

Te Kēmu Hauora

Designing a mobile game to facilitate education and improve healthcare engagement

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A 90-point thesis submitted to Victoria University of Wellington, in partial fulfilment of the requirements for the degree of Master of Design Innovation.

Victoria University of Wellington,
2018

Additional Thesis Content

This thesis is accompanied by a mobile game. See Appendix A for installation and demonstration instructions. An Android device with a back facing camera is required.

Acknowledgements

Thanks to all who helped in the process of writing this thesis, in particular:

My supervisors Dr Edgar Rodríguez Ramírez and Kah Chan, for the excellent research guidance and design advice.

The iMoko team for their assistance with organising testing sessions and expert healthcare knowledge.

My family and friends for the support and encouragement, I would have struggled without you all.

Abstract

This thesis addresses the research question “How could a mobile game be designed to facilitate education and improve healthcare engagement around skin sores in children?”.

Health behaviour issues such as lack of education and low adherence to treatment regimes impact the success rates of treatments in children for common ailments such as skin sores. Skin sores are a particular health issue in New Zealand where the rates of admission to hospital for serious skin infections in 2006 were double that of USA and Australia (Craig et al., 2007, p. 278-282). Hospitalisation can be prevented by ensuring treatment regimes for skin sores are correctly completed after early diagnosis (Gray et al., 2013, p. 2).

Literature states that game design is a viable solution to healthcare issues, as it can be used alongside persuasive strategies to engage and educate children around their treatments. However, there is a gap in the literature and existing precedents for health games addressing treatment of common ailments.

This thesis addresses the research question through developing design criteria for a health game by identifying suitable theories to encourage positive health behaviors and educate children. These include: simulation, personalisation, reward and flow theory, as well as the information, motivation, strategy model to increase engagement with treatment. These criteria are used alongside user personas and journey maps methods to create the design output of a mobile health game to educate and engage New Zealand children around the treatment of skin sores.

The game was tested for education, engagement and usability during the design process. Methods for user testing included observation, an adaption of the System Usability Scale and semi-structured interview questions. Thematic analysis of the testing results showed that most participants were engaged with the game and gained education around treatment steps. Insights on user testing with children for education, engagement, and usability are reported. The final output was refined and accessed against the design criteria.

Findings from this thesis discuss how game design techniques including simulation, flow theory and reward can be used to educate and engage children with treatments of common ailments.

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1 Introduction

Health behaviour issues are a current and global problem, notably a lack of education and engagement with treatment (Gokhale & Gokhale, 2015, p. 55; Plenda, 2016). Common childhood ailments such as skin sores can cause serious health complications when treatment is not completed correctly. This is a particular concern in New Zealand, where there are high rates of serious skin infections in children (Craig et al., 2007, p. 278-282). Correct completion of treatment regimens for skin sores after early diagnosis can prevent hospitalisation (Gray et al., 2013, p. 2). The fact that it is avoidable for New Zealand children to experience these serious health complications provides motivation for research into how treatment engagement and education could be improved. Serious games are a viable solution as they can educate and/or persuade players to change their behaviour (Lieberman DA, 2001, p. 26). Most serious games for health address chronic conditions or broader topics of health. Therefore, there is an opportunity and need for research addressing how to design a game focusing on minor ailments that could have major long-term impacts. This thesis proposes the design of a game to engage and educate children around the treatment of skin sores.

Aims and Objectives

The two main aims and respective objectives below address the research question of “How could a mobile game be designed to facilitate education and improve healthcare engagement around skin sores in children?”.

1. **Create a set of criteria for a serious game to improve healthcare engagement and education in children.**
 - a. Describe what issues exist around health behaviours and engagement, and the current approaches to resolving them.
 - b. Situate the research within the current body of literature on serious game design. Focus on techniques for children that could be used to help them manage their own medical conditions. Look into persuasive techniques for education and engagement around medication and other steps of treatment.
 - c. Define design criteria for developing a health game, by identifying suitable game design techniques to educate and engage children with their treatments.
2. **Design a serious game to improve to healthcare engagement and education around the treatment of skin sores in children between the ages of 5-7 years, primarily from New Zealand.**
 - a. Discussion of current treatment regimens for skin sores and the issues affecting treatment completion in New Zealand children. Identify suitable game design techniques to address them.
 - b. Develop suitable game art and interactions to fulfil the criteria and create the design output of a mobile game.
 - c. Test and discuss how the iterations and final output compare to the criteria developed over the research period and answer the research question.

