti, while collecting balls and coins to earn points. The player wins by accumulating twenty points (represented by the balls and coins) and loses after colliding with the harmful obstacles three times.



Figure 5.7: Lucky the Fish game

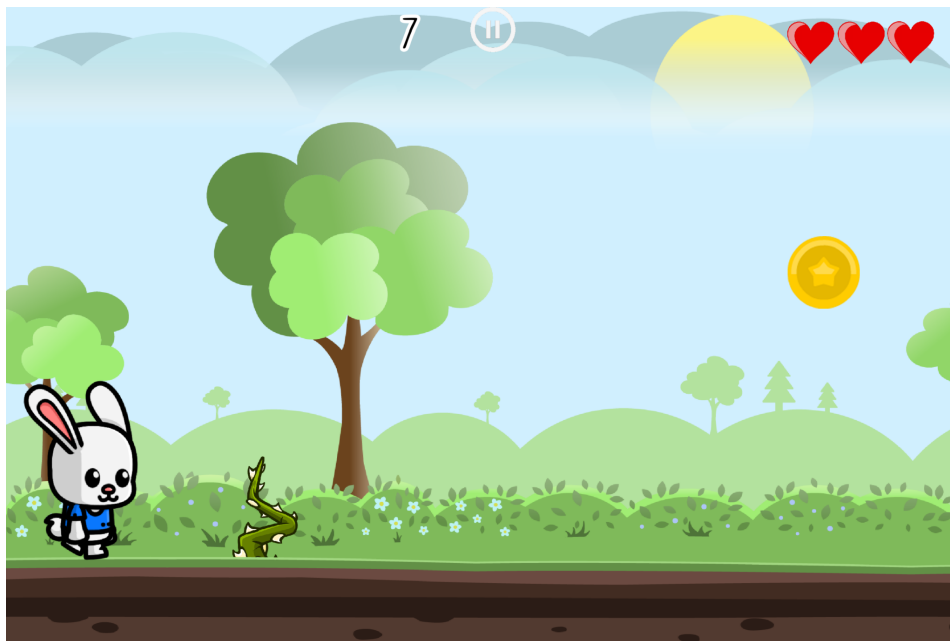


Figure 5.8: Elephant and his shoe game

The game's outdoor setting aligns with a holistic theme of promoting physical activity and digital well-being. It promotes fine motor skills and hand-eye coordination, as players must click on the screen to make the rabbit

jump and avoid obstacles. The gameplay features varying levels of difficulty to provide structured challenges: the easier level offers numerous collectible items for points, while the harder level introduces additional obstacles, such as birds, to increase engagement and complexity.

Beyond its entertainment value, the game aims to instil healthy habits among children. By emphasising the importance of outdoor play, it positions outdoor activities as a positive alternative to excessive screen time, contributing to overall digital well-being. The game's message encourages players, particularly children, to replicate these behaviours in real life and raises awareness of the importance of balancing digital technology use with physical activities.

Upon completing the game, players will receive visual and auditory feedback to indicate their win or loss. They can then choose to replay the game or return to the main menu to explore additional poems.

Below is a numbered list of the various elements depicted in the figure above:

1. Game instructions - This component outlines the rules of the game and is read aloud to the player.
2. Level slider - This component adjusts the game's difficulty level, with level 1 as the easiest to level 10 as the most challenging.
3. Level indicator - This component displays the currently selected level.
4. Play button - When the player is ready, they click this button to begin the game.
5. Score indicator - This component displays the player's score, starting at zero. The player wins the game upon reaching a score of twenty. Note that some games may not include a score indicator.
6. Pause button - This component pauses the game, and includes options such as Restart, How-To (which displays the instructions), and a main menu button.
7. Lives indicator - This component shows the player's number of lives, starting at three. If the player's lives drop to zero, they lose. Some games may not include a lives indicator.

In Table 5.4, the essential elements of the game to develop an effective and enjoyable serious game for preschool-age children, as identified in Sections 4.1 and 4.4, are presented along with their implementation into the game scene.

Table 5.4: Implemented game design elements into the game scene

Game element	Implementation
Competition and goals	The goal of each game is clearly outlined in the accompanying instructions. Each game has specific conditions for winning. Since these games do not have opponents, the competitive element lies in players surpassing the challenges presented by the games themselves.
Rules	The rules for each game are outlined above, detailing the actions that will lead to a win for the player.
Choice	The game scene enables players to make both tactical and strategic choices. Tactical choices are demonstrated through the player's actions, while strategic choices include selecting a level, playing the game, pausing, navigating to the main menu, and replaying. These options ensure that players do not feel constrained in their gameplay experience.
Structured challenge	The structured challenge is implemented through a level selector that allows players to progress from easier levels to more challenging ones based on their individual skill sets. This approach accommodates both experienced players and beginners, facilitating skill development as they advance from lower to higher levels.
Fantasy	The fantasy element is implemented into the game scene through a jungle theme, accompanied by jungle music and animations at the end of each game.
Aesthetics	The aesthetic element is prominent through the use of visual and auditory components. Each game features unique visual elements and sound effects that enhance the overall jungle theme.
Simplicity	The element of simplicity is achieved through a consistent jungle theme, large buttons, and clearly defined rules, allowing players to navigate effortlessly.
Clear and simple goals	The rules and goals of each game are presented at the beginning of the scene, both visually and audibly. They are clear and straightforward, offering players all the necessary instructions to achieve their objective. In addition, when players pause the game, they can click on the instructions to reinforce their understanding.
Engaging visuals	Each game features engaging visuals, with some implemented animated characters that enhance the gaming experience by providing varied visual feedback.
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Table 5.4: Continued from previous page

Game element	Implementation
Quality feedback and rewards	Quality feedback is provided upon the player's completion of the game. Throughout gameplay, players receive audio feedback through sound effects and visual cues that indicate their success or failure.
Game characters	Each game features distinct characters that align with its story, enhancing relatability to the poem. Some games may not include characters, but instead implement specific elements from the poem's scene.
Appropriate interface	The game scene provides a user-friendly experience by presenting information clearly and concisely. It features large buttons to enhance usability. The lower levels are designed for easy tapping, sliding, and dragging on the screen, with larger components that improve interaction and accessibility for children.
Quality interactions	The game scene features seamless interaction through large, vibrant buttons that are visually accessible and comfortable for the player. The interactions, such as releasing, tapping, sliding, and dragging, promote the development of motor skills and hand-eye coordination in children.

5.4 Design process

As stated in Section 1.4, this study employs a design science research methodology. During the evaluation phase, the game was reviewed by eleven experts: game designers and developers, human-computer interaction (HCI) specialists, user experience (UX) experts, and a select group of preschool educators as part of a pilot review. This comprehensive approach ensured that both technical and pedagogical aspects of the game were thoroughly considered. The study followed an iterative, user-centred design process, continuously integrating expert feedback into the development cycle to better align the game with the needs of the target audience, as shown in Figure 5.9.

Expert reviews were chosen due to ethical considerations, direct involvement with children was not permitted. Experts were also selected for their ability to provide domain-specific insights, ensuring the game incorporated best practices in design, usability, engagement, game elements, and educational alignment. Their feedback improved the game's design by enhancing engagement mechanisms, refining usability features, and keeping the interface age-appropriate for preschool children. The inclusion of preschool educators added pedagogical validity by evaluating the game's relevance to early

childhood learning objectives.

However, expert reviews also have limitations. While their input is valuable, the quality and reliability of feedback depend on the reviewers' expertise and may not fully reflect the experiences or preferences of preschool children. Conflicting recommendations between expert groups may arise during the design process. Additionally, the limited number of experts can restrict the findings, potentially overlooking the diversity and practicality needed for the game.

The game was designed and developed based on elements for creating an effective, engaging, and enjoyable experience for preschool-aged children. These elements include competition and goals, rules, choice, challenge, simplicity, feedback, and rewards. The game development used technical tools including the Godot game engine, Paint.NET, and Synfig Studio.

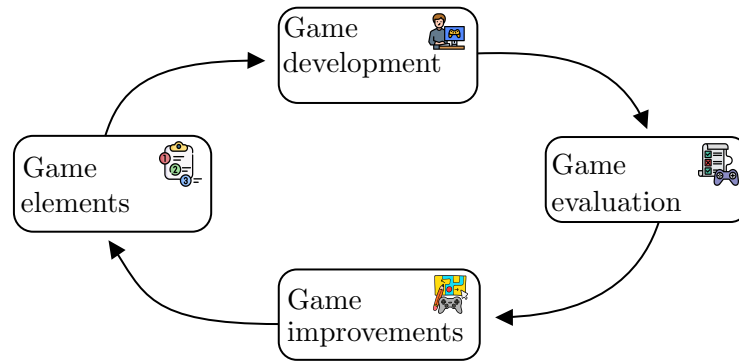


Figure 5.9: Iterative user-centred design process of the game, comprising identification of game elements, game development, evaluation and improvements to refine and enhance the overall game experience

Following development, the game was evaluated by these experts using a questionnaire that assessed usability, engagement, and game elements.

Experts were selected through purposive sampling to ensure a diverse range of relevant expertise. Game designers, developers, HCI and UX specialists were requested based on their professional experience in game development and user experience, while preschool educators were selected for their background in early childhood education.

Feedback suggested several improvements, including modifications to the instructions in the poem scene. For instance, if the game is played on a desktop, the prompt should read “Click anywhere on the screen to display the paragraph” instead of “Tap anywhere on the screen to display the paragraph”. In addition, it was recommended to implement “Continue” and “Menu” buttons in the poem, allowing players to display the paragraph without tapping on the screen and providing an option to return to the Main menu if they select an incorrect story. An information button was implemented in the poem scene for players who are unsure of what to do.

Consistent audio throughout the game was suggested, ensuring it does not overshadow the poem text, quiz instructions and game instructions.

Implementing a “How-to” guide when the player clicks “Pause” in the game scene would benefit those who may have skipped the initial instructions. Furthermore, adding a “Restart” option to return to the menu screen is suggested. Finally, quality of life improvements, such as returning to the initially selected game when the Menu option is clicked in the game scene, adding controls in the Settings option, refining the collection mechanism in “Elephant and his shoe”, adjusting the speed of the emails in “Lucky the Fish” game and other improvements, were also recommended.

In Table 5.5, the improvements made during the iterative design process are presented, with the old and new design changes implemented in the game.

Table 5.5: Changes from old to new design in the game

Old design	New design
No controls of the games available in the Settings option.	Added controls in the Settings option for easier access.
No instructions button in the poem scene.	Added an instructions button in the poem scene to assist players who are unsure what to do.
No “Continue” or “Menu” buttons in the poem scene.	Added “Continue” and “Menu” buttons for better navigation.
Inconsistent audio levels across scenes.	Audio made consistent and balanced so it does not overshadow text and instructions.
No “How-to” guide accessible in the pause menu.	Implemented a “How-to” guide accessible from the pause menu.
No “Restart” or easy return to menu option in the pause menu.	Added a “Restart” option in the pause menu.
Collection mechanism in “Elephant and his shoe” had bugs.	Improved collection mechanism for smoother gameplay.
Speed of emails in “Lucky the Fish” game was too fast.	Adjusted email speed for better playability.
Returning to the Main menu always redirected the player to the “Safety Snail e-mails” story, irrespective of the selected story.	The Main menu now correctly redirects the player to the selected story, ensuring a consistent and intuitive user experience.

These game improvements were implemented and evaluated against existing game elements to determine their effectiveness for preschool-aged children. This included adding new tactical choices to the pause mechanism, such as the Restart and Main menu buttons. This iterative process ensured the game was in its best possible version. Some of the feedback obtained during the pilot study was incorporated into a paper published as part of this research, provided in Appendix G.

5.5 Summary

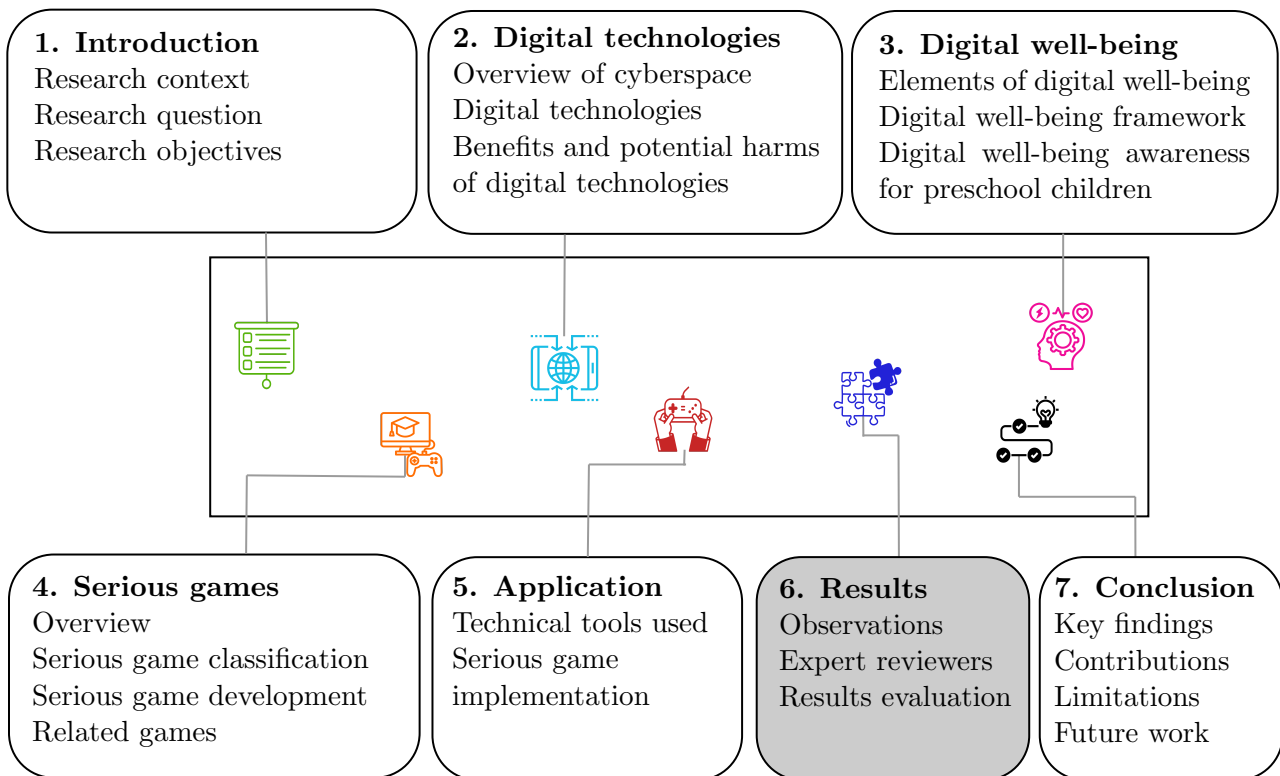
In this chapter, an overview of the developed application was presented. The first section focused on the design of the game, including the various key elements required to develop a serious game aimed at enhancing the digital well-being and cybersecurity awareness of preschool children. The technical tools used in the development of the serious game were detailed, along with the rationale behind their selections, in the second section.

