The Story of Safety Snail and Her e-Mail: A Digital Wellness and Cybersecurity Serious Game for Pre-School Children

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Keywords: Digital Wellness for Children, e-Mail Security Awareness, Serious Games.

Abstract: Cyber threats are part of our everyday life. Even children are exposed to cyberspace as they are provided with electronic devices that have online connectivity. Due to their vulnerability and lack of education about cyber threats, there is a need to address their digital wellness. Digital wellness refers to one's complete well-being in cyberspace. This is a balance between one's mental and physical state when using different digital technologies. This is achieved by developing a serious game that incorporates educational and game elements appropriate to the targeted age group. The aim of this paper is to present aspects of this game, in which the story of "Safety Snail's e-mail" is used to address their digital wellness regarding e-mail related threats as an example of online interaction. The methods used were, designing and developing a serious game based on critical game elements from literature, and making use of a structured expert review to validate the game and elements thereof. The review indicated that the critical game elements as identified in literature were successfully used in the game. This research further contributes by identifying five additional game elements through analysis of the expert review feedback. It is shown in this paper how a serious game, using critical game elements and age appropriate stories, can address the digital wellness of pre-school children.

1 INTRODUCTION

The advent of the information age has irrevocably changed the way in which we work and socialise, even more so in developing countries. For all the convenience we associate with the contemporary technological landscape, our exposure to possible harm with respect to our privacy and security has similarly increased. Children have traditionally been deemed a vulnerable population, especially outside the home as was evident in erstwhile awareness campaigns in (pre-)schools that often sought to teach children about concepts such as *stranger danger*, referring to the possible abuse or abduction by persons unknown. In today's world, the proverbial *stranger* is no longer only a danger outside the home, but is one that is practically invited into the residence through digital channels. Parents (and caregivers), especially in developing countries, are cognisant of *physical dangers* that children are confronted with, however, they have little knowledge of the threats that *cyberspace* can hold for their children. Therefore, they may not be equipped to provide them with the required knowledge and skills. This lack of awareness leads to children being given *carte blanche* access to electronic devices and the internet without appropriate supervision. It is therefore paramount that awareness is created among both children and parents about these threats and novel interventions are staged to equip children to be safe and happy in the digital sphere.

This can be referred to as their overall *digital wellness*. The digital wellness education of pre-school children (typically between the ages of five and six) in particular poses a unique challenge as they are typically only starting to learn to read and traditional text based approaches will not be effective.

Literature shows that imaginative play is a feasible way to teach pre-school children (Yogman et al., 2018). When combined with visual and auditory stimulation, play provides a creative space for children to interact with new concepts and knowledge.

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Drevin, G., Snyman, D., Drevin, L., Kruger, H. and Allers, J.
The Story of Safety Snail and Her e-Mail: A Digital Wellness and Cybersecurity Serious Game for Pre-School Children.
DOI: 10.5220/0011682200003405
In *Proceedings of the 9th International Conference on Information Systems Security and Privacy (ICISSP 2023)*, pages 519-527
ISBN: 978-989-758-624-8; ISSN: 2184-4356

Given the contemporary digital immersion of children and their eagerness to interact with these technologies, and given the feasibility of play as a teaching method, it stands to reason that a mobile serious game provides an ideal way of teaching children about digital wellness and cybersecurity concepts. A serious game is an application that has the "purpose of influencing the players' thoughts and actions in real life contexts" (Mitgutsch and Alvarado, 2012).

A number of games targeted at children with the goal of teaching or spreading awareness of cybersecurity exist, however, in the current literature there are no games with a focus on *pre-school children* (Hill et al., 2020) and, therefore, the novelty of this research, which was part of an MSc project (Allers, 2021), is the creation of such a game to contribute to filling this gap. The game, as proposed in this research, is intended to be used under the supervision of a parent and, therefore, can contribute to the simultaneous education of both parent and child. The focus of this paper is, however, to present an evaluation of the game that is based on the experience of the child through the lens of expert reviewers in pre-school education. The expert review is performed with a view to improve upon the current iteration of the game before it is play-tested by the target group in the following phase of this ongoing project. The paper further contributes the identification of new critical game elements from the expert review that can be used in the development of similar games.