Thesis Structure

The thesis structure reflects the research aims and objectives by division into chapters: context, design phase one, testing, design phase two and discussion. These chapters are in chronological order to reflect the iterative design process.

Context:

This chapter addresses the first research aim of situating the research through background research, a literature review, and precedent analysis.

Design Phase One:

This chapter addresses the first objective of the second aim through specific research into treatment of skin sores in New Zealand children. This chapter also contains the initial game design process to address the issues affecting treatment completion, as required by the second objective.

Testing:

This chapter meets the third objective of the second aim by testing and analysing results to discuss whether the initial design is engaging, usable, and provides education around treatment steps.

Design Phase Two:

This chapter uses the findings from the testing results to refine the initial design into the final output. This chapter also discusses how use of the final output and other concepts could affect the treatment completion of skin sores.

Discussion:

The third aim of the second objective is met in the discussion chapter of the thesis, where the final output is compared to the criteria.

2 Context

2.1 Background

Common childhood ailments can cause serious health issues when left untreated, skin sores is one ailment particularly causing issues in New Zealand. In 2006 hospital admission rates for children with serious skin infections in New Zealand were double those in USA and Australia (Craig et al., 2007, p. 278-282). Untreated skin sores can result in hospitalisation as they can turn into serious skin infections or lead to blood poisoning (Workbase Education Trust, 2012, p. 2). Some evidence shows that children with certain types of serious skin infection such as impetigo may also be at risk of rheumatic fever (Tilyard & Harris, 2012, p. 15), which can lead to rheumatic heart disease (Craig et al., 2007, p. 274).

Some key factors that influence the high rates of skin infections in New Zealand include a lack of knowledge about skin infection (Simpson, 2017, p. 70), access to primary health care (Craig et al., 2007, p. 278-282) and socioeconomic deprivation (O'Sullivan, Baker, Zhang, Davies & Cramp, 2012, p. 47). iMoko is a program looking to address some of these issues by placing technology into schools to access and treat common childhood health problems, including skin sores, via telehealth (Navilluso Medical LTD, 2016). However, there is a need to ensure treatment is completed correctly.

Treatment for skin infections includes steps such as cleaning wounds, washing hands, covering sores, cutting fingernails and taking antibiotics (Hunt, 2004, p. 40; Koning et al., 2012, p. 2; Ministry of Health, 2017). Patients need to adhere to their antibiotic medication when treating skin sores until it is finished, even if they appear to be healed (Workbase Education Trust, 2012).

This thesis is part of a research project in partnership with Navilluso. The aim of the project is to create a mobile health game to be played alongside their iMoko app, to engage and educate children around the treatment of skin sores. Education through iMoko and the game should lower the chance of recurrent skin sores, as the treatment steps include preventative measures such as teaching children to cut their nails. The iMoko program begins at age 5 and the highest rates of skin infection are in children age 0-9 (O'Sullivan & Baker, 2012, p. 75). The research project is focused on a target audience of children between 5-7 years. The research team includes staff and students at Victoria University as well as research advisors and healthcare professionals from iMoko.

2.2 Literature Review

This literature review covers topics surrounding health behaviours and persuasive techniques for education and engagement within serious games. There is a focus on techniques suitable for children to help them manage their treatment steps.

2.2.1 *Health Behaviour Issues*

Health behaviour issues such as lack of education and patient nonadherence are widespread (Gokhale & Gokhale, 2015, p. 55; Plenda, 2016) which results in less effective treatment of ailments in children. It is important for a patient to adhere to their prescribed medical regimen in order to have a successful treatment outcome (Jorge, Feres, & Teles, 2011, p. 20; Workbase Education Trust, 2012). Patient nonadherence is a widespread health behaviour issue that affects the efficiency, cost and safety of healthcare treatments (Gokhale & Gokhale, 2015, p.55). Successful treatment outcomes are more likely for adherent patients than patients that exhibit low medical adherence (DiMatteo et al., 2002, p. 805). Health behaviours can be difficult to change as there are often multiple factors influencing the behaviour that need to be targeted (Thompson, 2012, p. 807). Game design could be used to educate children about their treatments and help them engage with their healthcare to address these factors.