In the third section, the game was presented, highlighting the distinct elements within each scene and delineating the implementation of the game components identified in the existing literature. Upon completion of the development process, the game was reviewed by game designers and developers, human-computer interaction, and user experience experts, as well as a select group of preschool educators as part of an iterative user-centred design process, ensuring the game was in its best version, which was discussed in the final section. After several iterations, the serious game was sent to experts to validate its efficacy and propose a framework to understand the impact of the game on the digital well-being of preschool children.

In the next chapter, the results of the reviewers will be presented and analysed.

Chapter 6

Results



In this chapter, the observational and expert review results are presented and discussed. In Section 6.1, the participants involved in this study are presented. In Section 6.2, the observations made during gameplay are discussed. The expert reviewers' background information, a summary of their views on digital well-being and cybersecurity education, parental monitoring, parental education, the importance of teaching digital well-being and cybersecurity awareness, and the incorporation of these concepts into the curriculum, along with their evaluations of the serious game, are presented in Section 6.3. Finally, the proposed extension of the digital well-being framework, incorporating new categories identified in this study, is presented in Section 6.4.

6.1 Participants

In this section, the participants involved in the study are discussed. The participants consist of forty-three individuals, including twenty-nine children aged 3 to 7 years and fourteen expert reviewers, consisting of eight educators, four caregivers, and two academic researchers, whose opinions are detailed in Section 6.3. The number of participants involved in this study is presented in Figure 6.1.

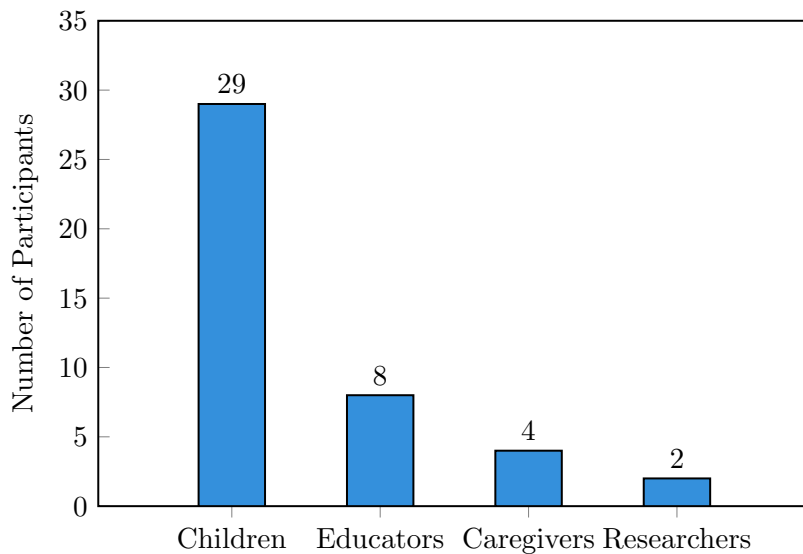


Figure 6.1: Distribution of participants involved

This study has received ethical approval from the Faculty of Natural and Agricultural Sciences Ethics Committee at North-West University, with ethics number NWU-01325-24-A9, as provided in Appendix A. Approval for conducting this research was obtained from the North West Department of Education, as provided in Appendix B. Furthermore, consent from the

caregivers of the children is provided in Appendix C. Due to ethical considerations, only observations of the children playing the game were conducted, and expert reviews.

6.2 Observational results

In this section, the observations made during gameplay are discussed. Observation 1 involved 24 children, comprising 12 preschoolers and 12 Grade R learners, aged five to six years. These two groups were selected to evaluate the game's performance across different age ranges. The session was conducted in a computer lab and was organised into four separate sessions, each lasting 30 minutes and focusing on six children.

Observation 2 included five Grade R learners, aged five to six years, in a classroom setting, lasting 45 minutes. The children were observed in a naturalistic environment as they interacted with the game under the guidance and supervision of their educators. The researcher did not interact with the children; only non-intrusive observations were conducted.

6.2.1 Observation 1

When provided with guidance, the children demonstrated the ability to navigate the selection menu and choose a story with ease. During the poem scene, the majority of the children clicked the "Continue" button to display the poem. Given that most of them had not yet achieved proficiency in reading, the narration of the poem was particularly beneficial, as it enabled them to listen to the moral lessons presented at the conclusion of each story. Once the narration concluded, they clicked on "Continue" to proceed to the next paragraph or page. In addition, the animations accompanying the poem text helped maintain their engagement. One notable observation was that some children rushed through the stories to reach the gameplay, showing less patience or interest in the reading component.

The quiz scene evaluated the children's comprehension of the poem. Most children encountered difficulties with certain technical terms presented, such as "phishing," "unknown source," "surprising offer," "pop-up advertisements," "educational website," and "screen time." However, when their educator provided clear explanations in simpler terms, the children engaged with the questions effectively. In addition, some children participated in discussions among themselves to decide between "Yes" or "No" responses. This scene facilitated communication between the educator and the children. After completing the quiz questions, the children remained fully engaged as they proceeded to the game. Their motor skills and hand-eye coordination contributed to their success in the game.

Most of the Grade R children struggled a bit initially; however, during their second play time they began to understand how the game worked. Fur-

thermore, in the game scene they reached Level 2, with some Grade R children advancing to Level 4. Additionally, one Grade 1 learner asked, “*Where can I get this game?*” The learners played the game multiple times and expressed their desire to play it again.

6.2.2 Observation 2

Initially, the children received guidance on navigation in the main menu, after which they independently navigated between stories and selected a story. In the poem scene, the children tapped the “Continue” button to progress to the next paragraph or page.

In the poem scene, one child noted that “*I cannot read, but if you tell me, I will understand.*” During the poem scene, when the educator explained the poem story following each narration, the children listened attentively, although one child appeared to lose interest quickly. In addition, the accompanying visuals in the poem scene maintained the children’s engagement. However, the moral lessons at the end of each poem, such as “What is Google?”, were a bit technical for the children to understand.

During the quiz scene, the children tapped and engaged in brief discussions among themselves to decide between “Yes” or “No” responses, which was not challenging for them, as they also discussed with their educator. Finally, the game scene engaged the children; they improved with each replay and managed to advance to Level 3–4, which enhanced their hand-eye coordination, particularly when playing “Lucky the Fish” as the emails moved upward and required tapping.

Overall, the children appeared to enjoy playing the game, and they could benefit from individual sessions with their caregivers. The game functioned as a tool for facilitating discussions between children and their educator, despite children having a shorter attention span during the poem scene. These observations indicated that the game was not limited to preschool children, as it offered challenges and information that appealed to a broader demographic.

The design features, particularly the large buttons and engaging visuals, facilitated user-friendly navigation and enhanced engagement. Numerous children demonstrated enthusiasm and expressed a desire to continue playing the game. The game served as an educational resource that introduced concepts of cybersecurity and digital well-being. This approach benefited both children and their caregivers, fostering discussions and activities that extended beyond mere restrictions on technology use.

6.3 Expert reviewers

The expert reviewers were selected through purposive sampling, a method used to select participants who can provide informed opinions on a subject relevant to their knowledge, background, experience, or expertise. A questionnaire, provided in Appendix D, was employed to conduct the review and was distributed to fourteen experts in the fields of preschool and primary education, caregiving and academic research.

6.3.1 Methodological analysis

The methodological analysis for the evaluation of the serious game was guided by the structure and content of the questionnaire provided in Appendix D. Data was collected using an online form which included various types of questions: multiple choice, checkboxes, dichotomous (yes/no), and closed-ended and open-ended questions. The online form automatically collated responses, which were then exported for analysis.

Upon collection, the data was reviewed for completeness and consistency. Responses were anonymised and categorised by participant role (Educator, Caregiver, Researcher) to contextualise feedback.

For Likert-scale responses were coded numerically (1 = Strongly Disagree to 4 = Strongly Agree). Most of the numerical responses were averaged to provide a summary score of each item, allowing for a comparison across the different aspects.

Multiple choice and checkbox responses were categorised according to predefined options and presented in tables and figures. Dichotomous items were analysed using simple frequencies to indicate the proportion of participants responding positively on negatively.

Dichotomous (yes/no) questions were analysed using simple frequencies to indicate the proportion of participants responding positively or negatively.

For open-ended and short-answer questions, a basic content analysis was conducted. Responses were read to identify recurring ideas and themes, which were then grouped into broader categories reflecting the main areas of feedback, such as usability, engagement, educational value, and suggestions for improvement. Illustrative quotes were selected to support the findings.

6.3.2 Reviewer information

The questionnaire demographic information about the experts; those who were preschool or primary school educators were asked additional questions regarding their experiences with children. The remaining questions, applicable to all experts, focused on digital well-being and cybersecurity education, as well as the role of digital technologies in children's lives, game elements, digital well-being theory, and game evaluation.

The questionnaire revealed the following backgrounds among the fourteen participants: eight educators in preschool and primary education, four caregivers, and two researchers.

The educational qualifications of the experts included three doctorate degrees, two master's degrees, two honours degrees, six bachelor's degrees, and one high school diploma. Regarding computer literacy, two reviewers demonstrated expert level proficiency, seven reviewers exhibited advanced proficiency, three displayed intermediate proficiency, and two were at a novice level.

Table 6.1: Reviewer information

Information	Details
Number of reviewers	Total: 14, (8 Preschool and primary educators, 4 caregivers, 2 researchers).
Educational background	- 3 Doctorate degrees; - 2 Master's degrees; - 2 Honours degrees; - 6 Bachelor's degrees; and - 1 High school diploma.
Computer literacy	- 2 Expert; - 7 Advanced; - 3 Intermediate; and - 2 Novice.
Experience with children	Total: 8, (3 with 0–2 years, 4 with 3–5 years, 1 with 6–10 years).
Age group	Total: 8, (7 with children aged 5–6, and 1 with children aged 7+ years).
Use of digital devices for teaching	Yes: 5, No: 3.
Use of resources to teach digital well-being and cybersecurity	Yes: 1, No: 7.

Among the eight experts in preschool and primary education, three had between zero and two years of experience working with children, four had between three and five years of relevant experience, and one had six to ten years of experience. Additionally, six educators primarily worked with children aged five to six years, while two educators worked with children aged seven years and older.

Five out of eight reviewers in preschool and primary education reported using digital devices, such as laptops or computers, in their teaching practices. However, only one reviewer indicated they use educational resources, such as books, to educate children about digital well-being and cybersecurity.

ity, while the remaining seven do not use such resources. In Table 6.1, a summary of the reviewers' educational backgrounds is presented, highlighting their educational backgrounds, computer literacy levels, experience with children, and use of educational resources in educational settings.

6.3.3 Digital well-being and cybersecurity education

Reviewers were presented with questions regarding digital well-being and cybersecurity, as well as the role of digital technologies in children's lives, particularly the digital landscape to which preschool children are exposed and its implications for their safety and well-being.

Reviewers' familiarity and views on children's digital exposure

Eleven reviewers indicated familiarity with digital well-being and cybersecurity, while two indicated partial familiarity and one was not familiar. Regarding their experience of children's exposure to various digital technologies, one reviewer reported that children are not exposed, two indicated that children are somewhat exposed, five reported that children are moderately exposed, and the final six reviewers reported that children are highly exposed.

This perspective was supported by several experts. Educator 3 stated, *"Most children are forced to use a smartphone or iPad/tablet from a very young age."* Educator 5, similarly noted, *"At home, the children are on their phones as often as they wish."* Educator 6 observed, *"I have observed a number of parents buying tablets for their three-year-old children, without monitoring their usage, which exposes children to social media."*

Educator 7 added, *"Nowadays, it is common to find a 9-year-old using and owning a cellphone, which is why they are highly exposed."* Similarly, Caregiver 1 stated, *"They use their parents' cellphones and household smart TVs all the time."*

In addition, Caregiver 2 further reinforced this perspective, *"My children are exposed to digital technology through video games, phones, YouTube Kids, and computer classes in their schools."* Caregiver 3 added, *"Children have access to several devices providing access to the Internet."*

Finally, Researcher 1 stated *"They [children] start using online platforms at an early age, often without a clear understanding of the potential dangers or risks involved."*

Interpretation The findings indicate a normalisation of early and unsupervised use of digital technologies among children, reflecting a media-centric parenting approach with limited supervision. Most reviewers acknowledged that children are highly exposed to digital technologies, which may affect their digital well-being. For example, Caregiver 3's response supports previous research showing that children are exposed to these devices due

to their increased accessibility. Similarly, Researcher 1's observation that children lack the necessary skills and knowledge aligns with the findings of Esfandiari et al. (2025), Quayyum et al. (2021), and von Solms and Fischer (2017). These results underscore the importance of active parental involvement. Caregivers should closely monitor their children's digital activities, set screen limits and be mindful how they use digital technologies, as parental behaviour significantly influences children's digital habits.

Concerns about children's exposure to digital technologies

All the reviewers expressed concern regarding children's digital exposure, with levels of agreement ranging from "somewhat agree" to "strongly agree." Particularly, three experts indicated somewhat agreement, five agreed, and the remaining six strongly agreed that this digital technology is concerning.

This concern was supported by several experts. Educator 3 noted, *"Children are not developing properly because they are not playing outside as they used to. This stunts both fine and gross motor skills."* Educator 5 reinforced added, *"Children are still developing their brains, and being in front of a TV, phone, or computer for extended periods is not good for their cognitive development."*

Caregiver 1 acknowledged, *"Sometimes we parents allow them [children] to use technology more than necessary so we can focus on other responsibilities."* Caregiver 3 added, *"There is not enough supervision and control over the content to which children are exposed."*

Four experts noted concerns about inappropriate content. Educator 1 noted, *"There are a lot of videos that are not suitable for children."* Similarly, Educator 4, noted, *"Because they [children] can then see things they are not supposed to,"* Caregiver 2 noted, *"Often, when unsupervised, they [children] visit sites that are inappropriate for their age,"* and Caregiver 4 added, *"Digital technology exposes our children to all sorts of problems on the Internet, such as inappropriate content and unpleasant experiences."*

Educator 6 noted a wider perspective:

"Slowly but surely, more children are becoming addicted to cell-phones and tablets, which impacts the true meaning of enjoying childhood by creating great memories with others, as we did. The memories they are likely to have will revolve around spending time with their devices rather than with their peers, which may hinder their ability to socialise with others when they grow up."

Educator 7 added, *"We are entering an AI century that will require people to continually learn new things. As a young person, getting accustomed to technology at an earlier age can be advantageous."* Researcher 1 remarked, *"The risk with having access is that one cannot always monitor your child's interactions, particularly if one does not understand the issue at hand."*

Interpretation These findings indicate a consensus among experts that children’s digital exposure is widespread and may contribute to developmental risks, particularly those associated with excessive screen time. Caregiver 1’s response supports the findings Park and Park (2021), highlighting that caregivers often use digital technologies to occupy children while attending to other tasks, which can result in limited supervision and increased exposure to unregulated content. Additionally, the perspectives of Educator 3, Educator 5, and Educator 6 suggest that digital technologies can negatively impact physiological well-being through sedentary behaviour, as well as psychological and behavioural development, especially in relation to problematic smartphone use. Conversely, Educator 7’s response points to potential benefits, noting that early exposure to technology may help children develop essential skills for navigating an increasingly digital world, provided that such exposure is guided and responsible.

