



HAL
open science

Children's Awareness of Digital Wellness: A Serious Games Approach

J. Allers, Günther R. Drevin, D. P. Snyman, H. A. Kruger, L. Drevin

► **To cite this version:**

J. Allers, Günther R. Drevin, D. P. Snyman, H. A. Kruger, L. Drevin. Children's Awareness of Digital Wellness: A Serious Games Approach. 14th IFIP World Conference on Information Security Education (WISE), Jun 2021, virtual, United States. pp.95-110, 10.1007/978-3-030-80865-5_7. hal-03739151

HAL Id: hal-03739151

<https://inria.hal.science/hal-03739151>

Submitted on 27 Jul 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

Children's awareness of digital wellness: A serious games approach

J Allers^[0000-0002-6896-4020], GR Drevin^[0000-0002-9173-9542],
DP Snyman^[0000-0001-7360-3214], HA Kruger^[0000-0001-8514-4422], and
L Drevin^[0000-0001-9370-8216]

School of Computer Science and Information Systems
North-West University, Potchefstroom, South Africa
`gunther.drevin@nwu.ac.za`
`dirk.snyman@nwu.ac.za`

Abstract. Children today are more exposed to cyberspace and cyber threats than any of the previous generations. Due to the ever-evolving nature of digital technologies, devices like cell phones and tablets are more accessible to both young and old. Although technological advancements create many opportunities to its users, it also exposes them to many different threats. Young users are especially vulnerable, as they are rarely educated about these threats and how to protect themselves against them. One possible solution to this problem is to employ serious games as an educational tool to introduce concepts relating to cyber-security and overall digital wellness on a level that is appropriate to a younger audience. This paper, therefore, presents the development of a mobile serious game to promote the digital wellness and foster cybersecurity awareness of pre-school children by incorporating existing literature in a new format. In order to assess its appropriateness as an educational tool, the resulting serious game was subjected to expert review with a focus on its value of conveying security and wellness concepts at the proper level, thereby promoting children's safety in the digital world.

Keywords: Digital wellness · serious games · cybersecurity awareness · cyber safety for children · digital wellness for pre-school children.

1 Introduction

Technological advancement holds many advantages and it also presents many new opportunities to the younger generations, but with these advantages there are also many dangers. One issue that arises from this exposure to cyberspace, is that young people are much more likely to be exposed to negative online experiences and cyber threats than other groups. The reason why these individuals are more likely to have negative experiences is because they are exposed to cyberspace without knowledge of how to maintain good digital wellness [1].

Digital wellness can be defined as being healthy in a digital society. This involves being able to distinguish between dangers and opportunities in the digital

realm, acting responsibly in online situations and aligning online behaviour with offline values, thereby to ensure digital safety and security [2]. It does not only mean avoiding threats to data, assets and security, but it also means maintaining a physical and mental well-being.

Individuals especially at risk to the dangers of cyberspace are pre-school children. They are exposed to cyberspace and all of its dangers from a very young age and usually do not (yet) possess the skills and knowledge to protect themselves from these dangers [2]. Although there are a lot of educational material and awareness strategies that focus on the awareness of cybersecurity and the education thereof, these methods rarely address educating pre-school children about how to protect themselves against cyber threats. Existing resources are not suitable in this context, because there are different and specific requirements for facilitating teaching and learning at this level. One of these requirements is to present information in different modalities to provide for different methods of learning, e.g., most pre-school children are not able to read or write and content should be tailored accordingly. Another requirement is that the content should be presented in an easily understandable and fun way, to ensure that they will be interested and motivated to participate.

Although the increasing number of pre-school children using mobile devices to access cyberspace creates security risks, it also creates an opportunity to educate them about cyber threats and about the dangers of cyberspace. Because children learn through playing games [3], using a serious game on a mobile platform could be considered to be a viable method of promoting the different concepts of digital wellness among pre-school children. A serious game is an application that presents serious aspects with utilitarian functions, as a video game [4, 5]. By using a serious game which appeals to pre-school children, on mobile devices that they are familiar with, they could be educated about the dangers that exist in cyberspace and how to defend themselves and act against these dangers.

Using a mobile serious game is a viable method of promoting digital wellness among pre-school children, however, the success of such a game is not guaranteed [6]. There are certain factors that can be considered and elements that can be implemented that will increase the game's chance of success. By identifying these different factors and critical elements, it becomes possible to create a mobile serious game that contributes to the goal of spreading awareness of digital wellness among pre-school children.

Therefore, the primary aim of this study is to *develop a mobile serious game to effectively promote digital wellness among pre-school children*. To validate the effectiveness of the game, the following secondary objective is identified: Use expert reviews to validate the various educational aspects of the mobile serious game. This paper is based on the first author's Master's dissertation [7].