2.2.2 *IMS Model*

The IMS heuristic model was created to address the issue of treatment nonadherence (DiMatteo, Haskard-Zolnieriek, & Martin, 2012, p. 79). This model provides three areas to work on in order to improve adherence – information, motivation and strategy (IMS). By separating care into these three areas the unique needs of each patient can be discovered.

Care in the information area is required as the patient cannot carry out their treatment if they don't know how or why they need to do the tasks required. Game design could address this by educating a player about their treatment and why it is necessary, through simulation of treatment steps.

The motivation of the patient is affected by their self-efficacy and their trust in the treatment affects their adherence. Self-efficacy in regard

to healthcare involves the patient believing they are able to complete their treatment steps. Game design may be able to improve self-efficacy by educating players on how to do their treatment steps to increase confidence levels.

The strategy part of the IMS model looks at overcoming barriers to ensure the patient is able to do their treatment (DiMatteo, Haskard-Zolnierrek, & Martin, 2012, p. 84). Barriers can include costs of treatment, scheduling doses of medicine, stigma and more. Strategizing solutions through game design such as reminders could assist in overcoming barriers to successful treatment.

2.2.3 Attitudes Towards Healthcare

Improving engagement with healthcare in children is important as they generally have negative attitudes towards medicines and can even be scared of them (Hämeen-Anttila et al., 2005, p. 433). These attitudes could be a barrier to successful treatment if they cause children to resist taking medicines or completing treatment.

Studies show that communication normally happens between the parent and doctor with the children only being involved in the assessment (Sanz, 2003, p. 859). However children are interested in learning how to use medicine properly including dosages, timing, and appropriate administration (Hämeen-Anttila et al., 2005, p. 429-433).

It should also be considered when teaching children about healthcare that they have the right to know about medicines involving them and that personalized communication should occur between the child and the physician (Sanz, 2003, p. 859). Communication to children about healthcare should be age appropriate whilst remaining accurate (Bennett, 2016, p. 205), game design could be used to deliver this communication in a playful form. Attitudes towards medication could be better if the child was more informed, which could positively impact treatment by making the child more likely to engage with their medication regimen.

2.2.4 Serious Games

Serious games are games designed to change behaviours and attitudes, inform the player and teach them new skills instead of playing for the single purpose of entertainment (Thompson, 2012, p. 807). More research is needed within serious video games including areas of

game design that have the biggest effect on behaviour - narrative, avatars, characters, or a combination (Thompson, 2012, p. 809-810).

Serious games are a viable solution to health behaviour issues as they can expose players to content repeatedly, providing endless opportunities to practice skills and see relatable results of health choices within them (Lieberman DA, 2001, p. 26). Players can learn treatment routines in an entertaining virtual environment with no consequences. The benefits to the patient can include improvements in adherence, their relationship with their physician and in the treatment outcome (Gokhale & Gokhale, 2015, p. 55). The reach of health games is an added benefit given that the digital age allows anyone with a smartphone to download an application from the internet.

The majority of existing health game examples are for either chronic health conditions or preventative health games. There is potential for further development in health games that aim to improve health behaviours around common health ailments. Good health behaviours such as adherence are still important for a fast recovery even when the condition is not enduring. An example of this is patients needing to adhere to their antibiotic medication when treating impetigo until it is finished even if they appear to be healed (Workbase Education Trust, 2012). Health games could be used to inform patients of knowledge such as this to positively impact health outcomes of common ailments.

2.2.5 Persuasive Strategies

Serious games often use persuasive strategies as motivators to influence health behaviours. These strategies aim to change behaviour by persuasion and social influence instead of methods such as coercion or deception (Oinas-Kukkonen & Harjumaa, 2008, p. 200). Digital platforms allow easy access to users and are a convenient place to implement persuasive strategies (Oinas-Kukkonen & Harjumaa, 2009, p. 486).

Different persuasive strategies have varying effects on motivation in different people with varying personality traits (Orji, 2017, p. 1019-1022) therefore tailoring a game to the audience is likely to make it more effective. Considering that the target audience for this research was not selected by personality traits it was better to pick strategies that work for broader audiences. The simulation, personalization, goal-setting and suggestion strategies are positive motivators for most traits and will not

have a negative effect on the other Big Five Personality traits (Orji, 2017, p. 1022-1023).