Children’s digital technology use: benefits and potential harms

In relation to digital technologies, all reviewers noted that children regularly engage with a range of digital technologies on a daily basis, including mobile devices, television, video games, and computers. Among these, mobile devices are the most prevalent, followed by television, then video games, and computers are less commonly used.

Experts noted that these technologies provide several benefits. Educator 1, stated, *“Children learn rhymes, colours, etc.”* Similarly, Educator 2 stated *“They [children] learn from it [digital technologies], discovering colours and how to follow instructions.”* Educator 3 highlighted, *“Learning how to code and being educated broadly. Acquiring content knowledge that is not taught in school.”*

Educator 5 added, *“It [digital technologies] helps them [children] in understanding safe practices on the Internet and also aids in their learning through educational shows and videos,”* and Caregiver 1 remarked, *“Educational programming, following storylines that can enhance vocabulary.”*

Caregiver 2 stated:

“There are many benefits to technological exposure. In an increasingly digital world, completely restricting children’s access to technology may hinder their future development. However, it is essential that their use of technology is closely supervised and guided to ensure they derive optimal benefits from it.”

Educator 6 highlighted:

“For educational purposes, cellphones and tablets have a significant impact, as they can teach children how to count, read, identify colours, and more. Additionally, television offers educational shows that teach kids nursery rhymes and counting. Therefore,

if these devices are used correctly, they can enhance a child's cognitive skills."

Educator 7 added *"Children get exposed to different languages, allowing them to see various perspectives of the world."* Similarly, Caregiver 3 stated, *"Exposure to other languages."* Finally, Caregiver 4 and Researcher 1 noted that they learn to use technology, and enhance their technological knowledge.

Interpretation This suggests that digital technologies should not be completely taken away but used intentionally under appropriate guidance and supervision. As they serve as effective tools for children, offering personalised learning, life skills, numeracy and contextual learning that can shape children's cognitive development. Additionally, these technologies not only extend beyond basic literacy, but may provide children with an understanding of cultural diversity and prosocial behaviour.

While digital technologies provide numerous benefits, several experts also expressed concerns regarding their potential harms to children.

Educator 1 stated *"Children spend too much time on technological devices, which negatively affects their development."* Educator 4 observed *"Too much screen time leads to a short attention span and addiction, affecting critical thinking and preventing the development of a strong core."*

Educator 6 further highlighted:

"They [children] can become too dependent on technology to an extent where they are unable to use their cognitive skills. For example, when it comes to counting, children may rely on applications or calculators. Additionally, excessive television viewing can negatively impact children's sleep routines."

Educator 7 added *"This limits their ability to make friends in person, as many of them prefer being indoors most of the time."* Caregiver 4, similarly noted, *"They [digital technologies] can lead to social and behavioural issues."*

Caregiver 1 highlighted that *"Potential exposure to foul language, and content with violent themes."* Caregiver 2 listed several issues, including *"attention problems, developmental issues, cyberbullying, exposure to harmful content, and mental health issues,"* and Caregiver 3 added, *"Exposure to unsuitable content."* Finally, Researcher 1 noted that potential harms of digital technologies on children include laziness and increased anti-social behaviour.

Interpretation The findings are consistent with existing literature, which demonstrates that excessive digital technology use adversely affects children's physiological, behavioural, and psychological well-being (Hill et al., 2016; Neumann, 2015; Nikkelen et al., 2014; Robidoux et al., 2019).

Physiologically, prolonged screen time, particularly television viewing has been linked to increased body mass index and childhood obesity, primarily due to sedentary behaviour, unhealthy programming, and disrupted sleep patterns that influence “hunger hormones.” These concerns were reiterated by Educator 1 and 6, who noted that children engage in digital technologies for extended periods with minimal physical activity, impacting their sleeping routines.

Behaviourally, excessive technology use is associated with disruptive and potentially addictive behaviours, such as problematic technology use, as noted by Educator 6. Caregiver 4 and Researcher 1 further indicated that digital technologies contribute to behavioural issues and decreased prosocial behaviour.

Psychologically, the risks include an increase in attention deficit hyperactivity disorder (ADHD), cyberbullying, and social isolation. Exposure to age-inappropriate content (content risk), as identified by Livingstone and Stoilova (2021), remains a significant concern, reiterated by the experiences of Caregivers 2 and 3 and Educator 4. Additionally, concerns were raised about the negative impact of these digital technologies, including effects on cognitive abilities, independent reasoning, and memory.

Parental monitoring of technology use

Regarding parental monitoring of their children’s use of technology, three strongly disagreed while ten partially agreed and one agreed.

This perspective was supported by several experts. Educator 2 observed *“Some parents leave their children unsupervised with technology,”* while Educator 3, noted *“Most parents are not educated in cyber safety.”* Educator 4, remarked *“They sometimes do, but mostly they do not. Parents give it to them to keep the children busy.”* Similarly, Researcher 1 noted *“Digital technologies are often used as a childminder [digital babysitter].”* Educator 7 highlighted a knowledge gap, stating, *“Some parents are unaware of the harm that digital technology can cause to their children.”* Similarly, Researcher 2 added, *“The problem with this is that general awareness is low; if parents are unaware of the risks, they are unlikely to monitor their usage effectively.”*

Caregiver 1 added, *“Sometimes parents may be focused on other responsibilities and not fully realise what their kids are exposed to. However, it is often possible to notice when the algorithms begin suggesting inappropriate content.”* Finally, Caregiver 2 expressed,

“It seems that many parents do not monitor their children’s screen time, as numerous children are allowed to use their tablets until bedtime, and watch television late into the night. If parents monitored their use of digital technology, most children would likely spend more time reading books than using technology.”

Interpretation These findings reveal insufficient parental involvement in active mediation, and supervision. While parents always want to protect their children, their lack of awareness about digital well-being and cybersecurity hinders their effectiveness. Furthermore, some parents appear to be unaware of the potential effects of digital technologies, often providing devices to occupy their children while they attend to other responsibilities; consequently, these technologies are increasingly used as digital babysitters. This underscores the need for interventions aimed at both parents and children to foster and sustain healthy digital habits.

Parental education on digital well-being and cybersecurity

Regarding parents educating their children about digital well-being and cybersecurity concepts, three experts noted that parents do not provide such education, nine indicated they rarely do so and two experts remarked that parents often educate their children.

Educator 1, Educator 3, Educator 4, Educator 5, Researcher 1, and Researcher 2 all noted that some parents are not fully aware of these concepts and the potential risks involved.

This perspective was supported by experts. Educator 5 observed, *“Not all parents are aware of cybersecurity and digital well-being, so it may be difficult for them to teach their children about it.”* Similarly, Researcher 2 added, *“Parents cannot teach what they do not know.”* Educator 6 remarked, *“Parents often do not take the initiative to teach their children about cybersecurity and digital well-being, as evidenced by allowing them to use social media at an early age.”* Educator 7 noted, *“Some parents allocate less time to spend with their children.”* Similarly, Educator 8 reinforced this point, *“They [parents] are too occupied.”*

Caregiver 1 stated, *“We do not expect children to be targets of cyberattacks. Rather, we expect them to play games and watch videos.”* Caregiver 2 remarked, *“Most parents are actually not aware of the potential harm.”* Finally, Researcher 1 noted, *“This [concepts] does not receive enough attention.”*

Interpretation These findings indicate that many parents either are not fully aware or are unaware of these concepts, which makes it difficult for them to teach their children. This observation aligns with existing research conducted by Pons-Salvador et al. (2022) and von Solms and Fischer (2017). Most reviewers noted that these concepts are not receiving adequate attention, partly because parents often perceive them as issues primarily affecting adults, they expect children to engage in playing. Finally, some parents may be preoccupied with other responsibilities, resulting in insufficient time to educate their children, which can affect caregiver-child interactions that play a significant role in neurocognitive and behavioural development (Bozzola

et al., 2018).

Importance of teaching digital well-being and cybersecurity

Regarding the importance of teaching children about digital well-being and cybersecurity awareness, all reviewers emphasised the necessity, with responses ranging from “strongly agree” to “very important.”

This perspective was supported by experts. Educator 5 stated, *“If we do not teach children about digital well-being and cybersecurity, they will not be able to recognise warning signs.”* Educator 7 highlighted the impact of artificial intelligence, stating, *“As we enter an AI century, there is more harm to our information if we are not technologically equipped.”* Caregiver 2 stated, *“As digital skills are essential for education, careers, and daily life, early education in digital well-being and cybersecurity helps children recognise suspicious links and messages. This also provides them with a strong foundation for lifelong digital competence.”* Additionally, Caregiver 3 added, *“As there will not be supervision and control at all times, it is important to educate children to also know right from wrong.”* Finally, Researcher 1 added, *“Children must grow up with knowledge about these issues to ensure their safety.”*

Interpretation These findings demonstrate a consensus among experts on the importance of teaching digital well-being and cybersecurity to children. Early education in these topics is crucial, as it empowers children to protect themselves, recognise risks, and remain vigilant when using digital technologies. As artificial intelligence is increasingly integrated into daily life, it is essential to educate children about AI.

Incorporating digital well-being and cybersecurity into curriculum

Finally, the last question presented about digital well-being and cybersecurity education was regarding incorporating these topics into the basic curriculum. Two experts expressed that it is partially important to incorporate them, while six noted that it is important, and the remaining six noted that it is very important to incorporate these topics. This view was supported by experts.

Caregiver 1 noted, *“It’s good to touch on, but it should not replace existing fundamentals currently taught for the development of young children.”* Caregiver 2 added, *“Inasmuch as most schools are incorporating computer literacy into their curriculum, it is equally important that they also teach kids safety measures while in digital spaces.”* Caregiver 4 remarked, *“It is crucial for protecting children from an increasing number of cyber threats, fostering responsible online behaviour, and prepare them for the digital age.”*

Educator 6 highlighted, *“This will allow children to learn about the neg-*

ative aspects of using technology and provide them with safety tips on how to be cautious, as well as the importance of reducing screen time.” Finally, Researcher 2 remarked, “We need to educate the young, as they are the future. With the growth of technology, we cannot fully comprehend the threats that may lie ahead.”

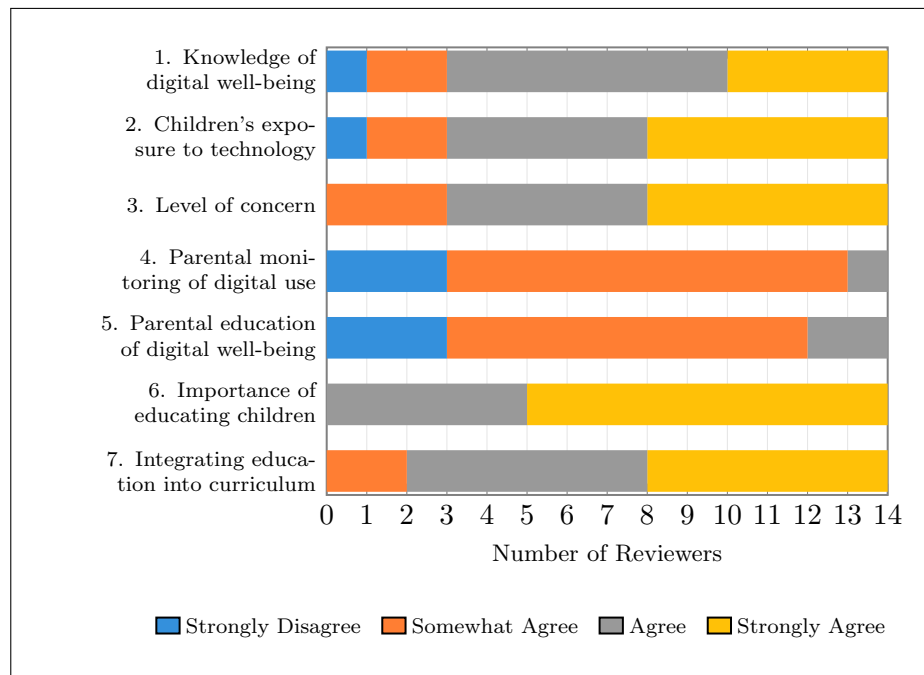


Figure 6.2: Summary of reviewers' responses on digital well-being and cybersecurity education

1. Experts' knowledge of digital well-being and cybersecurity
2. View on children's exposure to various digital technologies
3. Experts' level of concern regarding children's digital exposure
4. View on parental monitoring of children's digital technology use
5. View on parental education about digital well-being and cybersecurity
6. Importance of educating children on digital well-being and cybersecurity awareness
7. View on integrating digital well-being and cybersecurity into the educational curriculum

Interpretation These findings suggest that these topics are essential for fostering the development of healthy digital habits, including screen usage. This underscores the importance of incorporating digital well-being and cybersecurity education into foundational learning, as the world increasingly transitions to a digital environment. This incorporation can significantly influence long-term well-being and the ways they interact with technology. These findings are summarised in Figure 6.2.

6.3.4 Game design elements

The expert reviewers were requested to evaluate and validate the developed serious game and assess the implementation of its game design elements after playing it several times. A four-point Likert scale was used for scoring the game, ranging from strongly disagree to strongly agree. Within this scale, strongly disagree reflects a suboptimal level of implementation, while strongly agree indicates an optimal and appropriate level of implementation.

Optimal game elements

The results revealed a range of perspectives regarding the seven implemented optimal game elements for fostering an engaging and enjoyable gaming experience. Reviewers scored the competition and goals element a 2.5, while the rules in the game scored an average of 3.4. The game's provision of sufficient choices received a score of 3.5, and the structured challenge scored 3.3. The fantasy element received a score of 3, aesthetics scored a 3.8, and simplicity was rated a 2.3, as presented visually in Figure 6.3.

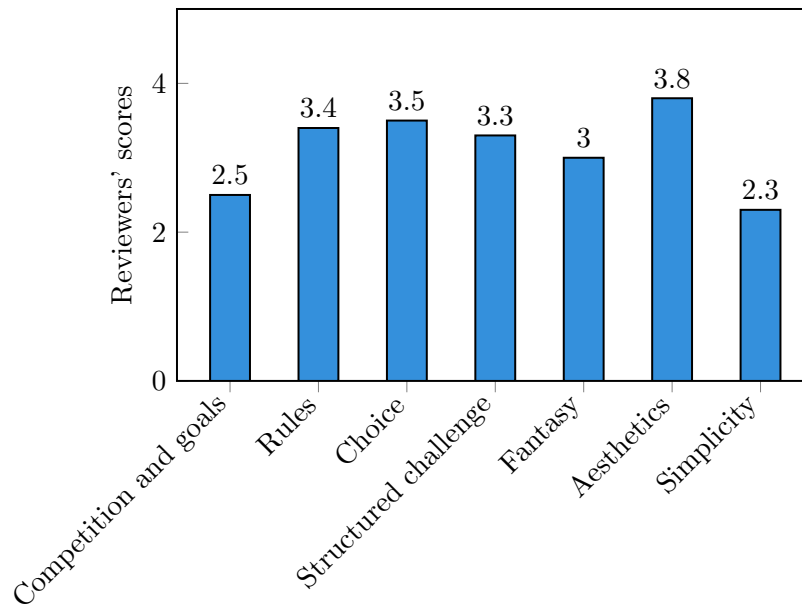


Figure 6.3: Average reviewers' scores of design elements implemented for developing an engaging, effective, and enjoyable game

Interpretation These results indicate that the game's aesthetics, including visuals, graphics and overall design are well implemented, increasing player engagement. The rules, choices, structured challenges and fantasy scored above average, indicating that each scene provides clear, easy-to-understand rules and a sufficient range of expressive, strategic, and tactical

choices. The game also offers an adequate level of structured challenge to engage children, support their development, and sustain their interest and motivation. Additionally, the storytelling aspect, combined with the jungle theme is appropriate for the target age group.