The remainder of the paper is structured as follows: In Section 2 a brief overview of concepts relating to digital wellness as well as serious games are provided. The mobile serious game that was developed is presented in Section 3. Section 4 is used to present the findings of the expert review of the game. Finally,

the study is concluded in Section 5 with a reflection on the findings and a look ahead to possible future work.

2 Related literature

In this section an overview of the literature regarding digital wellness and serious games will be given.

Creating awareness in the realm of cybersecurity refers to any activity intended to focus an individual's attention on cybersecurity issues. The aim is to enable an individual to be able to recognise the different cybersecurity threats and concerns and respond to them in the correct way [8]. Although many strategies, protocols and campaigns for the improvement of cybersecurity awareness among users exist, cybersecurity attacks still happen on a daily basis [9].

Evaluating the success of cybersecurity awareness campaigns suggest that these campaigns often fail [10]. The Information Security Forum [10] identified a number of reasons why cybersecurity awareness activities fail. Using the reasons why these awareness campaigns fail makes it possible to create and implement more effective strategies.

Simplicity has also been identified as an important element. It is important that the user feels in control of the situation and can follow specific behaviours if an awareness campaign is to be successful [11]. Also by keeping the rules simple and consistent, the user's perception of control will make it easier to accept the new behaviour [12]. The objective of this study is to create a game that successfully promotes digital wellness, therefore these elements are to be implemented in the game.

2.1 Digital wellness

Digital technologies can affect one's personal experiences in daily life with both positive and negative outcomes [13]. This ultimately means that these ever-evolving digital technologies have a direct and growing impact on the well-being of users. This fact leads to the need for a new evaluation, measure or standard to determine the well-being of users in the digital realm and that standard is called digital wellness [14].

Several definitions for digital wellness are found in literature [2, 14, 15]. From these definitions, the recurring theme of the overall well-being of the individual as (s)he interacts with content in a digital environment is central. Furthermore, digital well-being is not only dependent on how a person uses these digital technologies, but it is also affected by the user's ability to identify dangers in the cyber realm and how the user acts on these dangers.

Creating awareness in the realm of cybersecurity refers to any activity intended to focus an individual's attention on cybersecurity issues. The aim is to enable an individual to be able to recognise the different cybersecurity dangers and concerns and respond to them in the correct way [8]. Cybersecurity awareness is aimed at the end-users of a system and thus addresses the human element

of cybersecurity. Although many strategies, protocols and campaigns for the improvement of cybersecurity awareness among users exist, cybersecurity attacks still happen on a daily basis [9].

This means that digital wellness can be influenced by digital assets, digital threats and digital communications and thus to maintain a good well-being in the cyber realm, it is necessary to uphold cybersecurity protocols, while also maintaining a positive mental and physical health. Maintaining positive digital wellness does not mean following a set of rules and instructions, but to rather find the balance in which one is happy, comfortable, healthy and safe in a digital realm and how well balanced one's mental and physical state is when using different digital technologies and how safe users and their assets are.

The elements of digital wellness can be divided into three groups: *physiological*, *behavioural* and *psychological* [14]. To better understand what it means to maintain a digitally healthy lifestyle, these three categories are discussed.

The *physiological elements* of digital wellness refers to the physical well-being of a user. This means that the physiological elements of digital wellness are concerned with the health and safety of users. There are two main elements in the physiological category, namely screen time and technostress [14].

The *behavioural elements* of digital wellness are concerned with the behaviour and actions of users. This means that the behavioural aspects of digital wellness focus on how the use of digital technologies affect one's habits, actions and performance both in the digital realm and in the real world. Two of the main elements that affect one's overall digital wellness are the problematic use of the internet and media multitasking [14].

The final group of elements of digital wellness concerns the user's mental or psychological well-being. In addition to the mental well-being of the user, the *psychological elements* of digital wellness also focus on the emotional state of the user. The two main elements of this group are on-line security and on-line disinhibition [14].

Of particular interest in this study is online disinhibition as it relates to the digital wellness of children. The online disinhibition effect is a phenomenon where people behave differently online than they do in the real world [16].

One of the most common forms of online disinhibition, which is of particular concern to this study, is cyberbullying. Cyberbullying can be defined as an aggressive, intentional act carried out by an individual or by a group of people, using electronic forms of contact, repeatedly and over time against a victim who can not easily defend him or herself. It stands to reason that a child can be either the perpetrator (against other children) or the victim of cyber bullying.

The following are possible negative effects that cyberbullying can have on users (especially children and adolescents) [17, 18]:

- Increased levels of anger, powerlessness, sadness, and fear;
- Loss of confidence, disassociation from friends and school, and a general sense of uneasiness;
- Reactive behaviour that could lead to physical harm, which is likely to escalate the situation further;
- Increased levels of anxiety and depression; and
- Self-harm or suicidal thoughts.