Qualitative comments from Orji's study described simulation, personalization, goal-setting and suggestion as “not fun”, “boring”, “not engaging” and, “not incentivizing” enough (Orji, 2017, p.1023). Therefore, using these techniques alone could be uninteresting and they should be combined with fun or incentive based strategies to reinforce them (Orji, 2017, p.1023). Reward would be suitable as it is a significant motivator in three of the personality traits. In the traits which for reward was not a significant motivator the reasons given were based around reward being trivial or childish (Orji, 2017, p. 1022) - in this scenario the audience is children so this becomes much less of an issue. Reward through praise can have a positive impact and affect attitudes and behaviour (Fogg, 2002, p. 103).

2.2.6 Simulation

The game design element of simulation is used to show cause-and-effect or known relationships between subjects (Khaled et al., 2007, p. 44). Design elements for health games include removing unnecessary information to aid in cause-and-effect simulation and story-telling (Brox, Fernandez-Luque, and Tøllefsen 2011, p. 130). Simulation could be used to facilitate education of treatment steps by allowing the player to practice steps in a focused virtual environment. Simulation could also show that treatment steps are necessary showing the player the virtual health improvements.

2.2.7 Flow

It was important to consider whether the motivation within the IMS model would be intrinsic or extrinsic. Extrinsic motivation is problematic as a user can become reliant on a reward as motivation to complete an activity and not enjoy the activity itself (Csikszentmihalyi, 1975, p. 4). For the design of a health game intrinsic motivation is preferable considering healthy behaviours shouldn't only be completed for an external reward. Intrinsic motivation can come from the state of flow a person can get into when they are completing an activity with their full attention and actions seem to be completed to an internal logic (Csikszentmihalyi, 1975, p. 4). This state occurs when tasks are achievable yet challenging enough to engage the person and clear feedback on actions is provided (Csikszentmihalyi, 1975, p. 4; Chen, 2007, p. 34). Games can

Table 1. *Design criteria and related literature findings*

Criterion		Related Literature Findings
1	The game should provide education around why treatment is necessary as well as how to complete treatment steps.	2.2.2 IMS model 2.2.6 Simulation
2	The game should remind the player to complete each of their treatment steps on the required days.	2.2.2 IMS model
3	If the player is prescribed medicine the game should remind them to take the correct dose with parent/caregiver assistance.	2.2.3 Attitudes towards healthcare 2.2.2 IMS model
4	Healthcare communication should be personalized and directed to the child with age appropriate explanations, language and graphics.	2.2.3 Attitudes towards healthcare
5	The game should remind the user to continue treatment even once they feel and appear to be better, along with an explanation of why this is necessary.	2.2.4 Serious games 2.2.6 Simulation
6	The game should provide clear feedback to actions, including praise.	2.2.7 Flow 2.2.5 Persuasive Strategies
7	The game should become more or less challenging over time to adapt to the players skill.	2.2.7 Flow

be more engaging by aiming to create the state of flow as well as flow providing incentive to return. In order to do this the games challenge needs to increase alongside the players ability over time. If activities are less demanding of skill a smaller amount of flow can still occur and be intrinsically rewarding, this is referred to as microflow (Csikszentmihalyi, 1975, p. 141) and can be as simple as fidgeting.

2.3 Criteria

Criteria for the design of a children's health game were formed from the findings of the literature review and feedback from health professionals in the iMoko team, these can be seen in Table 1. The design output of this thesis aims to fulfil these criteria to create a mobile game to educate and engage children around the treatment of skin sores.

2.4 Precedents

Design precedents were found to see how previous research or products fulfilled the criteria formed from the literature review. Precedents that specifically addressed skin sores treatment, antibiotics or common ailments were looked for, however, there wasn't any available or being developed at the time of this thesis. Therefore, the precedents chosen are three children's games addressing a variety of health topics instead.

Re-Mission

Persuasive health game designs have been shown to be successful when designed for the specific condition they were addressing. An example of this would be ***Re-Mission*** ("Re-Mission", 2017), which is a serious health game for children fighting cancer. An intervention group showed an improvement in self efficacy and knowledge compared to a control group (Kato, Cole, Bradlyn, & Pollock, 2008). This game educated players about cancer treatments and the need for compliance to them (HopeLab, 2018) therefore it is an relevant precedent when considering how to fulfil criterion 1. It also is a useful precedent for the