However, the lower scores for competition and goals, and simplicity highlight areas of improvement. Educator 3 proposed enhancing competition and goals, stating, *“Maybe having the game as a multiplayer so that there is a competition element among players.”* In addition, the complexity of the poem presents challenges for children who have not yet developed reading proficiency, as noted by several experts. Educator 1 remarked, *“It is [the game] a bit complex for learners aged 5-6-years-old, as they cannot read yet and the concept is a bit above their knowledge.”* Similarly, Educator 2 noted, *“Some children, for example, those in grades R and 1, still cannot read, so they will need more additional support during the game to help them.”* Educator 5 further reinforced this by stating, *“For children who do not yet know how to read, it may feel as if they are unsure about what is happening.”*

Importantly, the game is intended as a collaborative tool, allowing caregivers to assist children in overcoming these barriers by explaining concepts during gameplay. Furthermore, the game not only facilitates learning for children but also underscores its value as an educational tool for caregivers. The main challenge appears to be ensuring that experts and caregivers recognise that this game is designed for collaboration between a child and their caregiver, and is not intended for independent play by the child.

Serious game elements for preschool children

The seven implemented game design elements tailored to meet the needs of children and unique cognitive abilities, received the following expert evaluations: clear and simple goals were rated at 3.3, while engaging visuals received a score of 3.5. The quality of feedback and rewards received a score of 3.5, and the interface appropriateness received a score of 3.3. Quality interactions scored 3, balanced simplicity and complexity received a 3.5, and short playtime was rated at 3.3, as illustrated in Figure 6.4.

Interpretation Analysing these results, the responses from the experts reflect an optimal implementation of serious game design elements for children, with ratings from 3 to 3.5. The clear and simple goals, appropriate interface, quality interactions, and short playtime indicate a strong foundation with potential for further enhancements.

The game provides clear and simple goals, explicitly stating what to do and how to do it. Educator 6 noted, *“The game is straightforward. The goals are clear, as are the instructions for the games.”* The high score for engaging visuals indicates that this element was well implemented, capturing the attention of children without overwhelming them. Quality feedback and

rewards are effectively provided through both audio and visual elements.

The appropriate interface score confirms that the game is child-friendly and the content is suitable for children, without being overwhelming. Educator 7 remarked, *“The content is perfect for children.”* Although quality interactions received an above-average rating, it was the lowest among these elements, suggesting a need for improved intuitive communication between the player and the game.

The balanced simplicity and complexity elements were well implemented, ensuring the game maintains appropriate complexity without being overly simple for the intended audience. The short playtime suggests that engaging visuals and sounds were effectively used to capture and sustain children’s attention. However, as Educator 4 noted, *“The story is a bit long and not at their [children] level of English,”* indicating that further development to ensure accessibility for all children.

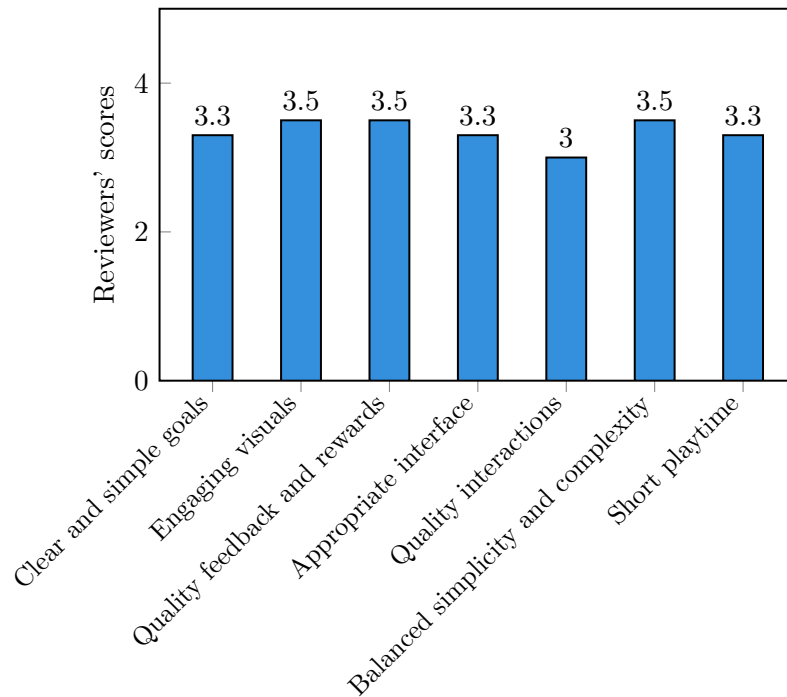


Figure 6.4: Average reviewers’ scores of the design elements implemented, tailored for preschool-aged children

The experts indicated that engaging visuals, simplicity, short playtime, choice, aesthetics, clear and simple goals were the most effectively implemented game elements that captured the children’s attention. However, they suggested that quality interactions, clarity and simplicity goals, balanced simplicity and complexity should be improved to enhance the game’s engagement and overall effectiveness.

6.3.5 Game evaluation

For the evaluation and validation of the game, a four-point Likert scale and an open-ended question were used.

The introduction of fundamental digital well-being and cybersecurity concepts received a score of 3. Age-appropriate scenarios received a score of 3, while the retention of the concepts taught was similarly rated at 3. Engagement and enjoyment for children received a score of 3.8. The game, serving as an effective collaborative tool for children and their caregivers, was rated at 3.3. The game's perceived effectiveness on enhancing digital well-being and cybersecurity awareness among preschool children received a score of 2.8. Additionally, for a recommended tool for educators and caregivers working with children, it received a score of 3.5, as illustrated in Figure 6.5.

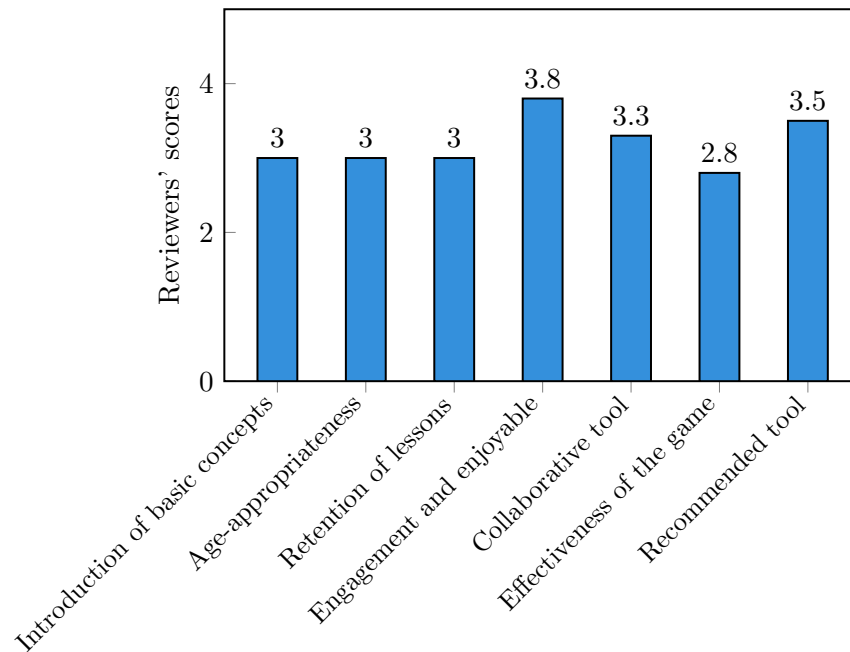


Figure 6.5: Reviewers' evaluation of the effectiveness of the serious game intervention

Experts supported the view that the game serves as a collaborative tool for children and their caregivers. Educator 5 stated, *"The children enjoyed it when I explained to them how the game works and what they must do."*

Caregiver 1 added,

"My grade R daughter enjoyed listening to and memorising details of the story and asked me to confirm certain details in the story. In the short questions afterwards, it [the game] gave us an opportunity to discuss certain digital well-being matters and she

could demonstrate her improved understanding of the topic when playing the game.”

Finally, Caregiver 2 added, *“It [the game] provided a platform for caregivers and children to engage in meaningful discussions about cybersecurity awareness.”*

The game’s effectiveness on enhancing digital well-being and cybersecurity awareness among preschool children received the lowest score. Experts indicated that this did not reflect ineffectiveness, but rather a misinterpretation of the game’s intended use. The game is designed to be played with a caregiver or educator, which is reflected in the score of 3.5. This score aligns with the rating for a recommended tool aimed at educators and guardians working with children, which also received a score of 3.5.

Experts supported the view that the game is recommended for educators and guardians. Educator 1 observed, *“If we conduct lessons on these topics, the learners will benefit from the content.”* Similarly, Educator 5 highlighted, *“This game is a fun and inclusive way to not only teach children about cybersecurity, but it is also a fun way to include the parents and guardians and teach them something they might not have known.”* Caregiver 1 emphasised, *“Children spend most of their day with educators and guardians; there is an opportunity to learn about more than the fundamentals. Once a week for an hour can be spent on digital wellness between parents and their children.”*

Educator 6 added, *“Educators can provide a practical example by using the game to teach children about digital well-being and cybersecurity awareness.”* Finally, Educator 7 remarked, *“It includes [the game] conversations that caregivers or educators typically would not think to have with their children.”*

The final open-ended question was about sharing any feedback and suggestions for improving the game, to which the experts responded. Educator 1 shared, *“The game is highly engaging and enjoyable.”* Educator 3 added, *“This [the game] has the potential to be a valuable tool.”*

Educator 4 suggested, *“The story is a bit long and not at the level of English that they are on.”* Caregiver 2 added, *“The game is well articulated. A little more simplicity in some grammar will enhance it the more.”* Educator 6 added, *“The lives should be increased from three to five, providing more chances to reach the game’s goals.”* Finally, Educator 7 added, *“Making the game multilingual.”*

Interpretation Analysing these findings, this evaluation indicates strong ratings, ranging from 2.8 to 3.8, demonstrating effective implementation. It is evident from the experts that the game serves as a potential educational tool for enhancing digital well-being and cybersecurity awareness, although there is still room for future developments. Finally, it is recommended as an educational resource for educators and caregivers working with children,

highlighting its potential for broader application in educational settings.

6.3.6 Digital well-being theory

Finally, reviewers were presented with questions regarding the impact of the serious game on children's digital well-being, in order to propose an extension of the digital well-being framework, which will be discussed in Section 6.4.

In relation to digital well-being theory, four questions were presented, comprising one closed question and three open-ended questions. Twelve out of fourteen reviewers reported the game encourages collaborative play. Educator 1 observed that, *"The children enjoyed playing together and working together to answer the questions."* Educator 5 added, *"The game teaches children how to play and share with their friends."*

Regarding the benefits of the game, reviewers identified several key advantages. Educator 2 added, *"Learning about cybersecurity,"* Educator 3 reinforced this, *"Awareness of right and wrong in cybersecurity."* Caregiver 2 observed, *"The game significantly enhanced children's understanding of digital environments and promoted responsive technology use."* Educator 6 added, *"It teaches children about Internet safety and what to avoid while online."*

Interpretation Overall, these findings revealed the game raised awareness among children and improved their caregivers' understanding of the digital environment, maintaining a positive well-being and responsible technology use. Regarding the potential harmful impacts of the game, twelve reviewers indicated there were none; however, Caregiver 1 stated, *"My child wanted to play more, so it is probably the basic risks that go with any game."* Similarly, Researcher 1 added that the potential harmful impacts might be increased screen time, but emphasised that this game should be played under the supervision and guidance of a caregiver or educator.

Regarding the complexity of the content in the game, nine of the fourteen reviewers indicated that the content presented in the game is perfect for children, while the remaining five reviewers noted that the content is somewhat complex for children who cannot yet read, and that the stories might be challenging for them to understand. However, this game is designed as a collaborative tool, caregivers will guide their children by explaining the content presented.

6.4 Extension of the digital well-being framework

One of the secondary objectives of this study is to propose an extension of the framework of Büchi (2024) to better understand how the use of digital technologies impacts the digital well-being of preschool children. From existing literature as well as feedback from the experts, the general digital

well-being by Büchi was extended, including the influence of the developed serious game on the digital well-being.

This framework was discussed in detail in Section 3.3 and comprises three interconnected components: (1) digital practice, which refers to the behaviours individuals use to interact with digital technologies; (2) associated benefits and risks, which represent the proximal outcomes resulting from these digital practices; and (3) subjective well-being, which focuses on an individual's self-evaluation of life, including aspects influenced by digital media. The findings presented in this section have been identified through a comprehensive literature review and expert evaluations.

The most commonly preferred digital practices among children, as identified from various studies in Section 2.2, include mobile devices, televisions, and video games; this was further confirmed by experts. These digital practices are associated with both proximal benefits and potential harms. Proximal benefits enhance digital well-being, while potential harms diminish it (Isaks et al., 2023).

Mobile devices are preferred by children due to their portability and touch-based interactivity, which facilitates the development of motor skills through actions, such as swiping, scrolling, and tapping. These devices offer opportunities for creativity, imagination, entertainment, and educational benefits, including early language acquisition, informal education, literacy, word recognition, phonics, and story comprehension. However, their widespread use has associated harms, including problematic smartphone use (which can result in headaches, muscle pain, sleep disruptions, anxiety, depression, stress, and impaired social interactions), diminished caregiver-child interaction, online vulnerabilities (including exposure to cyber threats, and phishing), and emerging issues related to artificial intelligence, particularly deepfakes, which present challenges to children's well-being and safety.

Television is the second most prevalent technology among preschool-age children, largely due to its accessibility in most households. It provides several benefits, including educational programming that can support children's basic arithmetic, cognitive abilities, contextual understanding, early language acquisition, teamwork, prosocial behaviour, reinforce life skills, responsibility, and social skills. However, television can also have harmful effects, including exposure to unhealthy programming, disrupted sleep patterns, increased sedentary behaviour, social isolation, and fast-paced or violent content, all of which can adversely affect children's development.