To avoid acting in an uninhibited way, it is important to self monitor one's actions and discussions online. Avoiding discussions and situations where a person might show signs of disinhibition, will reduce the opportunity and impulse to act in a way that the person normally would not behave. In situations where other users make a user uncomfortable, unsafe or unhappy, there are two recommended actions. The first is to avoid online contact with those users by blocking contact with them or avoiding websites or situations where they might make contact. The second option is to report these users to the corresponding authorities. These authorities may be the administrators of an application or website in an online capacity or the parents, guardians or teachers in the case of younger users [2]. However, ultimately the bullying behaviour needs to be addressed and corrected to prevent future incidents. It is widely recognised in cybersecurity literature that awareness is a method of improving unwanted behaviour of the perpetrator while simultaneously informing victims of avenues of recourse.

In the next section, digital awareness strategies for children will be discussed.

2.2 Digital wellness awareness for children

To better understand how to spread awareness of cybersecurity among children, the focus of this section is to identify how they learn and develop important skills. The early experiences that children have, play a big role in their overall development and exposing them to the concepts of digital wellness can have significant benefits [19].

Children, especially preschool children, learn in five different ways [20]:

- Observation - Visual learning via observation and imitation;
- Listening - Auditory learning;
- Exploring - Investigative learning;
- Experimenting - Physical learning via trial and error; and
- Asking questions - Inquisitive learning.

Although this shows that children are capable of learning in different ways, it is important to note that not all children learn in the same way. Some children might respond better to teaching methods that involve observing and listening, while others might receive more stimulation from practical experimentation and asking questions. Fortunately, preschool children are still at the age of learning

through play [3]. Play is a fun way for children to learn, regardless of their preferred method of learning. Play allows children the opportunity to observe, listen, explore, experiment and ask questions to solve problems.

By using play as a tool for learning, the method of teaching is not limited to only one or two of the different ways of learning, but can instead be set up to include all of these methods. By creating a game specifically aimed at children, it is possible to stimulate all forms of learning using only one learning medium. The observation and listening methods of learning can be achieved by presenting information using both audio and visual methods. The addition of audio and visual feedback can also contribute to the player’s overall learning experience [6]. By using different tasks and interactions, it is possible to include both the exploring and experimenting methods of learning and by adding thought provoking questions, the inquisitive learning method will also be included.

Another important factor that should not be overlooked when discussing the awareness of preschool children, is the involvement of the child’s parent, teacher or guardian. When the parent, teacher or guardian of a child knows how the child learns best, they can guide the child to optimize learning and thus spread awareness effectively. By showing interest in what the child is doing, playing games with them, reading to them and spending time with them, the child’s motivation and productivity will noticeably improve [21]. This is especially important for inquisitive learning as children who learn by asking questions should feel comfortable to ask these questions of people whom they trust.

Examples of digital wellness campaigns for children include both traditional paper based as well as contemporary game based attempts to promote digital wellness awareness. Two traditional paper based examples, with the purpose of making children aware of digital wellness and cybersecurity, are given in Table 1 while a number of serious games to the same effect are summarised in Table 2. Games will be further discussed in Section 2.3.

Table 1: Traditional paper based digital wellness content for children

Title	Content
Digital wellnests: Let us play in safe nests [22]	A book consisting of concepts, 14 poems and 14 messages set in the animal kingdom. Furthermore nine digital wellnests and cybersecurity morals are identified.
Savvy Cyber Kids [23]	A book series consisting of three books identifying three elements of digital wellness and cybersecurity specifically for children: <ul style="list-style-type: none"> – Online anonymity (not sharing information online); – Online bullying (tell people you trust when someone is being bullied); and – Limit screen time.

Table 2: Serious games to promote digital wellness for children

Game name	Digital wellness topic
Interland: Be Inter-net awesome [24]	A game and resources (that includes a curriculum for educators) which explores four different worlds teaching the user four different lessons about cybersafety: <ul style="list-style-type: none"> – Communicate Responsibly; – Know the Signs of a Potential Scam; – Create a Strong Password; and – Set an Example and take action against inappropriate behaviour.
Budd:e [25]	- Staying safe online - Protection against viruses and malware - Using social networks responsibly
Carnegie Cadets [26]	- Staying safe online - Protection against viruses and malware - Using social networks responsibly
FBI Cyber Game [27]	- Staying safe online
PBS Cybersecurity Lab [28]	- Staying safe online - Spotting scams - Defending against cyber attacks

Most cybersecurity content that is available online is of international origin. Videos make use of robots and pirates and provide information using an English accent. Children whose home language is not English find this material difficult to follow [2]. Furthermore, the use of academic terminology to discuss cybersecurity issues also make the concepts difficult to grasp for most users and even more so for children.