The remainder of this paper is deployed in the following manner: Existing digital wellness materials for pre-school children is presented in Section 2. Section 3 is used to illustrate how digital wellness and cybersecurity can be taught by means of a serious game. The game that was developed as part of this research is presented in Section 4 and the results of an expert evaluation of this game is discussed in Section 5. The contribution of this research, i.e., newly identified elements of serious game design for pre-school children is discussed in Section 6. The study is concluded with a summary and a look ahead to possible future work in Section 7.

2 DIGITAL WELLNESS FOR PRE-SCHOOL CHILDREN

Digital technologies have a direct and growing impact on the well-being of its users. Just as it is important to maintain a good and healthy lifestyle to ensure a positive well-being in the physical realm, it is important to maintain a good and healthy lifestyle in the digital realm to ensure a positive well-being. 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 and is defined by Von Solms and Fischer as follows:

"Digital wellness refers to the notion of 'being well in a digital society'. It is characterised by the ability of users to discern between the dangers and opportunities found in the cyberspace, act responsibly, and align their online behaviour with their offline values - to remain cyber safe." (Von Solms and Fischer, 2017, p. 156)

Digital wellness is, therefore, a measure of a user's well-being as affected by the use of digital technologies. This well-being not only refers to one's physical state of health, but also to the mental effects that the use of these technologies may have. 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.

A gap concerning serious games for the promotion of digital wellness, as defined above, among pre-school children was identified from literature. One example of the limited digital wellness content aimed at pre-school children, is that of *"Digital wellnests: Let us play in safe nests"*[1]. This electronically available book (Fischer and Von Solms, 2016; Von Solms and Fischer, 2017) has the goal to promote a cybersecurity culture specifically for pre-school children. It uses simple explanations as well as animals, that are familiar to African children, as the main characters.

The book consists of concepts, poems, and messages, that introduce digital wellness and cybersecurity topics to pre-school children. Selected content from the book was therefore used as the digital wellness fundamentals around which the game was built.

The main content of the book is provided in the form of poems. Each of these poems features animals interacting with technology and ends with a moral lesson. Easy to remember short messages, that serve as important cybersecurity-related lessons, supplement the main content (Von Solms and Fischer, 2017).

One of the poems, **Safety Snail's e-mails**, tells the story of a snail who receives an e-mail from a stranger. Instead of opening and reading the e-mail, she decided to delete the message. The moral lesson of the story is to not open any suspicious e-mails (and other messages) from unknown sources, and therefore addresses the online security and privacy element of digital wellness. The accompanying short message

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

roughly matches the moral of the *Safety Snail's e-mails* story (Fischer and Von Solms, 2016):

> *"Remember the golden rule, Online, in a game or outside your school. Don't talk to a stranger. This will keep you safe from danger"* (Fischer and Von Solms, 2016, p.37)

Even though pre-school children typically do not yet make use of e-mail as such, they can still be exposed to this and other online social interaction at an early age. It is, therefore, imperative that an awareness of the possible dangers is established early on so that they are prepared when they are inevitably confronted with a suspicious interaction. A parallel is also drawn between strangers in cyberspace and in the physical realm. It should be noted that, while the example of e-mail safety is used in this paper, the resulting game covers more cybersecurity and digital wellness aspects (Allers, 2021).

To better understand how to spread awareness of cybersecurity and digital wellness among pre-school children, it is imperative to identify how pre-schoolers 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 (McCall et al., 2019).

Pre-school children are still at the age of learning through play (Yogman et al., 2018). 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. These are all methods used by pre-school children to learn (Matthews et al., 2007).

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 mentioned above, 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. It is, however, important to note that even though the game is aimed at pre-school children, that parent involvement and guidance is of great importance in playing the game and to learn the lesson presented in the game.

3 SERIOUS GAMES FOR DIGITAL WELLNESS

It was shown that serious games have potential to be used as a tool for education and awareness of digital wellness. In this section, attention is given to the principles that are important for the design of educational serious games in general, followed by a discussion of the elements that are specific to games aimed at pre-school children.