Video games are favoured for their interactive features. When used constructively, they can benefit children in learning and development, improving cognitive and metacognitive skills, including spatial awareness, creativity, executive functioning, decision making, and problem solving. They can also provide children with conceptual development, prosocial behaviour, and facilitate a zone of proximal development. Nonetheless, excessive use or unsupervised gaming can lead to gaming disorders and inappropriate influences.

Most of these proximal benefits and potential harms for mobile devices, television, and video games were confirmed by the experts.

These benefits and potential harms can, in turn, impact the digital (subjective) well-being of children, including physiological, behavioural, and psychological elements.

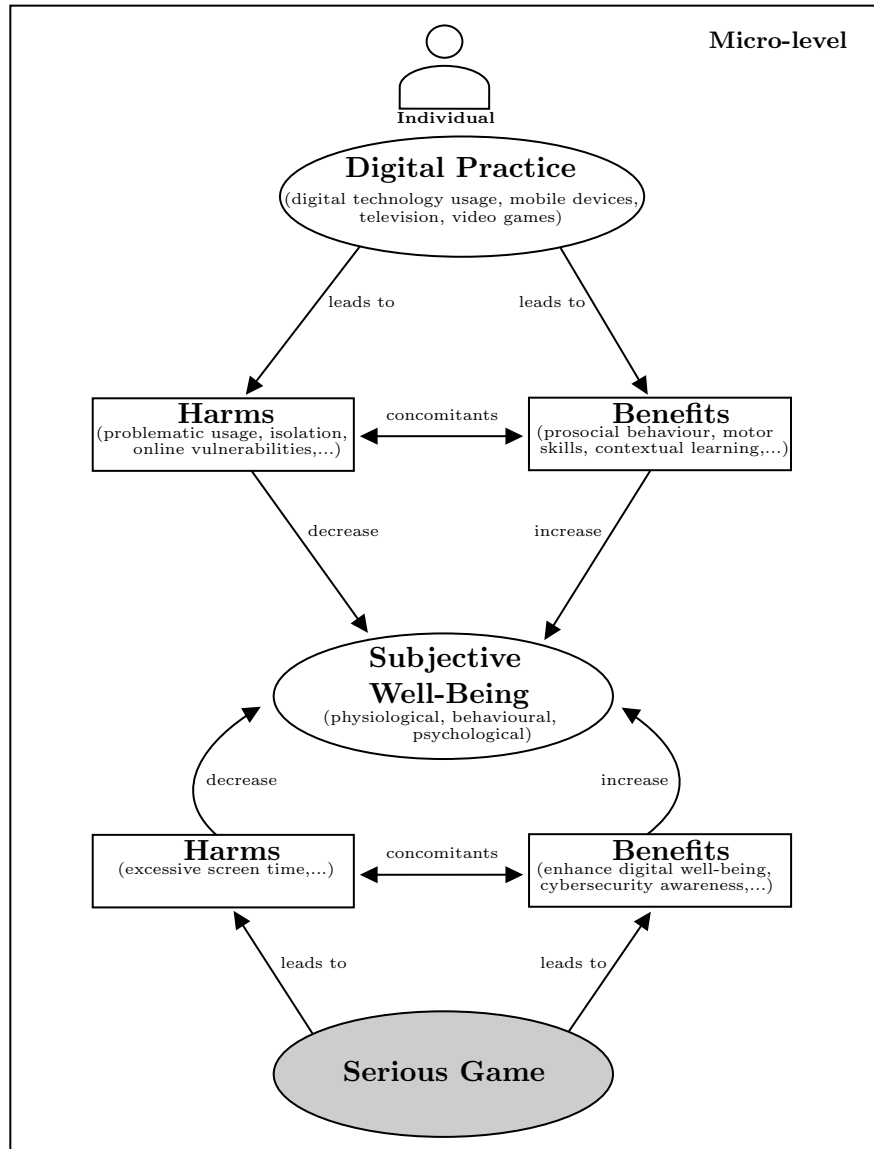


Figure 6.6: Extension of Büchi's (2024) Digital well-being framework, illustrating the interplay between digital practices, benefits, harms, and overall well-being in the context of preschool children's use of digital technologies. Included is the integration of a serious game intervention, along with its proximal benefits and harms

The impact of digital technology usage on preschool children is not deterministic, but rather mediated by various factors, including child-related aspects, such as the age at which children are first exposed to screens, caregivers' perceptions of screen time, and demographic and environmental factors such as socio-economic status, lockdown measures, peer influences, and the availability of digital technologies.

These factors affect the digital practices and subjective well-being of preschool children. Parenting styles and demographics play a crucial role in shaping the digital behaviours in which children engage. For example, the level of involvement from parents and caregivers in their children's digital technology usage can lead to both benefits and potentially negative outcomes, subsequently impacting their digital well-being. Rather than removing access to digital technologies, caregivers should actively monitor usage, encourage healthy digital habits, and set appropriate limits on screen time for their children.

To further enhance the digital well-being of preschool children and their caregivers, games have been identified as beneficial tools for children and will be used as an intervention to improve digital well-being while addressing the risks associated with digital technology usage in cyberspace. Games have been found to be valuable for language acquisition, spatial skills, the proximal development zone, and social skills. In addition, they have demonstrated success in enhancing children's digital well-being and awareness of cybersecurity, as discussed in Sections 2.2.3 and 3.4. However, it is critical to recognise the diverse learning methods, with play being the central component of early childhood development. These methods include hands-on experience, trial and error, parental involvement, self-directed exploration, inquisitiveness and auditory learning. Implementing these approaches into a game can result in an engaging and fun experience that enriches children's overall development.

The serious game intervention directly influences digital practices by promoting healthy digital well-being and contextual learning, which encompasses balanced digital technology use alongside physical activities. Furthermore, it actively fosters collaborative participation between caregivers and children.

This intervention effectively reduces harm by raising cybersecurity awareness and decreasing sedentary behaviour. The game significantly increases benefits by educating children about essential digital age concepts through an engaging format that supports cognitive development. However, the intervention may present potential harms when unsupervised, particularly excessive screen time, as confirmed by the experts. Finally, in Figure 6.6, a proposed extension of the framework by Büchi (2024), incorporating new components and themes that have been identified in this study regarding digital technology use and its influence on the digital well-being of preschool children is presented.

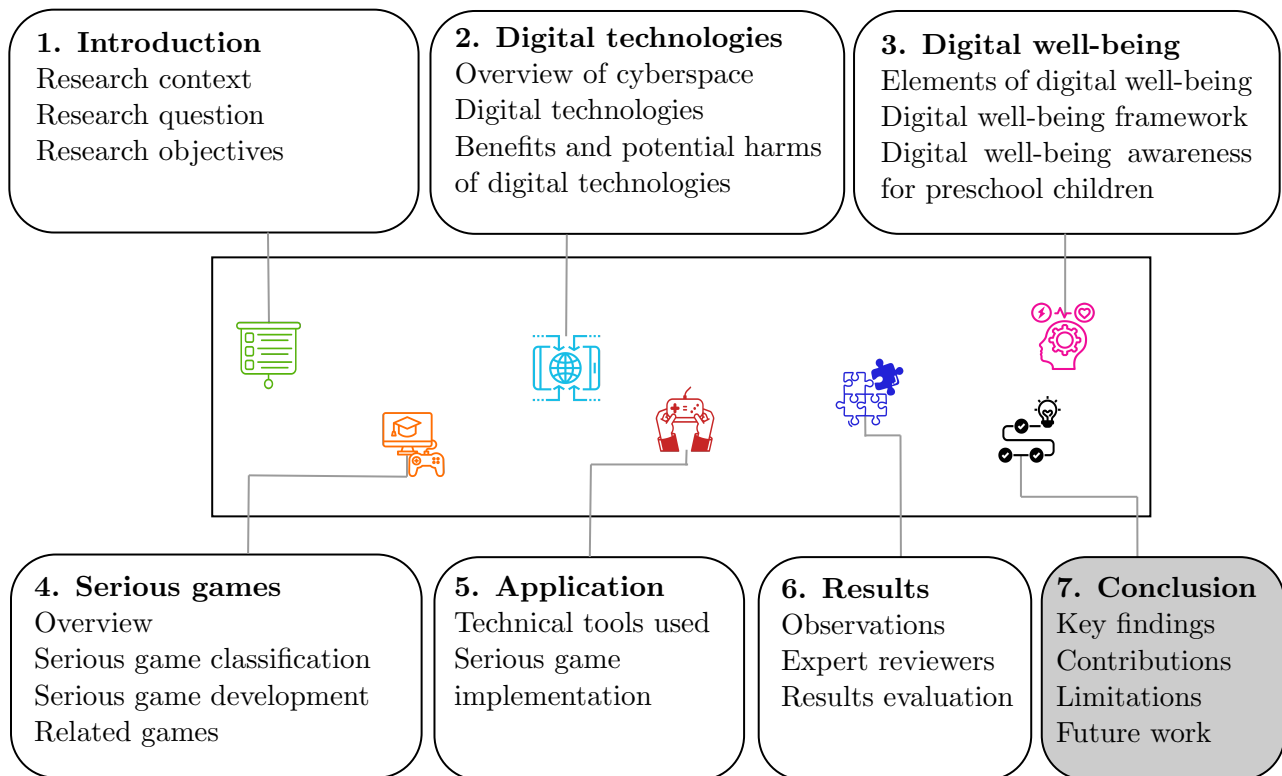
6.5 Summary

In this chapter, the observational and expert review results were presented and discussed. An overview of the participants involved in the study was provided; following this, the observational results were discussed. The third section provided information about the expert reviewers involved and summarised their views on digital well-being and cybersecurity education, parental monitoring, parental education, the importance of teaching digital well-being and cybersecurity awareness, and the incorporation of these concepts into the curriculum. The evaluation of the game design elements implemented in the serious game was then discussed, concluding with an analysis of the game's impact on the digital well-being of children. In the final section, the extension of the digital well-being framework of Büchi that emerged from this study, incorporating new components relevant to preschool children, was presented.

In the next chapter, a summary of the study, limitations, and suggestions for potential future research will be discussed.

Chapter 7

Conclusion



The primary aim of this study is to develop a serious game, guided by the digital well-being framework of Büchi (2024), as an intervention to enhance the digital well-being and cybersecurity awareness among preschool children. Experts in the fields of preschool and primary education, caregiving, and academic research evaluated the serious game.

In Chapter 1, the background and substantiation of this study were provided, including the research questions, objectives, design, structure, and publications.

An overview of cyberspace and various digital technologies relevant to this study, highlighting both their proximal benefits and potential harms, was presented in Chapter 2. The concept of digital well-being and its key elements were explored in Chapter 3, followed by the digital well-being framework of Büchi (2024) and a discussion of digital well-being awareness for preschool children. Serious games were presented in Chapter 4, examining the design challenges and critical elements necessary for creating an effective, enjoyable, and age-appropriate game for preschool children. An overview of the technical tools used to develop the game, alongside the game itself and the implementation of the design elements was discussed in Chapter 5. Finally, in Chapter 6, the observational results were presented, along with results from expert reviewers to evaluate the implemented elements and assess the effectiveness of the serious game, along with a proposed extension of the digital well-being framework for preschool children.

In this chapter, a summary of the study and suggestions for future research work is presented. In Section 7.1, an overview is provided by evaluating the extent to which the research objectives outlined in Section 1.3 were achieved. Next, the evaluation of the research process in Section 7.2. This is followed by Section 7.3, which presents the contributions of the study to the field of knowledge. The limitations encountered during the study are discussed in Section 7.4. Finally, in Section 7.5, potential future research and development are discussed.

7.1 Evaluation of research objectives

To achieve the aim of this study, five secondary objectives were established. In this section, a concise overview of how each secondary objective was achieved is provided.

1. Conduct a literature review on the beneficial and potentially harmful impacts of the use of digital technologies among preschool children.

To achieve the first objective, a comprehensive literature review was conducted to identify both the proximal benefits and potential harmful impacts of the use of digital technologies, including mobile devices, television, and

video games, which are the most prevalent among preschool children. This review is detailed in Section 2.2, with findings summarised in Table 2.2. Identifying these benefits and potentially harmful impacts laid the foundation for the digital well-being framework and the subsequent objectives.

2. Conduct a literature review on the design principles for a serious game suitable for preschool children.

The identification of benefits and potential harmful impacts has led to the development of a serious game intervention as games have been proven to be valuable tools for language acquisition, spatial skills, the zone of proximal development, and social skills. Additionally, they have proven successful in enhancing children’s digital well-being and awareness of cybersecurity, as reported in Section 3.4. The design elements for optimal game development are summarised in Section 4.3.2, while specific design elements for serious games tailored to preschool children are discussed in Section 4.4.

3. Develop a serious game to address the digital well-being and awareness of preschool children using identified design principles.

Subsequently, the game is designed to encourage active participation by providing children with a hands-on experience, supporting self-directed learning and promoting trial and error, as outlined in Section 5.1. Serving as a collaborative tool for children and their caregivers, its primary goal is to enhance digital well-being and cybersecurity awareness. The game serves as a proof-of-concept using the identified design principles, with its implementation detailed in Section 5.3. The system requirements to download a desktop version are found in Appendix E. A link to access the game can be found in Appendix F. The developed serious game demonstrates a practical implementation of these elements.

4. Use expert opinions to evaluate the implemented elements and assess the effectiveness of the serious game in enhancing the digital well-being of preschool children.

The fourth objective was to use expert opinions to evaluate the implemented game design elements and assess the effectiveness of the game in enhancing the digital well-being of preschool children as reported in Sections 6.3.4 and 6.3.5.

The first sub-objective was to evaluate the implemented elements that contribute to both a “good” game and a serious game for preschool children. Experts confirmed that all elements identified in the literature have been effectively implemented, as illustrated in Figures 6.3 and 6.4.

The second sub-objective was to assess the effectiveness of the game in enhancing the digital well-being of preschool children. This was validated

by experts, as illustrated in Figure 6.5. In addition, they recommended the game as an educational tool for educators and caregivers, indicating its potential for broader implementation in educational settings.

5. Propose an extension of Büchi’s framework to better understand the impacts of using digital technologies on the digital well-being of preschool children.

The final objective is to propose an extension of Büchi’s digital well-being framework, as the existing one serves as a guide for developing specific theories. In this case, it provides an understanding of the opportunities and challenges that can arise from the use of digital technologies by young children, which led to the development of a serious game intervention. An extension of the digital well-being framework is presented in Section 6.4.

In summary, the two research questions identified in Chapter 1 were addressed as follows:

1. “How can the use of digital technologies be beneficial or potentially harmful to preschool children?” A comprehensive literature review was conducted to identify the digital technologies used by preschool children, including, mobile devices, television, and video games. This review revealed a dual impact, highlighting both benefits and potential harms that may arise from the use of these technologies; and
2. “How can the use of digital technologies enhance the digital well-being of preschool children?” A serious game has been developed as a targeted intervention, specifically designed to enhance the digital well-being of preschool children and their caregivers, thereby improving their digital well-being while mitigating potential harmful effects.

The extended digital well-being framework directly addresses the two core research questions by explaining how digital technology can lead to both beneficial and potentially harmful outcomes, and how the serious game can promote digital well-being in early childhood contexts.