Among the identified related works, the book, “Digital wellnests: Let us play in safe nests” [22], aligns best with the aim of this study. This book identifies most digital wellness topics and is specifically aimed at preschool children. Both “Interland: Be Inter-net awesome” and “Savvy Cyber Kids” identify core digital wellness issues, but the number of issues are limited compared to that of “Digital wellnests: Let us play in safe nests”.

The book, which is available electronically¹, was created with the purpose to promote a cybersecurity culture amongst children. The book uses simple explanations and depict animals as the main characters. These animals are familiar to African children. In 2015, while this book was still in its developmental stage, it was presented at a workshop in Nairobi, Kenya. At this workshop the book received much praise for its clear approach and identifiable characters in the

¹ <https://www.up.ac.za/african-centre-of-excellence-for-information-ethics/article/2109737/digital-wellness-toolkit>

African context. Both academic and civil delegates present at the workshop praised the work for successfully achieving the aims of giving the topic a local flavour [2].

Selected elements of the book are used in the mobile application developed in this study.

The book consists of four main sections. The first is a foreword and introduction that are primarily aimed at the parent, guardian or teacher. The second section of the book contains a few technology-related concepts that are both explained and illustrated by a drawn representation. The main content of the book is provided in the third section in the form of poems. Each of these poems features animals interacting with technology and ends with a moral lesson. The fourth and final section of the book consists of short cybersecurity-related lessons that are easy to remember [2].

Concepts - The book describes technology-related concepts such as: Cell phone, Computer, E-mail and Social Media.

Poems - The poems in the book serve as the main content and it is used to teach the reader a moral lesson regarding cybersecurity and digital wellness. There are 14 poems, each with a cybersecurity-related theme, a moral lesson and what element or elements of digital wellness it addresses.

An example of these poems is **Buffy the Bully**. The story of Buffy the Bully follows a buffalo that feels sad and alone and acts out by sending cruel messages to his classmates online. After the class reports Buffy to the teacher, the teacher confronts the bully and tells him that he must speak about what is causing him to send the mean messages and the teacher tells him that bullying is not the solution to his problems. The moral of the story is that if one sees that someone is being a bully, it must be reported to a trusted adult. The moral of this story is related to the online disinhibition element of digital wellness as cyberbullying is a form of toxic disinhibition. A related poem is **Happy Hippo** in which the victim of cyber bullying is portrayed. This poem will be illustrated in Section 3 as part of the discussion of the game that was implemented.

Short messages from the animals - The final section of the book contains 14 short messages that convey cybersecurity-related lessons in a way that is fun and easy to memorize. The messages roughly match the lessons of the poems, the following is an example of one of the messages given in the book [22]:

“I got messages from kids at my school. They said things that were hurtful and mean and cruel. It made me feel really sad, Until I told my mom and dad. When someone is bullying you or a friend, Tell a grown-up so that it can end.”

Digital wellness for children By analysing the content of the book, we can identify the most important digital wellness elements for children as: screen time; the problematic use of technology and the internet; online security and privacy;

and online disinhibition. The general morals of the stories and messages can be summarized as follows:

- Do not share personal information online;
- Delete messages and friend requests from unknown people and suspicious sources;
- Report cyberbullying to trusted adults;
- Be honest when going online and do not visit dangerous or suspicious websites;
- Balance using technology (screens) and playing outside;
- Always set up strong passwords and keep them a secret from others;
- Remember to use and update anti-malware tools and software;
- Do not engage in illegal activities when using technology or the internet; and
- Do not physically meet strangers that you met online without adult supervision and consent.

2.3 Serious games

Games can be defined as a set of actions, that are restricted by rules and constraints, with a certain objective [29]. Over the last half century video games have transformed the way in which people play and spend their leisure. Due to the growth in popularity and use of games, the primary goal of some games is no longer restricted to the original purpose of pure entertainment. The types of games has now extend past entertainment games to also include concepts such as serious games and gamification.

A number of approaches to define serious games exist in the literature, but most of these are reduced to a simple definition: A serious game has the primary goal of combining fun and play with a serious or utilitarian aspect [4, 5]. Therefore, serious games are video games that do not only aim to be fun and entertaining, but also have a serious motive, such as teaching the user something or spreading awareness on a certain topic. In contrast to entertainment games, learning new information and skills while playing serious games is the intended outcome. It is important to note that in this context, video games refer to all games that are played using a digital medium or on a digital platform.