3.1 Guiding Principles for Educational Game Design

The design and development of effective educational games have received much attention in literature in the past few decades (Charsky, 2010; Malone and Lepper, 1987; Mildner et al., 2015; Mitgutsch and Alvarado, 2012). The goal is to formalise elements that, when included in the design and development of a game, will result an objectively good product.

For the purposes of this study, the elements identified by (Mildner et al., 2015) were implemented. Their work was informed by a number of previous studies that investigated critical elements that contribute to making a good game and is therefore representative of these types of investigations. They identify the following critical elements:

Challenge describes the problem or issue that has to be resolved by the player (Mildner et al., 2015) and requires a certain level of skill (Charsky, 2010; Malone and Lepper, 1987). An in-game task that is either too challenging, or not challenging enough, would have a negative effect on the player's motivation and enjoyment (Cowley et al., 2008).

Fantasy in a game, is the theme or setting of the game that distinguishes it from reality. It motivates players through increasing their involvement (Malone and Lepper, 1987) by either expanding their knowledge, or rewarding them (Charsky, 2010).

Choice refers to the options that a player has prior to, as well as during, a game. There are three forms of choice (Charsky, 2010). Expressive choices, such as picking or creating an avatar. Strategic choices, or game settings, that directly influence the gameplay, e.g. selecting the difficulty level. Finally, tactical choices are made while playing the game by, choosing answers from multiple prompts, and choosing between different paths to travel, as examples.

The **Rules** of a game is a set of constraints that limit the actions that a player can perform. In contrast to fantasy, a game's rules anchors it in reality and enables the lessons learned in the game to be translated to real life (Charsky, 2010).

Competition and goals form one of the most important elements of games, as most games incorporate this element (Charsky, 2010). Goal refers to the winning conditions of a game, while competition refers to the obstacles that need to be overcome to reach the goal.

Aesthetics, or the overall presentation of the game, refers to the visual and auditory appeal it evokes. It is used to get the player interested in the game and players are more likely to complete a game that is aesthetically pleasing (Mildner et al., 2015; Mitgutsch and Alvarado, 2012).

Two further principles identified in literature (Dincelli and Chengalur-Smith, 2020), specific to games aimed at teaching, were also considered and implemented:

Story-based agents, or game characters, should be employed to contextualise learning and act as facilitators of the learning process.

Reflection opportunities provide the player with structured opportunities to reflect on their learning experience and what they have learnt. The following sub-section is dedicated to game elements that are specific to games aimed at pre-school children.

3.2 Serious Games for Pre-School Children

When considering the use of games for teaching in the context of children's growing exposure to digital technology (Callaghan and Reich, 2018), it appears to be a viable approach to spread awareness about digital wellness topics. This has become evident by the number of serious games targeted directly at older children. Even though serious games targeted at pre-school children have become more popular over time (Shuler et al., 2012) these games are not necessarily optimised for this target audience. In a framework for games aimed specifically at teaching pre-school children, the following design elements were established (Callaghan and Reich, 2018):

Clear and Simple Goals - Children learn best with clear instructions and modelling which allows them to draw connections to existing beliefs (Cowley et al., 2008). This empowers them to complete their tasks with minimal disruption;

Quality of Feedback and Rewards - Feedback is used to encourage children and notify them when they do something wrong. At pre-school age, most children are not able to read and thus text feedback is not of any help to the child. Combine both visual and auditory feedback should rather be used;

Structure of Challenge - When structuring a challenge in a game, the level of performance of the target audience should be kept in mind. Adaptive scaffolding, i.e. dynamically increasing or decreasing difficulty levels, can greatly enhance the child's learning experience; and

Motion Based Interactions - Various physical actions can serve as an alternative to complex touch screen or pointer interactions that might be too difficult for many children. By being mindful of the physical capabilities of pre-school children (e.g., touchable object sizes, simplified touchscreen motions at first, etc.), the overall experience of the child will improve.

The four elements listed above are essential to ensure that a game is suited to a pre-school aged child and was therefore used in conjunction with the other design elements (Section 3.1) to guide the development of the game in this research.