7.2 Evaluation of research process

As stated in Section 1.4, this study employs the design science research approach. In this section, a concise overview of how the six processes by Alharahsheh and Pius (2020) were followed and achieved is provided:

1. Problem identification and justification - The first phase of the design science research approach was achieved through a literature review, which provided contextualisation of the problem and justification for this study (Chapter 1);

2. Establishing objectives for a solution - The objectives of the proposed solution were achieved through a comprehensive review of relevant research, including journal articles, conference proceedings, scholarly books, and credible publications related to digital technologies, digital well-being, and serious games in the context of preschool children (Chapters 2, 3, and 4);
3. Designing and developing - This phase was achieved by designing and developing a serious game aimed at enhancing digital well-being and cybersecurity awareness among preschool children (Chapter 5).
4. Demonstration - This phase was achieved by demonstrating the serious game. Additionally, it was presented to experts as part of a pilot study to identify potential improvements (Chapter 5);
5. Evaluation - Following the demonstration phase, the serious game was sent to experts in preschool and primary education, caregivers, and academic researchers, for review and evaluation (Chapter 6); and
6. Communication - Finally, the communication phase was accomplished through the documentation process of this dissertation, with subsequent publications to follow.

The design science research approach prescribes seven guidelines by March and Storey (2008) that were followed throughout this study.

Design as an artefact: A serious game was developed as the primary artefact, implementing game design elements identified from the literature with the aim of enhancing digital well-being and cybersecurity awareness among preschool children and their caregivers.

Problem relevance: The game was designed to address the prevalent early use of digital technology without the necessary skills and knowledge.

Design evaluation: The serious game was evaluated by expert reviewers. The review focused on the game's effectiveness, the implemented game design elements, and its potential impact on enhancing digital well-being and cybersecurity among preschool children.

Research contributions: The contributions of this study are discussed in the following section.

Research rigour: The game was developed following a classification model for serious games, established game design elements for developing an effective, engaging and enjoyable game, as well as elements tailored for preschool children, in addition to the Büchi (2024) digital well-being framework.

Design as a search process: An effective solution was found by using the available resources while adhering to the rules of the problem's context. This was achieved through an iterative process involving game designers and

developers, and a select group of preschool educators, who helped refine and enhance the overall game experience.

Communication of research: The outcomes are documented in this dissertation and disseminated through scholarly publications.

7.3 Contributions

This study contributes to the existing field of knowledge by applying the digital well-being framework proposed by Büchi (2024), which led to the development of a serious game intervention for preschool children using content from the book titled “Digital wellnests: Let us play in safe nests!” by Fischer and von Solms (2016). The game design principles identified in the literature were used and implemented in the game. The serious game was subsequently evaluated by expert reviewers.

This study made additional secondary contributions:

1. Relevant information regarding digital technologies and digital well-being was summarised through a literature review, which serves as a central source for future reference;
2. Game design principles for optimal and appropriate game development for children, along with two successful approaches for enhancing digital well-being and cybersecurity awareness, were identified. This also serves as a central source for future reference;
3. The content of the “Digital wellnests” book was presented in a fun, engaging, and effective manner within the developed game to enhance awareness of digital well-being and cybersecurity among preschool children; and
4. An extension of Büchi’s framework on the interplay between the use of digital technology and the digital well-being of preschool children was proposed.

7.4 Limitations

Due to ethical considerations, direct involvement of preschool children in the testing and evaluation phase was not permitted; only observations were allowed. This was the most significant limitation in this study. Furthermore, expanding the scope of the evaluation, including follow-up questions and observations, could provide a more comprehensive understanding of the game’s long-term effectiveness.

Another limitation was the number of experts available to participate in this review. Experts were selected based on their relevant expertise, knowledge, and accessibility, which inherently restricted the overall evaluation.

Additionally, a limited number of experts were willing to engage in the iterative evaluation process necessary for the game's development and refinement. However, the general ideas and feedback from the experts were valuable during the evaluation phase.

7.5 Future work

The research provided in this study presents opportunities for future work. The main objective was to develop a serious game, guided by the digital well-being framework of Büchi (2024), as an intervention to enhance digital well-being and cybersecurity awareness among preschool children. Future work consists of developing a complete game, including all the poems from the book "Digital wellnests," and making it available to preschool educators and caregivers as a supplementary resource. Refining the development of the game by improving the identified game design elements, audio quality, and visuals, and iteratively testing it with the target audience, could greatly enhance its quality as a learning tool.

Further research could include validating and assessing the game with various relevant experts, such as game designers, caregivers, child psychologists, human-computer interaction specialists, user experience designers, audio engineers, and game testers. Assessing the long-term impacts of the game could also further extend the digital well-being framework. Finally, a comparative evaluation between the game and the "Digital wellnests" book should be conducted. This assessment would measure the effectiveness of each medium in conveying digital well-being and cybersecurity awareness, and would involve testing two groups to evaluate engagement, retention, and understanding.

7.6 Summary

In this chapter, a summary of how the aim, sub-objectives, and research questions established in Chapter 1 were achieved was presented, alongside an evaluation of the research process. Following this, the contributions and limitations of this study were discussed. Finally, opportunities for future work were highlighted.

In conclusion, this study developed a serious game designed to empower children, in collaboration with their caregivers, by providing a foundational understanding of digital well-being. Through engaging gameplay and guided interaction, the game demonstrates how children can acquire lifelong skills and knowledge to navigate the digital environment safely. The study contributes to early childhood development by integrating technology into education and promoting secure digital habits among children and caregivers from an early age.

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Appendix A

Ethics approval letter

This is the ethical approval letter from the Faculty of Natural and Agricultural Sciences Ethics Committee at North-West University granting ethical clearance for this research study.

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: The use of serious games to enhance the awareness of digital wellbeing among preschool children															
Study Leader/Supervisor: Prof GR Drevin															
Student: G Mnisi															
Ethics number:	N	W	U	-	0	1	3	2	5	-	2	4	-	A	9
	Institution				Study Number					Year		Status			
Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation															
Application type: Single					Risk Category:					Minimal					
Commencement date: 23/05/2024															
Expiry date: 23/08/2025															
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)

Appendix B

District approval letter

This is the formal approval letter granting permission to conduct research within the Dr Kenneth Kaunda District.



education

Department:
Education
North West Provincial Government
REPUBLIC OF SOUTH AFRICA

8 O.R. Tambo Street, Teemane Building,
Potchefstroom 2520
Private Bag X1256, Potchefstroom 2520
Tel.: (018) 299-8264
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OFFICE OF THE DISTRICT DIRECTOR DR KENNETH KAUNDA DISTRICT

Enq: Mr B Monale	Cont: 018 299 8103	Email: bmonale@nwpg.gov.za
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03 FEBRUARY 2025

To: North-West University
Faculty of Natural and Agricultural Sciences
Attention: Mr G Mnisi (34292748)
From: Mr B Monale
District Director

SUBJECT: APPROVAL FOR MR G MNISI'S RESEARCH ON "THE DEVELOPMENT OF A SERIOUS GAME TO ENHANCE DIGITAL WELL-BEING AWARENESS"

I hope this letter finds you well. I am writing to formally grant approval to Mr G Mnisi to conduct his research titled "*The Development of a Serious Game to Enhance Digital Well-being Awareness*" within the Dr Kenneth Kaunda District, specifically targeting Grade R schools in Potchefstroom. This research is intended to explore and develop a serious game aimed at raising digital well-being awareness among both learners and teachers.

Mr Mnisi's proposed study aligns with our department's commitment to integrating technology in education while promoting healthy digital habits among students and educators. The research will contribute valuable insights into the effectiveness of serious games as a tool for educational development and well-being enhancement in early childhood education.

The participation of all involved, including learners and teachers, will be entirely voluntary, and consent will be obtained prior to participation. Importantly, Mr Mnisi has committed to ensuring that no teaching time will be disrupted during the course of this study, and all activities will be scheduled in a way that minimises any potential interruption to the regular educational schedule. Please feel free to reach out if you require any further information or documentation regarding this approval.

Thank you for your attention to this matter and your continued support of educational initiatives in our district.

With our Best Wishes

Mr B Monale
District Director
Dr Kenneth Kaunda District



Let's Grow North West Together



Appendix C

Consent letter

This is the consent letter provided to parents or guardians to obtain approval of their child to participate in this study. The letter was shared with parents or guardians who were asked to play the game with their children and complete a questionnaire. Links to the game and questionnaire were included in the letter.



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Dear Parent/Caregiver

My name is Given Mnisi, and I am a Master's student at North-West University (Potchefstroom Campus), under the supervision of Professors Günther Drevin and Lynette Drevin. As part of my research, I have developed a game aimed at enhancing digital well-being and cybersecurity awareness among preschool children. The game is currently available in English and is intended for use by children in collaboration with a parent or caregiver. This project has received ethical approval from the Faculty of Natural and Agricultural Sciences Ethics Committee at North-West University, with ethics number NWU-01325-24-A9.

The teachers will observe and guide the children during gameplay. Following this, they will provide their opinions and give feedback. The researcher will not interact with the learners; instead, the teachers will oversee the children during the game and complete the questionnaire. Consequently, no questions will be posed to the children, nor will feedback be obtained from them by the researcher.

I would like your child to participate in this study, which poses no risks to participants. Please note that participation is entirely voluntary, and no payments will be provided. This study will contribute valuable insights into the effectiveness of serious games as a tool for educational development and enhancement of well-being in early childhood education. It aligns with the Education Department's commitment to integrating technology into education while fostering healthy digital habits among children and educators.

Any information obtained in connection with this research that can be identified with the minor under your care will be kept confidential. It will be disclosed only with your consent and used exclusively for research purposes.

I, _____ (parent/guardian) of _____ (name of learner),
hereby confirm that I have read and understood the information above. I consent to the participation
of the child under my care in this study.

Signature

Date

Researcher:

Mr Given Mnisi
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Supervisors:

Professors Günther Drevin and Lynette Drevin
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Appendix D

Questionnaire

Digital wellnests: Expert review

Thank you for taking the time to participate in this expert review. My name is Given Mnisi, and I am a Master of Science in Computer Science student at North-West University. As part of my research, I have developed a game aimed at enhancing digital well-being and cybersecurity awareness among preschool children and their caregivers, in a fun and engaging way.

Today's children are immersed in a digital world, making it crucial to equip them with the skills and knowledge needed to navigate it safely and responsibly, thereby maintaining positive digital well-being. Digital well-being is concerned with the impact of digital media on one's overall wellness; it involves using technology responsibly and maintaining a balance between its advantages and drawbacks.

To address this issue, the book titled "Digital wellnests: Let us play in safe nests!" by Fischer and von Solms (2016) was developed to raise digital well-being and cybersecurity awareness among children. This book educates both children and adults about maintaining positive digital well-being through engaging stories, and the developed game aims to bring these concepts to life in an interactive and enjoyable way.

Please note: This game is a proof of concept, not a fully developed commercial product. The complete game will include all the poems, quizzes, and games, as well as support for additional languages and more features.

All information collected during this review will be kept confidential and used solely for research purposes. Thank you for your valuable contribution to this project.

*Indicates required question

Expert demographics

This section gathers demographic information about reviewers to contextualise their feedback and provide insight into their perspectives on the game.

1. What is the highest level of education that you have completed?*

- ☐ PhD
- ☐ Masters
- ☐ Honours
- ☐ Bachelor
- ☐ Diploma
- ☐ Other:

2. What is your level of computer literacy?*

- ☐ Expert
- ☐ Advanced
- ☐ Intermediate
- ☐ Novice

3. In what capacity are you evaluating the game?*

- ☐ Preschool and primary school education
- ☐ Game design and development
- ☐ Academia
- ☐ Parent/Caregiver
- ☐ Other:

Preschool and primary education

This section gathers information from preschool experts about their experiences with children.

4. School name*

.....

5. What is your role at the school mentioned above?*

.....

6. How many years of experience do you have working with children?*

- ☐ 0-2 years
- ☐ 3-5 years
- ☐ 6-10 years
- ☐ 11+ years

7. What age group do you primarily work with?*

- ☐ 0-2 years
- ☐ 3-4 years
- ☐ 5-6 years
- ☐ 7+ years

9. Are there any digital devices used in the school to teach children?*

- ☐ Yes
- ☐ No

10. Please list these devices*

.....

11. How often do you use resources to educate children about digital well-being and cybersecurity?*

- | | | | |
|-----------------------|-----------------------|-----------------------|-----------------------|
| Never | Sometimes | Often | Always |
| ☐ | ☐ | ☐ | ☐ |

12. Please list the resources

.....

Digital well-being and cybersecurity education

This section gathers information on digital well-being and cybersecurity, as well as the role of digital technologies in children's lives. It specifically focuses on the digital landscape that preschoolers are exposed to and its implications for their safety and well-being.

13. You have good knowledge of digital well-being and cybersecurity*

- | | | | |
|-----------------------|-----------------------|-----------------------|-----------------------|
| Strongly Disagree | Somewhat Agree | Agree | Strongly Agree |
| ☐ | ☐ | ☐ | ☐ |

14. In your experience, to what extent are children exposed to various digital technologies?*

Not at all Somewhat Exposed Moderately Exposed Highly Exposed
☐ ☐ ☐ ☐

15. Please motivate*

.....

.....

16. This level of exposure to digital technology is concerning*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

17. Please motivate*

.....

.....

18. What specific digital technologies do children commonly use daily?*

- ☐ Mobile devices (Smartphone or tablet)
- ☐ Game console
- ☐ Computer
- ☐ Television
- ☐ Other:

19. What potential benefits do these technologies have on children?*

.....

.....

.....

20. What potential harms do these technologies have on children?*

.....

.....

.....

21. Parents monitor their children's use of digital technology*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

22. Please motivate*

.....

.....

23. Do you think parents educate their children about digital well-being and cybersecurity?*

Not at all Rarely Often Always
☐ ☐ ☐ ☐

24. Please motivate*

.....

.....

25. It is important to teach children about digital well-being and cybersecurity awareness*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

26. Please motivate*

.....

.....

27. How important is it to incorporate digital well-being and cybersecurity education into the basic curriculum?*

Not Important Somewhat Important Important Very Important
☐ ☐ ☐ ☐

28. Please motivate*

.....

.....

Game elements

These questions validate elements implemented in the serious game intervention to improve the digital well-being of preschoolers.