The fact that preschool children learn through play [3] allows educators and parents to make use of games as an additional method to teach children new skills and building on existing knowledge. When the idea of using games for teaching and spreading awareness is considered in the light of children's growing exposure to digital technology [6], using video games appears to be a viable approach to spread awareness among children. This has become evident by the number of serious games targeted directly at young children as well as the increase in their popularity [30]. However, even though more games directed at preschool children have been developed, it does not mean that these games are optimised for their target audience. In an attempt to address this problem Callaghan et al [6] identified four design elements based on how preschool children learn.

The first element is *Clear and simple goals*: Children learn best when given clear instructions. Therefore, giving clear and simple goals at the start of the game will result in the child less likely to become confused and overwhelmed. The result will be that they will their tasks with minimal disruptions.

The second is *Quality of feedback and rewards*: Feedback is a powerful and important tool to both encourage children as well as notify them when they are doing something wrong. Preschool children most likely are not able to read and thus text feedback is of no use to them. A more effective approach is to combine visual and auditory feedback that can be easily understood by the child.

Next is the *Structure of the challenge*: When structuring a challenge, the level of performance of the target audience should be kept in mind. By adapting the level of challenge of an application to gradually increase in difficulty as the child understands more of the material, as well as decrease in difficulty when the child appears to struggle, it becomes possible to scaffold the child's learning.

The final element is *Motion based interaction*: This refers to physical methods that children can use to interact with applications. These interactions can serve as an alternative to complex touch screen activities that might be too difficult for many children. By creating the game in such a way that it aligns with the physical capabilities of preschool children (e.g., touchable object sizes, simplified touchscreen motions, etc.), the overall experience of the child will improve.

These four elements are essential to ensure that a game is suitable for a pre-school aged child. One of the objectives of this study is to create a game that is suitable for pre-school children, therefore these elements are to be implemented in the created mobile serious game.

3 Overview of the game



Fig. 1. Main menu of the game

The aim of this study is to implement a mobile serious game that can serve as a method to promote awareness of digital wellness among pre-school children. The resulting game should satisfy the following three criteria: the game should be (1) fun to play, (2) appropriate for pre-school children and (3) spread awareness of digital wellness.

The game consists of four main scenes. Each of these scenes contribute to the main goal of spreading awareness of digital wellness among pre-school children.

The first scene that the user can interact with is the main menu screen. This scene primarily serves as a selection screen for picking the poem, quiz and game that the user will play. A screenshot of the main menu scene is given in Figure 1. The user can navigate through the poems using the two green arrows pointing left and right. The poem currently selected is shown in the center, in in Figure 1 it is the Happy Hippo poem, and is a selectable animation. Tapping on this part of the screen will take the user to the selected poem.

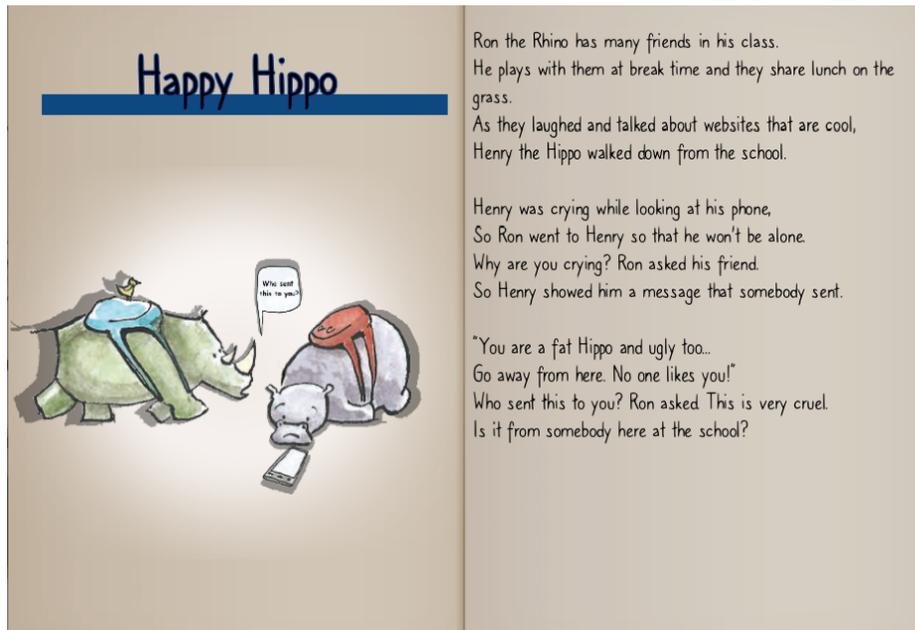


Fig. 2. Happy Hippo poem scenes

Once the user selects a poem in the main menu scene, the application will display the poem scene. In this scene the selected poem will be displayed on the screen and it will be read to the user. The user interacts with the screen by tapping anywhere to move to the next paragraph or page. The main goal of this scene is to inform the user and spread awareness of the dangers of cyberspace in an enjoyable way.