4 DIGITAL WELLNESTS GAME

In this section, an overview of the application is given. This is done by highlighting the layout and function of each scene and its components. The resulting serious 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, by implementing some of the elements identified in Section 3.1 and Section 3.2 thereby increasing the overall fun factor of the game which adds to the overall motivation and enjoyment experienced by the children.

Main Menu - The main menu screen (Figure 1) which serves as a selection screen for picking the poem and associated quiz and game that the child will play.

Poems - In this scene the selected poem (Figure 2) will be displayed on the screen and it will be read to the child. The main goal of this scene is to educate the child and spread awareness of the dangers of cyberspace in an enjoyable way.

Quiz - The aim of the quiz scene (Figure 3) is to determine whether or not the child understands the problem described in the poem by motivating them to answer four questions about the topic. The quiz does not block progress if the child's results are subpar. The child's progress does not get blocked for two reasons: The goal of the game is not to educate in the sense of formal teaching and learning activities, including formative and summative assessments, but rather to spread awareness on the material. Awareness being informal teaching without an emphasis on assessment and performance. Therefore, the quiz is only meant to be used by parents as a tool to motivate the child to keep track of their efforts and progression.

Game - This scene allows the child to play a mini-game based on the poem that they have chosen and serves as reward for completing the poem and quiz scenes. Instructions and goal of the game are displayed on the screen and read out loud (shown in Figure 4). The child can then use the slider to pick a level

Figure 1: Application main menu.

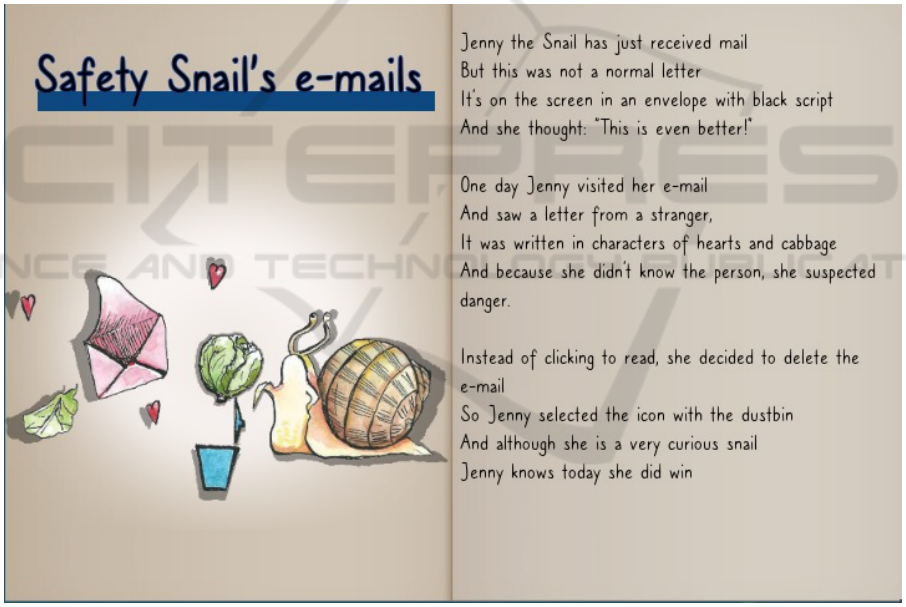

Figure 2: Poem scene.

and play the game.

The objective of the game (Figure 4) is to move the different coloured envelopes to the same colour column before the envelope reaches the bottom. This game is an exercise in small motor movement and colour matching and has the underlying message of sorting through e-mails and either answering or ignoring the message based on its appearance.

To validate the overall applicability of the game and how well the above-mentioned design elements were implemented, the opinions of a number of pre-school education experts were sought. The results of the evaluation are presented in the next section.

5 EXPERT REVIEW

Six experts in the field of pre-school education were approached to give their feedback on the game. They were asked to comment on the critical game elements identified from literature, and to suggest any other elements that they deem necessary for the overall success

Figure 3: Quiz question screen (left) and results (right).