29. The goals are clear and easy to understand*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

30. The rules are clear and easy to understand*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

31. The game provides sufficient choices for the player to control the flow of the game*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

32. The level selector in the games effectively offers a structured challenge for children*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

33. The storytelling aspect of the game is suitable for children*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

34. The visual and auditory elements in the game appeal to children*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

35. The game is easy for children to navigate and straightforward to understand*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

36. The instructions in the game are clear and well-structured*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

37. The visuals of the game are appealing and engaging for the child*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

38. The feedback and rewards in the game are well-structured and valuable*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

39. The content, animal characters, levels, and interface are appropriate for children*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

40. The quality of the gameplay elements, including visuals, audio, and buttons is good*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

41. The game maintains a balance between simplicity and appropriate challenge*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

42. The length of the game is suitable for the child*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

43. Which game elements captured the attention of the child the most?
 (Mark all that apply)*

- | | |
|--|---|
| ☐ Competition and goals | ☐ Clear and simple goals |
| ☐ Rules | ☐ Engaging visuals |
| ☐ Choice | ☐ Quality feedback and rewards |
| ☐ Structured challenge | ☐ Appropriate interface |
| ☐ Fantasy | ☐ Quality interactions |
| ☐ Aesthetics | ☐ Balanced simplicity and complexity |
| ☐ Simplicity | ☐ Short playtime |

44. Which game elements could be improved? (*Mark all that apply*)*

- | | |
|--|---|
| ☐ Competition and goals | ☐ Clear and simple goals |
| ☐ Rules | ☐ Engaging visuals |
| ☐ Choice | ☐ Quality feedback and rewards |
| ☐ Structured challenge | ☐ Appropriate interface |
| ☐ Fantasy | ☐ Quality interactions |
| ☐ Aesthetics | ☐ Balanced simplicity and complexity |
| ☐ Simplicity | ☐ Short playtime |

Digital well-being theory

This section assesses how the game can impact the digital well-being of preschool children.

45. Does the game encourage collaborative play?*

- ☐ Yes
- ☐ No

46. What are the potential benefits of the game?*

.....

.....

.....

47. What are the potential harmful effects of this game?*

.....

.....

.....

48. Is the content too complex for children? Please elaborate*

.....

.....

.....

Game evaluation

This section assesses the effectiveness of the serious game intervention to improve the digital well-being of preschoolers.

49. The game effectively introduces basic concepts of digital well-being and cybersecurity*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

50. The scenarios in the game are age-appropriate for preschool children*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

51. Children are likely to retain the lessons on digital well-being and cybersecurity*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

52. The game is both engaging and enjoyable for children*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

53. The game serves as an effective collaborative tool for children and caregivers*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

54. Please motivate*

.....

55. The game effectively enhances digital well-being and cybersecurity awareness*

Strongly Disagree Somewhat Agree Agree Strongly Agree
☐ ☐ ☐ ☐

56. This game is recommended for educators and guardians working with children*

Strongly Disagree	Somewhat Agree	Agree	Strongly Agree
☐	☐	☐	☐

57. Please motivate*

.....
.....

58. Please share any feedback or suggestions for improving the game

.....
.....
.....

Appendix E

System requirements

Minimum requirements

The following are the minimum requirements to run the Digital wellnests game:

- Operating System: 64-bit Windows 10 or newer
- Processor: Intel Core i3-10110U @ 2.10GHz or equivalent
- Memory: 8 GB RAM
- Graphics: Integrated UHD Graphics 620
- Storage: 2 GB available space on HDD

Recommended requirements

The following are the recommended requirements to run the Digital wellnests game:

- Operating System: 64-bit Windows 10 or newer
- Processor: Intel Core i5-9300H @ 2.4GHz or equivalent
- Memory: 16 GB RAM
- Graphics: NVIDIA GeForce GTX 1660 Ti
- Storage: 2 GB available space on SSD

Appendix F

Download instructions

To play the game, please visit the following link: <https://givenmnisi6.it.ch.io/digital-wellnests>

Instructions

After downloading the Digital wellnests.exe game file, users may encounter a security warning indicating that the file is not commonly downloaded and may be unsafe. This warning is a standard security measure triggered by unsigned applications. To proceed, please follow these steps:

1. Locate the warning in the browser or saved location.
2. Select an option such as “Keep,” “Allow,” or “Open anyway.”
3. If additional options are shown, including “Show more” or “More info,” click to reveal additional options to continue.
4. Confirm to keep or open the file.
5. Double-click on the downloaded file to start the game.

Appendix G

Publications

This appendix contains a full peer-reviewed conference paper titled “Lucky the Fish Teaches Children About Phishing.” The paper was presented at the 17th IFIP WG 11.8 World Conference on Information Security Education (WISE 2025), held in Maribor, Slovenia, May 21–23, 2025. It is published in the conference proceedings as part of the *IFIP Advances in Information and Communication Technology* (Volume 742) book series and is indexed in Scopus.



Lucky the Fish Teaches Children About Phishing

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Abstract. Digital technologies have become an integral part of everyday life, making them unavoidable for people, particularly children who grow up surrounded by them. Today, most households have at least one digital device, making it challenging to keep children away from these technologies and exposing them to online risks including cyberbullying, phishing, and deepfakes. Given that many children are predominantly engaged with gaming, it has emerged as an effective tool for educating them about cybersecurity and fostering positive digital habits. This paper reports on a study where a serious game was developed aimed at raising phishing awareness among preschool children. The game is designed as a collaborative tool for children and their caregivers, encouraging discussions and activities that extend beyond merely restricting technology use. The design science research methodology, in conjunction with qualitative methods, was employed. Eleven expert reviewers evaluated the game regarding the usability, engagement, and design elements of the game. The findings indicated favourability towards enhancing digital well-being and cybersecurity awareness.

Keywords: Digital well-being · Preschool children · Cybersecurity · Awareness · Phishing · Serious games

1 Introduction

In the contemporary digital era, children are immersed in a world saturated with digital media, including smartphones, tablets, television, video games, and social media. This digitalisation presents new ways of how children interact and develop.

This prevalent digital environment makes it challenging to protect children from its influence. Children's inherent need for attention is increasingly satisfied through digital technologies rather than through interactions with their peers and caregivers, which include parents, guardians, teachers, educators, and childcare providers. From an early age, many children are introduced to digital technologies, with their first encounter with screen time occurring as early as four

months. This early exposure enables them to interact with distant family members and become accustomed to screen time by the time they reach preschool age [1,2].

While traditional games such as hide-and-seek, marbles, kite flying, and hopscotch remain integral to children's childhoods, digital devices provide new avenues for connecting with peers online.

Although digital technologies offer significant benefits to users, such as learning, acquiring information, and entertainment, they also present potential risks, including cyberbullying, phishing, malware, viruses, and deepfakes. This is particularly concerning regarding children, who may lack the knowledge and experience to protect themselves [3,4].

Maintaining positive digital well-being is similar to maintaining a healthy lifestyle in the physical world. This involves an individual's ability to identify potential threats and opportunities, behave responsibly, and align their digital and physical behaviour to ensure safety [4].

Among several forms of digital media, video games are also prevalent among preschoolers, as indicated by numerous studies [2,5–9]. Gaming is a popular activity for children, offering various benefits, including fostering creativity, improving social skills, providing relaxation, improving cognitive abilities, and creating learning opportunities [10]. Furthermore, games have been identified as valuable tools for cultivating digital well-being awareness in children and play a significant role in enhancing cybersecurity and digital well-being awareness in this age group [3,11].

Although most video games are primarily designed for entertainment purposes, a distinct category known as serious games is specifically developed for educational purposes. They extend beyond conventional teaching methods by integrating behaviour change theories, empowering users to apply acquired knowledge proactively [12].

The primary objective of this paper is to *culminate in the development of a serious game intervention aimed at enhancing digital well-being and cybersecurity awareness among preschool children*.

The methodology followed in this study was design science, during which an artefact was developed; in this case, a serious game, and evaluation was conducted using qualitative methods, particularly purposive sampling, to gather feedback from expert reviewers.

The remainder of this paper is structured as follows: Sect. 2 presents a review of the literature on cybersecurity, cybersecurity awareness, cybersecurity for preschool-age children, and serious games. In Sect. 3, the developed proof-of-concept serious game is discussed. The results and findings of the expert reviewers are provided in Sect. 4. Finally, in Sect. 5, the conclusion and potential directions for future research and development are presented.

2 Literature Review

In this section, an overview of the pertinent literature related to two primary aspects of this study: cybersecurity and serious games, is provided. In

Sect. 2.1, background information on cybersecurity, particularly phishing, is provided. Section 2.2 discusses two approaches to enhancing cybersecurity awareness. Section 2.3 outlines the key stakeholders whose involvement is essential for the effectiveness of these strategies, along with the learning methods suitable for children. Finally, Sect. 2.4 presents the critical design elements necessary for developing a successful game, along with design elements specifically tailored for preschool-aged children.

2.1 Cybersecurity

The widespread adoption of mobile devices among children has become increasingly common, as numerous caregivers allow their use during mealtimes as a means of encouraging them to eat, calming them down, or as a distraction while working. However, caregivers may not be aware of the potential consequences that these devices have on their children's digital well-being [13, 14].

Although anyone can be a victim of various risks associated with the digital world, children are the most vulnerable demographic due to their inexperience and inquisitive nature [15]. As a result, cybersecurity for children has gained significant attention and is becoming a prominent topic driven by the increased accessibility of the Internet for children and their subsequent exposure to various online threats, including phishing, cyberbullying, password security, online strangers, identity theft, financial scams, and privacy [3].

This paper specifically focuses on phishing, as it is often underestimated and perceived as a problem affecting mainly adults [16]. Phishing is a type of attack in which an attacker uses deception and disguise techniques to gain access to confidential information of a user online [17]. In layman's terms, a phishing attack does not obtain a victim's sensitive information by compromising them but deceives a person into willingly providing it. These attacks can be carried out for personal gain or to steal someone's identity.

2.2 Cybersecurity Awareness Attempts

A study was conducted to develop strategies that have been shown to be effective in increasing cybersecurity awareness and promoting the digital well-being of children, including the implementation of digital applications and early intervention measures [18].

Digital Applications

Anti-Phishing Phil is an educational game that teaches players about phishing attacks and how to prevent them. Players control Phil, a young fish that distinguishes between real and fake worms, guided by his experienced father. The game covers phishing recognition and safe online practices [19].

*Digital Compass*¹, developed by Common Sense Education, teaches children about digital citizenship and the consequences of online behaviour. Players navi-

¹ <https://www.digitalcompass.org/>.

gate scenario-based situations, including avoiding phishing scams and protecting personal information, where they must make wise choices in the digital world.

Google developed an interactive digital game called *Interland*² that educates children about digital safety and citizenship. Players navigate four floating islands to help Internauts combat bullies, hackers, and phishers.

CyberAware is a digital application that teaches preschoolers about cybersecurity. It covers various topics such as email spam filters, security updates and patches, antivirus software, and firewalls through simulations, interactive lessons, and quizzes [20].

Tanzanite Collector is a mobile game developed for African contexts, focusing on Tanzania. Players control *Tanzanite Collector*, collecting genuine tanzanite stones while avoiding malicious ones. The game incorporates numerous phishing concepts such as emails, phone calls, and message-based attacks [15].

Although these games have been proven effective in promoting digital well-being and cybersecurity among children, they have their own limitations, particularly for preschool-aged children.

Anti-Phishing Phil lacks cognitive development, as many children may find it difficult to identify URLs, which can also be complex for adults. In addition, it lacks contextual learning and does not have a level selector that could structure the challenges for players. While *Digital Compass* offers contextual learning, it lacks sufficient choices for players. In addition its long playtime, combined with instances of being solely in a text-based format, may limit engagement for some children who have not yet developed reading skills.

Although *Interland* includes content that may be challenging for children to grasp, it requires caregiver involvement to reinforce the concepts presented. Similar to the other games, *Tanzanite Collector* lacks a difficulty selector and does not encourage caregiver engagement, which is critical for child development. Finally, *CyberAware* can be challenging for children due to the high speed of the balls and time limitations that may restrict engagement, and the information provided within the game may be insufficient for players to progress.

Early Intervention Campaigns

Early intervention programs that have been shown to be effective in improving children's digital well-being and providing cybersecurity awareness training include the implementation of a school curriculum, using digital comics, interactive storytelling, and educational videos, essentially incorporating educational resources [3].

There are key components necessary for fostering early intervention campaigns aimed at developing children's digital well-being and cybersecurity awareness. These components include consistency, simplicity, engaging content, and appropriateness [21]. Some of the resources designed specifically for children include an interactive educational e-book titled *Cyberheroes*³, which teaches

² https://beinternetawesome.withgoogle.com/en_us/interland.

³ <https://www.leahzhangkennedy.com/cyberheroes>.

children about online anonymity, password security, cyberbullying, and location sharing. This e-book facilitates discussions about online privacy between caregivers and children and includes a discussion guide for caregivers [22].

Chicken Clicking, is a children's book that discusses online safety. It follows a young chick who discovers a farmer's laptop and explores cyberspace. The chick unknowingly shops online for the farm and eventually befriends an individual on the Internet. As the chick shares personal information and arranges a meeting, the friend turns out to be different than expected [23].

Digital Wellnests: Let us play in safe nests! is a book designed to enhance digital well-being and cybersecurity awareness among preschoolers. It features 14 poems with animal characters, each containing a lesson, and questions for children to ask their caregivers [24].

This resource is the main focus of this study as it addresses various cybersecurity and digital well-being topics, including phishing, hacking, cyberbullying, password ontology, and other related topics. The book introduces new concepts with clear explanations and uses simple language that is suitable for all readers, including non-native English speakers. The events occur in a fictional animal world, with characters familiar to African children such as fish, cats, snails, and sheep using various digital technologies [25]. The book is divided into four parts: a foreword, explanations of technology-related terminology, poems, and 14 short messages. More information can be found in [24].

2.3 Cybersecurity in Preschool Education

For the two approaches, digital applications and early intervention campaigns, to be successful, it is essential to have involvement and support from various stakeholders to ensure their effectiveness. This includes [26]:

- Government: setting up systems that promote and assist in creating a secure online environment;
- Law: establishing legislation to protect children from cybercrime;
- Schools: conducting and creating initiatives centred on digital well-being and cybersecurity awareness;
- Teachers: being well-equipped in terms of cybersecurity education and digital well-being;
- Caregivers: supervising their children when they use the Internet, as they have a direct impact on how it is used; and
- Peers: motivating and assisting their friends.

While this is feasible, it requires a significant amount of time, as well as commitment, especially in developing countries where resources are scarce. To promote digital well-being and cybersecurity awareness among children, it is essential to understand their learning preferences and optimal approaches. Children learn in various ways, with play being a central component in their early childhood development. Play is a multifaceted concept observed not only in humans but also across various species, allowing individuals to hone their skills [27,28].

Playing allows children to explore, observe, and make sense of their surroundings. Some ways in which children learn include hands-on experience, trial and error, social interaction, parental involvement, and self-directed learning [29].

Additional learning methods may include inquisitiveness and auditory learning [21]. It is important to note that not all children learn in the same way. Some may learn through listening, while others may learn through building structures, and some may require assistance from their caregivers. Integrating these components into a game can be a beneficial and captivating method that enhances children's overall learning experiences and helps achieve the desired objective.

2.4 Serious Games

Games have long been a popular recreational pursuit across generations. A game is defined as a competition, whether mental or physical, that is played according to predetermined guidelines for the purpose of entertaining the player [30]. They have been identified as a valuable solution for raising awareness of digital well-being among children [11]. Although most video games are designed primarily for entertainment purposes, there is a distinct category called serious games, which serve a "serious goal."