The first screen of the Happy Hippo poem, which covers the aspect of online bullying, is shown in Figure 2. The second screen continues the conversation between Ron (the Rhino) and Henry (the Hippo). Henry says that he does not know from who the messages are, but that maybe it is not a big deal as it is only text messages. Ron replies that it still is a case of bullying and that they should go and tell the teacher so that the bullying can end. This is then what they do as is shown on the third screen of the poem. The third screen of the poem also gives the moral of the story: “When you are being bullied or see someone is being bullied, tell someone you trust” as well as poses the question “Why is online bullying just as hurtful as physical bullying?”

The quiz scene is entered immediately after the user completes the reflection questions in the poem scene. The aim of this scene is to determine whether or not the user understands the problem described in the poem by motivating them to answer four questions about the topic. These questions are randomly chosen from a pool of questions to provide a form of replayability and to ensure that a pattern cannot be memorised when answering the questions. The quiz does not block progress if the user’s results are sub par. The user’s progress does not get blocked for two reasons: The goal of the game is not to formally educate children of the dangers, but rather to spread awareness on the matter; and the quiz is only meant to be used by parents, teachers and guardians as a tool to motivate the user keep track of their efforts and progression.

The final scene of the application is the game scene. This scene allows the user to play a mini-game based on the poem that they have chosen. Each of these games are different and serves as the final reward for completing the poem and quiz scenes. Before the game starts, the instructions and goal of the game are displayed on the screen and it is read out loud (shown on left in Figure 3) . The user can then use the slider to pick a level and play the game.

The Happy Hippo game is shown on the right in Figure 3. The objective of this game is to tap on the bullies (buffaloes) as they appear, while avoiding tapping on the hippos. The game can be won by tapping on twenty bullies and the game is lost if three hippos are tapped. The bullies and hippos spawn every few seconds at a random location that does not overlap other targets. This game is an exercise in small motor movement and reflexes. The message of the game is to take action against bullies by reporting them to an adult. A higher difficulty level increases the speed at which targets appear and disappear and the size of the targets.

When the game is finished, a message is displayed to notify the user whether they won or lost. This message is accompanied by a matching animation relating to the poem. The user is then given the option to play again or return to the main menu. If the user decides to play again, the user is redirected to the level selection screen.

After its creation, the serious game was sent to experts in the field of pre-school education, for review.

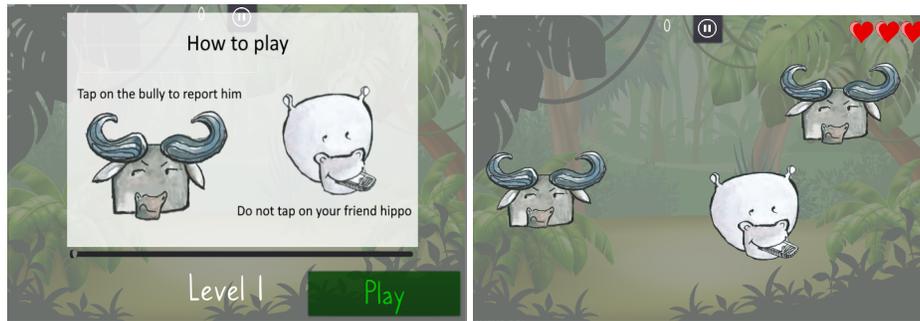


Fig. 3. Happy Hippo game

4 Expert review and validation

In this section the results of this expert review of the mobile serious game that was developed are discussed. Six experts were asked to review the game. The reviews were conducted using a questionnaire and it was followed up by a brief phone interview to gather more information. The questionnaire consisted of several questions regarding the reviewers experience and opinion of the problem, and a review of the mobile serious game and the **educational elements** implemented in the game.

Based on the questionnaire responses, the reviewers had a combined experience of 168 years working with pre-school children, resulting in an average of 28 years of experience. The age of the children that the reviewers generally work with ranged between three and nine years old.

All six of the reviewers have indicated that they have either a good or very good understanding of the different dangers and threats of the cyberspace and digital technologies, but have also indicated that they believe that the parents of the children are not very aware of these dangers. When asked whether or not the reviewers believe that the parents effectively teach the children about these dangers, all responded negatively.

Even though five of the six reviewers indicated that they believe that the current level of exposure of children to digital technologies is problematic, none of the reviewers were aware of any resources that can be used to promote digital wellness and cybersecurity and none of the reviewers used any resources for this purpose.

The validation of the mobile serious game was conducted using a scoring system. After playing the game multiple times, the reviewers were asked to score the implementation of educational element on a scale of one to five, where one indicates poor to no implementation and five indicates excellent implementation. In Table 3 the average implementation score of each element is shown, with comments from the reviewers.

Table 3: Reviewer scores.