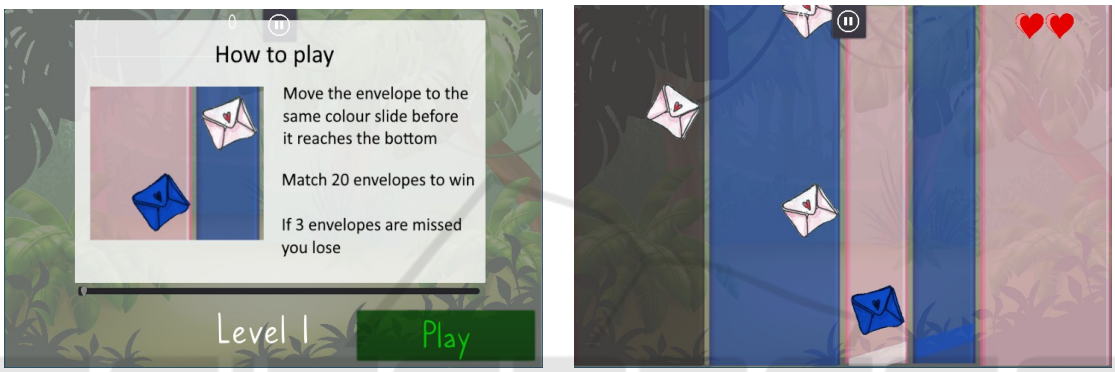

Figure 4: Safety Snail's e-mail game menu screen (left) and game (right) .

of the game.

The reviews were conducted using a questionnaire which was followed by an interview. The questionnaire elicited responses about the reviewers' experience and opinion of the problem; a review of the game and the design elements that were implemented in the game, based on Likert scale responses (the higher end of the scale representing positive sentiment); and questions about additional elements that could be identified. The follow-up interview was used to gain a better understanding of how the reviewers reacted to each design element and to gather more information on the additional elements that they identified. The information regarding the background and experience of the reviewers is given in Table 1.

All the reviewers had either a good or very good understanding of the different dangers and threats of the cyberspace and digital technologies, but 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 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.

5.1 Validation of the Game

The validation of the game was conducted using a scoring system. After playing the game multiple times, the reviewers were asked to score the implementation of each element on a Likert scale of one to five, where one indicates poor to no implementation and five indicates excellent implementation. The average implementation score of each element, with comments from the reviewers is given in Table 2. These results indicate that the implementation of each element was satisfactory. The reviewers were also asked to score the game based on the following criteria: how much fun the game is; how suitable the game is for pre-school children; and how effective the game will promote the awareness of digital wellness. All three of these criteria were awarded an average score of 4.5 out of 5 and a range of 4-5.

Table 1: Reviewer information.

Information	Reviewer responses
Years of experience	Total: 168, Average: 28
Age of children that reviewer works with	Youngest: 3, Oldest: 9
Awareness of the dangers of cyberspace	4/5 (Good)
Children's exposure to digital and online technologies	4.3/5 (A lot - too much)
View of whether this level of exposure is a problem	Yes: 5, No: 1, Maybe: 0
Knowledge of existing resources that promote awareness of digital wellness to pre-school children	Yes: 1, No: 5
Use existing resources that promote awareness of digital wellness to pre-school children	Yes: 0, No: 6
View on parents' awareness of the dangers of cyberspace	2.2/5 (Poor - average)
View on parents' effectiveness teaching children of the dangers of cyberspace	1.5/5 (Very poor - poor)

5.2 Validation of the Elements Identified in Literature

The validation of the elements identified from literature was done during interviews. The reviewers were asked which elements they felt were unnecessary or not critical and also which elements they deemed most important. This was done to verify that the elements identified from literature can be considered critical elements.

The reviewers stated that all the elements identified from literature can be considered critical elements. One reviewer noted that if even one of the elements were not implemented, the game would be dramatically less effective.

Even though the reviewers indicated that each of the identified elements are critical, they did highlight certain elements as being more important than others. The most important elements according to the reviewers, ranked from most important to least important, are (the score in parentheses shows the number of experts that identified the element as important): **Aesthetics** (6); **Appropriate content** (5); **Structured challenge** (2); **Feedback and rewards** (2); and **Appropriate interface** (1). It is important to note that these five elements are just the elements that the reviewers felt contribute most to the final goal. The best results will be obtained when all elements are incorporated into the game design.