Serious games are a type of video game in which the main objective goes beyond mere amusement [31]. They can take on various forms, such as educational games, role-playing games, and simulations, and are designed to achieve specific objectives, which can include promoting health, providing training, facilitating education, and raising awareness [32].

Design Elements for Serious Games

Developing serious games can be challenging because it involves integrating different game design principles to make them successful [33]. The fundamental principle of developing an optimal serious game is to make it both entertaining and educational. However, there are various design principles or elements that contribute to the overall quality of a serious game and distinguish it from other games. Several studies have identified optimal design principles [34–38].

The game principles relevant to this paper are those discussed in [35, 36, 38]. These studies explored the guiding principles for developing serious games for preschool-age children, analysed commonly used design principles in twenty-two cybersecurity serious games, and examined the characteristics for an effective game, respectively. The design principles include competition and goals, rules, choice, challenge, fantasy (also known as narrative), aesthetics, simplicity, feedback, and rewards.

Serious Game Development for Preschool Children

When developing serious games for preschool children, there are additional design elements that align with their unique cognitive abilities, as they process information differently compared to older individuals. Since their cognitive memory is still developing, preschool children typically have shorter attention spans

and limited visual processing capabilities and hand-eye coordination. Incorporating these elements can harness the natural enjoyment of play and establish a successful medium for their learning experience [39]. The elements of game design that meet the needs of preschoolers include: engaging visuals, quality feedback mechanisms and reward systems, structured challenges, physical interactions, balanced simplicity and complexity, short playtime and quality interactions [40].

The elements mentioned above are essential for developing a game specifically for preschool children. These elements are incorporated into the serious game as they have the potential to effectively meet the needs of preschool-age children.

3 Overview of the Game: Lucky the Fish

In this section, the developed serious game is presented. The story of Lucky the Fish was chosen to raise awareness about phishing among preschool children, using design elements and additional elements suited for this age group.

The game was developed using the Godot game engine⁴ and its built-in scripting language, GDScript. The visuals were edited with Paint.NET⁵ and the animations were created using Synfig⁶.

The game consists of four main scenes: the main menu, poem, quiz, and game scene. The main menu scene, as presented in Fig. 1, serves as the initial interface for the user, allowing them to select a poem.



Fig. 1. Main Menu scene for game selection.

Each poem is accompanied by a corresponding quiz and game. When the game begins, all the poems are animated; however, the animations are only

⁴ <https://godotengine.org/>.

⁵ <https://getpaint.net/>.

⁶ <https://www.synfig.org/>.

active once a specific game is selected. These animations are designed to capture the child's attention. The left and right arrow buttons are used to navigate between the various poems in the main menu. The settings include sound configurations, credentials, and assets; additional settings will be incorporated into future versions of the game.

Upon selecting a poem from the main menu, players are directed to the poem scene. In this scene, the chosen poem is presented visually and audibly (read to the player). Players can progress through the text by clicking anywhere on the screen, allowing them to advance to subsequent paragraphs or pages. If a player clicks on the wrong poem, they can return to the main menu using the back button.

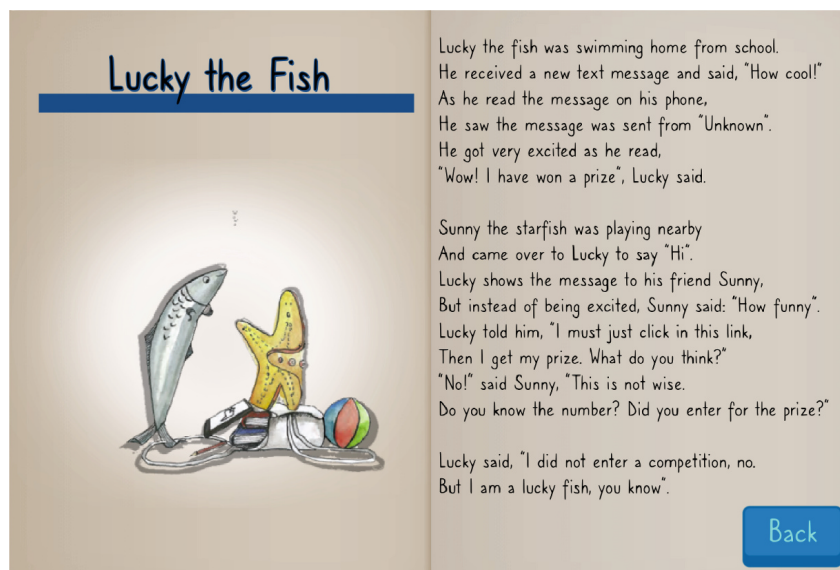


Fig. 2. Lucky the Fish poem scene.

The primary objective of this scene is to raise awareness about phishing in an engaging and entertaining manner. The specific poem presented in Fig. 2 addresses the topic of phishing. A fish named Lucky receives a message informing it that it has won a prize and should click on the link to claim it, even though it knows it has not entered any competition. However, its friend Sunny advises it to delete the message as it might be a trick.

The quiz scene is the third scene that the player encounters, following the poem scene as presented in Fig. 3. The objective of this scene is to assess the player's comprehension of the problem presented in the poem by requiring them to answer four random questions related to the topic, thereby introducing an element of replayability.

The progress of the game is not contingent upon the player's performance; even if the player achieves suboptimal results, they advance to the next scene.



Fig. 3. Quiz scene presenting four random questions based on the poem.

This scene aims to raise awareness of a specific topic in an engaging manner, rather than providing formal education. It can also serve as a collaborative tool for children and their caregivers.

The game scene is the final scene that the user encounters. Each poem is paired with a distinct game, which serves as a reward for the player after completing the poem and quiz. In Fig. 4a, a snapshot of the game menu containing instructions is presented to the player and read aloud.



(a) Lucky the Fish game instructions



(b) Lucky the Fish game

Fig. 4. Lucky the Fish game scenes, including the instructions and the mini-game.

In Fig. 4b, the game featured is the “Lucky the Fish” game. The objective of this game is to raise awareness when it comes to distinguishing between safe emails, indicated by a green checkmark and safety signs, and unsafe emails, represented by caution and phishing signs, as they appear from the bottom of the screen.

The player must collect twenty safe emails to achieve victory; however, clicking on three unsafe emails results in a loss. The game enhances hand-eye coordination, thus improving fine motor skills. In addition, it educates players on

the importance of identifying secure and malicious messages, promoting awareness, and promoting digital well-being. The inclusion of a level slider encourages players to replay the game in order to improve their skills.

Upon completion of the game, players receive visual and auditory feedback that informs them of their win or loss. The player has the choice to replay the game or return to the main menu to explore additional poems.

The Lucky the Fish game extends beyond existing digital applications in terms of its target audience, combining storytelling with interactive animations in the poem scene. This makes the learning process engaging and allows for collaboration between caregivers and children in the quiz scene. As a result, it serves as a great tool for contextual learning, providing an immediate feedback mechanism through auditory and visual feedback. After the quiz, players receive additional feedback. In addition, this game offers players choices, such as a difficulty level selector, which most existing games lack.

4 Findings

In this section, the results obtained from the expert reviewers are presented. Expert reviewers were selected through purposive sampling, a technique that involves selecting participants based on specific expertise or knowledge related to the subject matter.

A questionnaire was distributed to eleven expert reviewers. They included experts in preschool education (teachers), game design and development, academia, engineering, cybersecurity, and software development. Preschool teachers assessed the content and educational value, while the other experts evaluated the technical aspects of the game. The questionnaire consisted of multiple choice, open-ended, Likert scale, and dichotomous questions. Subsequently, expert reviewers were asked about their background, cybersecurity and digital well-being education, digital technologies, usability of the game, game evaluation, and game elements. This feedback was required as part of the evaluation phase of the design science approach.

Reviewer Background

The questionnaire responses revealed the following educational background among the reviewers: one had a high school education, one had a diploma, five had bachelor's degrees, and four had honours degrees. In terms of experience in their field, six of the reviewers had between one and three years, three had four to six years, and the remaining two had less than one year.

Feedback on Cybersecurity Education

Ten of eleven reviewers indicated their familiarity with cybersecurity and digital well-being. When it comes to usage of resources, two of the reviewers reported using CyberPatriot, Common Sense Education books, and other guides to educate their children. All the reviewers emphasised the importance of educating

children about these topics. Nine of the eleven respondents believed guardians do not teach their children about cybersecurity awareness and digital well-being.

This perspective is primarily motivated by the fact that in developing countries, caregivers often lack an understanding of cybersecurity and digital well-being, making it challenging for them to educate their children. Some parents provide their children with digital technologies to occupy them while they work, without monitoring their usage. Some of the expert reviewers noted that cybersecurity and digital well-being concepts are not prioritised in parenting. However, two reviewers stated that they were taught these concepts prior to using the Internet and implemented limits on their screen time.

These findings highlight the need for intentional parenting regarding cybersecurity and digital well-being awareness. Ten of the experts suggested incorporating these topics into the basic curriculum to raise awareness and equip children with essential knowledge and skills to navigate the Internet. One reviewer responded that it can be time consuming and suggested that rather than being part of the curriculum, it could be an extracurricular activity.

Feedback on Digital Technologies

Reviewers were presented with questions regarding digital technologies to gather information about the role of digital technologies in children's daily lives, particularly focusing on the digital landscape to which preschoolers are exposed and its implications for their safety and well-being. The reviewers rated it on a Likert scale of 5, with a score of 3.7 indicating that children are exposed to various digital technologies, including tablets and smartphones, while a smaller proportion use gaming consoles, computers, and smart TVs. Eight of the eleven of reviewers believed that this exposure is concerning and supported their concerns with the following statements:

- *“Too much exposure to the wrong kind of content on the Internet can affect young children’s critical thinking development and can even lead to mental disorders.”*
- *“As they spend more time online, children become more vulnerable to cyber threats such as phishing, cyberbullying, and inappropriate content.”*

While the majority of reviewers expressed concern, a minority did not find it concerning, asserting that children should be familiar with the latest technology to avoid difficulties in the future and that parents should establish boundaries and limit the use of digital technologies. These findings show that while the use of technology is predominant in this generation, it should be used responsibly and with parental guidance. The final question revealed that seven of the reviewers believe that parents do not monitor their children's digital technology usage, which can increase the risk of cybersecurity threats, while the remaining four reviewers believe that parents do supervise their children's online behaviour.

This underscores the importance of cybersecurity and digital well-being awareness, as the majority of children are exposed to digital technologies, and a substantial proportion of parents do not supervise this usage. Consequently, the

development of a game that addresses the gap in spreading awareness among children and their parents is crucial, fostering healthy habits when it comes to using digital technologies.

Game Evaluation

The game evaluation used a five-point Likert scale and an open-ended question. The game received a score 4.4 for introducing fundamental cybersecurity and digital well-being concepts, 3.9 for age-appropriate scenarios, 4.5 for promoting cybersecurity awareness and digital well-being, and 4 for children's retention of the lessons taught. Some responses to the open-ended question to support the previous answer were:

- *“The concepts being presented, even though they are from a very technical field, are presented in a very simple and gamified way. The fact that the game is narrated or read by a child makes it even more appropriate for pre-schoolers.”*
- *“The game is engaging, interactive, and age-appropriate.”*

These findings indicate that the game is generally effective in disseminating cybersecurity and digital well-being awareness. Notably, this game serves as a collaborative tool for children and their parents. In instances where children encounter difficult scenarios due to their age, their guardians can provide further explanations, thereby enhancing educational impact of the game.

Game Usability and Engagement

Regarding the usability and engagement of the game, a five-point Likert scale and an open-ended question were presented. The questions covered various aspects, including participation in the game, suitability of animal characters, storylines, design of the game for the target audience, clear objectives, easy-to-understand rules, gameplay structure, and interface. These questions received scores ranging from 4.1 to 4.8. An open-ended question was posed to gain deeper insights on the usability and engagement of the game, with the following responses:

- *“Introducing a pointer or indicator to prompt the user to touch the screen for additional lines could be helpful.”*
- *“Making it web based so it is more accessible.”*

These findings indicate that the game is well received, but suggest areas of improvement in future development, including accessibility and the user interface.

Game Design Elements and Effectiveness

For game design elements, another five-point Likert scale was used. The structured levels for children scored 3, whilst the rewarding elements of the game to maintain children motivated and engaged received 3.7. The simplicity of the game scored 4.8, its effectiveness in promoting cybersecurity and digital well-being scored 4.2 as indicated in Fig. 5a, and its ability to foster collaboration

between children and their caregivers scored 4.5. Expert reviewers scored 4.5 for recommending the game to educators and guardians who work with children, as shown in Fig. 5b.

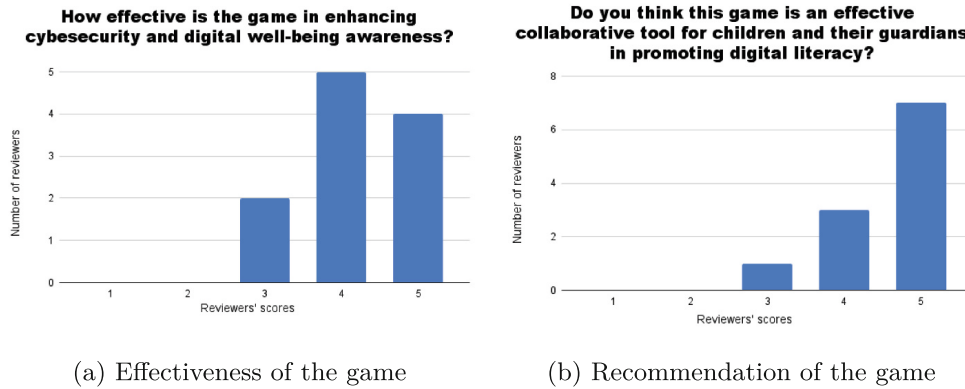


Fig. 5. Reviewer's overall perception of the game.

The experts reviewers indicated that engaging visuals, appropriate interface, balanced simplicity and complexity are the most well integrated serious game elements for children, whilst quality feedback mechanisms and reward systems, quality interactions and structured challenge should be improved to enhance the game's engagement for preschool children.

In response to the open-ended question, reviewers commended the game's engaging visuals and appropriate interface while suggesting improvements in the feedback mechanism and quality of interactions. The final question was about sharing their feedback and suggestions on the game's educational value; this included the following:

- “The game does an excellent job of presenting the concepts of cybersecurity and digital well-being through a gamified approach, which is an effective way to engage children.”
- “The game has strong educational points. It is ideal for parents and educators to engage with their children when playing the game”.

5 Conclusion and Future Work

The primary contribution of this paper is *in the development of a serious game intervention aimed at enhancing digital well-being and cybersecurity awareness among preschool children*. The findings revealed that the serious game is effective in enhancing cybersecurity and digital well-being awareness and serves as a collaborative tool for children and their guardians. It is positively received by the expert reviewers in terms of engaging, easy to play and overall interface.

Future developments include incorporating the remaining poems into games to create a complete game, improving the serious game elements, adding multi-lingual support, and allowing the target audience to play the game to gain better insights into its real-world efficacy.

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