Educational element	Mean score	Answer range	Comments
Clear and simple goals	4	3-5	<i>“Perhaps clearer instructions on how the story works. (click to turn the page etc.)”</i> (on suggestion for further development)
Feedback and rewards	4	3-5	<i>“Good feedback, but more colours can be good.”</i> (Overall comments)
Structured challenge	4	3-5	<i>“I love the different levels of play”, “More difficult levels are too difficult (in envelope game)”</i> (from interview)
Appropriate interface	4.3	3-5	<i>“This application is very child friendly. I will not change a thing.”</i> (on suggestion for further development)
Appropriate materials	4.5	4-5	<i>“It [the animal theme] was very fitting and the children will love it.”, “The different concepts are explained to them (the children) very well.”</i> (from interview)
Appropriate method of presenting the materials	4.5	4-5	<i>“I like that it [the game] uses sounds, pictures and words so everyone can understand it.”</i> (from interview)

From Table 3, it is evident that the reviewers found the implementation of each element was satisfactory, but there is still room for improvement. To further validate the game, the reviewers were also asked to score the game based on the following two criteria how suitable is the game for pre-school children; and how effective will the game spread awareness of digital wellness? All three of these criteria were awarded a mean score of 4.5 out of 5 and a range of 4-5, meaning that the reviewers believed that the game would be an overall success.

5 Conclusion and future work

The aim of this study was to *develop a mobile serious game to effectively promote digital wellness among pre-school children*. A secondary objective was identified to gauge the effectiveness of the game by means of expert review. Section 4 was used to illustrate the opinions of the experts. The game was scored high in all of the identified educational aspects. Therefore, this study’s main contribution to the current body of knowledge is a successful serious game for pre-school children that has been developed based on the concepts identified by Fischer and Von Solms [2]).

Future studies may consider focusing on both the development and deployment of this mobile serious game. The effectiveness of this game can be compared

to that of other, traditional methods of spreading awareness in order to validate if a mobile serious game is an effective tool to spread awareness of digital wellness among pre-school children. Furthermore, the validation of both the game and critical elements could be done by a more diverse group of experts from different, but relevant, fields (pre-school teachers, child psychologists, application developers etc.) and by observing pre-school children while playing. The knowledge gained from observing the children playing the game could lead to a better insight of the needs of the children.

References

1. Burton, P., Leoschut, L., Phyfer, J.: South African Kids Online : A glimpse into children’s internet use and online activities. Tech. rep., UNICEF (2016), http://www.cjcp.org.za/uploads/2/7/8/4/27845461/south_african_kids_online_brochure.pdf
2. Von Solms, S., Fischer, R.: Digital Wellness : Concepts of Cybersecurity Presented Visually for Children. In: Furnell, S., Clarke, N.L. (eds.) Eleventh International Symposium on Human Aspects of Information Security & Assurance (HAISA 2017). vol. 11, pp. 156–166 (2017)
3. Yogman, M., Garner, A., Hutchinson, J., Hirsh-Pasek, K., Golinkoff, R.M.: The Power of Play: A Pediatric Role in Enhancing Development in Young Children. *Pediatrics* **142**(3), e20182058 (2018). <https://doi.org/10.1542/peds.2018-2058>
4. Dörner, R., Göbel, S., Effelsberg, W., Wiemeyer, J. (eds.): *Serious Games*. Springer (2016). <https://doi.org/10.1007/978-3-319-40612-1>
5. Ritterfeld, U., Cody, M., Vorderer, P. (eds.): *Serious games: Mechanisms and effects*. Routledge (2009)
6. Callaghan, M.N., Reich, S.M.: Are educational preschool apps designed to teach? an analysis of the app market. *Learning, Media and Technology* **43**(3), 280–293 (2018). <https://doi.org/10.1080/17439884.2018.1498355>
7. Allers, J.: A mobile serious game to promote digital wellness among pre-school children. Master’s thesis, North-West University (2021)
8. Kissel, R.: Glossary of Key Information Security Terms. Tech. Rep. Revision 2, National Institute of Standards and Technology, Gaithersburg, MD (2013). <https://doi.org/10.6028/NIST.IR.7298r2>
9. Kirlappos, I., Parkin, S., Sasse, M.A.: Learning from “Shadow Security”: Why understanding non-compliance provides the basis for effective security. In: *Workshop on Usable Security*. pp. 1–10 (2014). <https://doi.org/10.14722/usec.2014.23007>
10. *Information Security Forum: From Promoting Awareness to Embedding Behaviours*. Tech. rep. (2014)
11. Ajzen, I.: Perceived behavioral control, self-efficacy, locus of control, and the theory of planned behavior. *Journal of Applied Social Psychology* **32**(4), 665–683 (2002). <https://doi.org/https://doi.org/10.1111/j.1559-1816.2002.tb00236.x>
12. Bada, M., Nurse, J.R.: The social and psychological impact of cyber-attacks. In: Benson, V., Mcalaney, J. (eds.) *Emerging Cyber Threats and Cognitive Vulnerabilities*, pp. 73–92. Academic Press (2020). <https://doi.org/https://doi.org/10.1016/B978-0-12-816203-3.00004-6>
13. Dauden Roquet, C., Sas, C.: Digital Wellbeing: Evaluating Mandala Coloring Apps. In: *CHI Conference on Human Factors in Computing Systems* (2019)