6 NEWLY IDENTIFIED SERIOUS GAME DESIGN ELEMENTS

During the interview that followed the evaluation, each reviewer was asked to identify any additional elements, that, when implemented in a mobile serious game, should result in a game that effectively promotes digital wellness among pre-school children. One of the main results of the review process is the identification of the following design elements aimed specifically at pre-school children:

Balanced Simplicity and Complexity - One of the reviewers pointed out the importance of not oversimplifying serious games. The intelligence of children should not be underestimated, as they will quickly lose interest in anything that is oversimplified. This may be seen as an extension of the original simplicity element.

Short Playtime - Children have active brains and thus a short attention span. In order to optimize the effects of the awareness project, it is crucial that the child does not lose focus. There are two methods of achieving this: one is to use engaging visuals and audio to attract attention; and the other is to limit play time to the length of the child's attention span.

Balanced Work and Play - A reviewer mentioned that many serious games for children are overly focused on the serious (work) aspect of the game. This may result in a game where the child feels forced to play without experiencing fun. It is important that there should be a balance between work and play to ensure that the game is both fun and effective.

Quality Interactions - While playing a game, the only method of communication to and from the game is done via the interactions made available by the application itself. In order to ensure that this communication is clear and effective, it is necessary that the interactions of an application are of a high quality and comprehensive.

Further investigation of these elements in the design and development of serious games aimed at preschool children is required.

Table 2: Reviewer scores.

Game element	Average score	Answer range	Comments
Challenge	4	3-5	"The younger children might find the app too challenging." (interview)
Fantasy	4.3	3-5	"The animal theme was very fitting and the children will love it." (interview)
Choice	4.5	4-5	"More stories" (suggestion for further development)
Rules	4.5	4-5	N/A
Competition and goals	4.5	4-5	N/A
Aesthetics	4.3	3-5	"Was colourful.", "Visuals", "It is very interactive and colourful." (on which elements stood out most)
Clear and simple goals	4	3-5	"Clearer instructions on how the story works. (click to turn the page etc.)" (suggestion for further development)
Feedback and rewards	4	3-5	"Good feedback, but more colours can be good." (Overall comments)
Structured challenge	4	3-5	"I love the different levels of play", "More difficult levels are too difficult (in envelope game)" (interview)
Appropriate interface	4.3	3-5	"This application is very child friendly. I will not change a thing. " (suggestion for further development)
Simplicity	4	3-5	"Do not over simplify it [the content of the game]", "Don't underestimate the children's intelligence" (interview)
Appropriate materials	4.5	4-5	"The animal theme was very fitting and the children will love it.", "The different concepts are explained to them (the children) very well." (interview)
Appropriate method of presenting the materials	4.5	4-5	"I like that it [the game] uses sounds, pictures and words so everyone can understand it." (interview)
Focusing on different topics	3.5	3-4	"More stories" (suggestion for further development)

7 CONCLUSION AND FUTURE WORK

In this paper, a mobile serious game to promote the digital wellness and cybersecurity of pre-school children was presented. Section 2, highlighted existing digital wellness materials for pre-school children. Section 3 was used to illustrate how digital wellness can be taught by means of a serious game. The game that was developed as part of this research was presented in Section 4 and the results of an expert evaluation of this game was discussed in Section 5. In Section 6, novel elements of serious game design for pre-school children that were identified through the review process was discussed.

A possible limitation of this research is that only experts in pre-school education were consulted for the evaluation. It is therefore still necessary to perform an evaluation with experts in serious game design.

Possible future work includes the expansion of the game to include more scenarios and related content from the *Digital wellnests* book while incorporating the new design elements that were identified in the expert review. A pilot study can also be done where children from the designated age group play this game in order to get better feedback on the effectiveness of the game. Feedback can include the observation of the children while playing the game. Furthermore, gamification concepts can be investigated as an approach to enhance the learning experience.

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