14. McMahon, C., Aiken, M.: Introducing digital wellness: Bringing cyberpsychological balance to healthcare and information technology. In: 2015 IEEE International Conference on Computer and Information Technology; Ubiquitous Computing and Communications; Dependable, Autonomic and Secure Computing; Pervasive Intelligence and Computing. pp. 1417–1422 (2015). <https://doi.org/10.1109/CIT/IUCC/DASC/PICOM.2015.212>
15. Royal, C., Wasik, S., Horne, R., Dames, L.S., Newsome, G.: Digital Wellness: Integrating Wellness in Everyday Life with Digital Content and Learning Technologies. In: Keengwe, J., Bull, P.H. (eds.) Handbook of Research on Transformative Digital Content and Learning Technologies. pp. 103–117 (2017). <https://doi.org/10.4018/978-1-5225-2000-9.ch006>
16. Rose, E.: “Would you ever say that to me in class?”: Exploring the Implications of Disinhibition for Relationality in Online Teaching and Learning. In: Bayne, S., Jones, C., de Laat, M., Ryberg, T., Sinclair, C. (eds.) 9th International Conference on Networked Learning. pp. 253–260 (2014)
17. Hamm, M.P., Newton, A.S., Chisholm, A., Shulhan, J., Milne, A., Sundar, P., Ennis, H., Scott, S.D., Hartling, L.: Prevalence and effect of cyberbullying on children and young people: A scoping review of social media studies. *JAMA Pediatrics* **169**(8), 770–777 (August 2015). <https://doi.org/10.1001/jamapediatrics.2015.0944>
18. Hinduja, S., Patchin, J.W.: Bullying, cyberbullying, and suicide. *Archives of Suicide Research* **14**(3), 206–221 (2010). <https://doi.org/10.1080/13811118.2010.494133>
19. McCall, R.B., Groark, C.J., Hawk, B.N., Julian, M.M., Merz, E.C., Rosas, J.M., Muhamedrahimov, R.J., Palmov, O.I., Nikiforova, N.V.: Early Caregiver–Child Interaction and Children’s Development: Lessons from the St. Petersburg-USA Orphanage Intervention Research Project. *Clinical Child and Family Psychology Review* **22**, 208–224 (2019). <https://doi.org/10.1007/s10567-018-0270-9>
20. Matthews, D., Lieven, E., Tomasello, M.: How toddlers and preschoolers learn to uniquely identify referents for others: A training study. *Child Development* **78**(6), 1744–1759 (2007). <https://doi.org/https://doi.org/10.1111/j.1467-8624.2007.01098.x>
21. Cheung, C.S., Pomerantz, E.M.: Value development underlies the benefits of parents’ involvement in children’s learning: A longitudinal investigation in the United States and China. *Journal of Educational Psychology* **107**(1), 309–320 (2015). <https://doi.org/10.1037/a0037458>
22. Fischer, R., Von Solms, S.: Digital wellness. *ACEIE* (2016)
23. Halpert, B.: Savvy Cyber Kids (2014), <https://savvycyberkids.org/families/kids/>
24. Google: Be internet awesome: Google Digital Literacy and Citizenship Curriculum (2019), <https://www.google.ch/goodtoknow/web/curriculum/>
25. Australian Department of Broadband Communications and the Digital Economy: Budd:e (2011)
26. Carnegie Mellon University: The Carnegie Cyber Academy - An Online Safety site and Games for Kids (2011), <http://www.carnegiecyberacademy.com/>
27. FBI: FBI — Cyber Task Forces (nd), <https://www.fbi.gov/about-us/investigate/cyber/cyber-task-forces-building-alliances-to-improve-the-nations-cybersecurity-1>
28. PBS: Cybersecurity Labs, <https://www.pbs.org/wgbh/nova/labs/lab/cyber/>
29. Stenros, J.: The Game Definition Game: A Review. *Games and Culture* **12**(6), 499–520 (2017). <https://doi.org/10.1177/1555412016655679>
30. Shuler, C., Levine, Z., Ree, J.: iLearn II: An analysis of the education category of Apple’s app store. Tech. rep., Joan Ganz Cooney Center (January 2012)