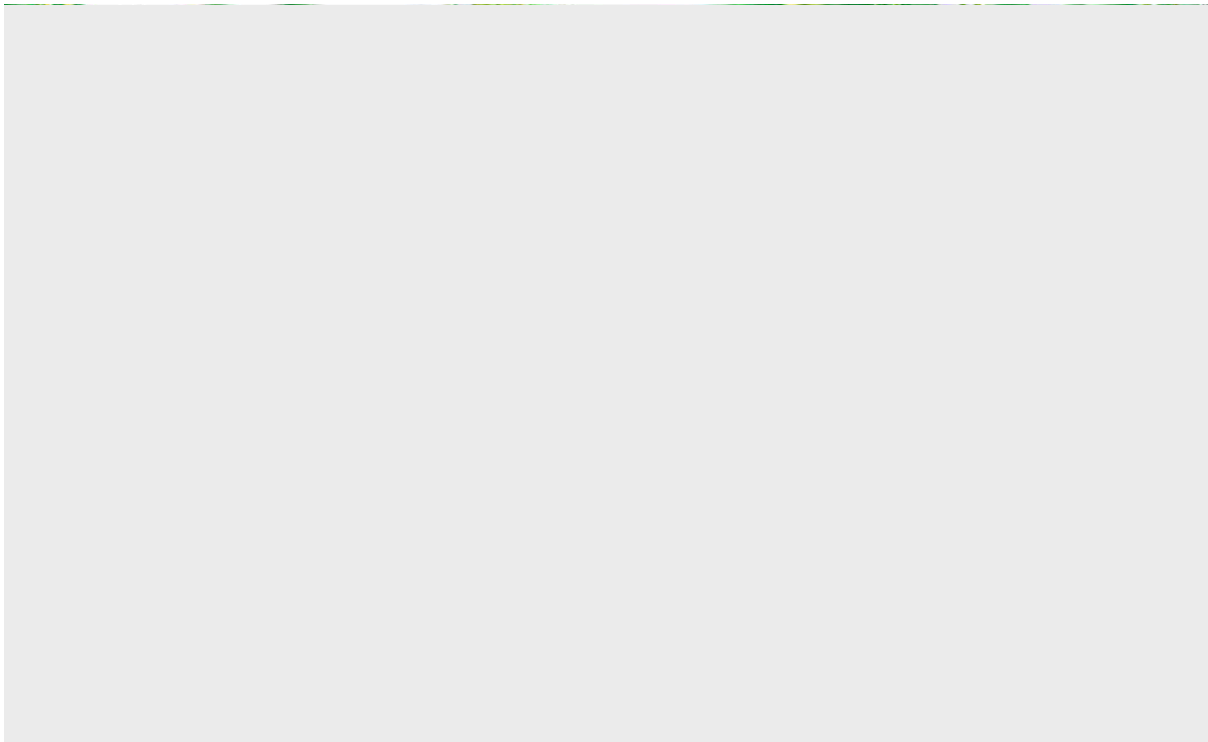


Figure 1. Re:Mission 2 stem cell defender game.

simulation game design technique, as cancer treatment is simulated by the player controlling a nanobot killing cancer cells inside a patient's body. The health education was delivered by changing the format to be appropriate for a younger audience.

Precedent for criterion 1:

Education around why treatment is necessary as well as how to complete treatment steps should be included.

Precedent for criterion 4:

Healthcare communication should be personalized and directed to the child with age appropriate explanations, language and graphics.

Packy and Marlon

Another interesting precedent that shows the success of health games is the diabetes self-management platform adventure game *Packy and Marlon*. Players had to help the characters with diabetes self-management steps over four simulated days. A 6-month randomized controlled clinical trial of the game showed that a treatment group with the game had a 77 percent drop in diabetes related urgent medical visits compared to the control group which had no decline (Lieberman DA, 2001, p. 35). One of the steps the player had to help the character with was taking appropriate amounts of insulin, therefore this precedent confirms the value of criterion 1 and 3. The game was limited in that it could only be played on the Super Nintendo Entertainment System (SNES) home console. When comparing the 49.1 million sales of the SNES console overall (Moriarty, 2014) to Apple selling around 212 million iPhones in the 2016 fiscal year (Statista Inc., 2017) the reach of *Packy and Marlon* was fairly restricted by its platform. A modern health game using a smartphone platform could have a much broader audience.

Precedent for criterion 1:

Education around why treatment is necessary as well as how to complete treatment steps should be included.

Precedent for criterion 3:

If the player is prescribed medicine the game should remind them to take the correct dose with parent/caregiver assistance.

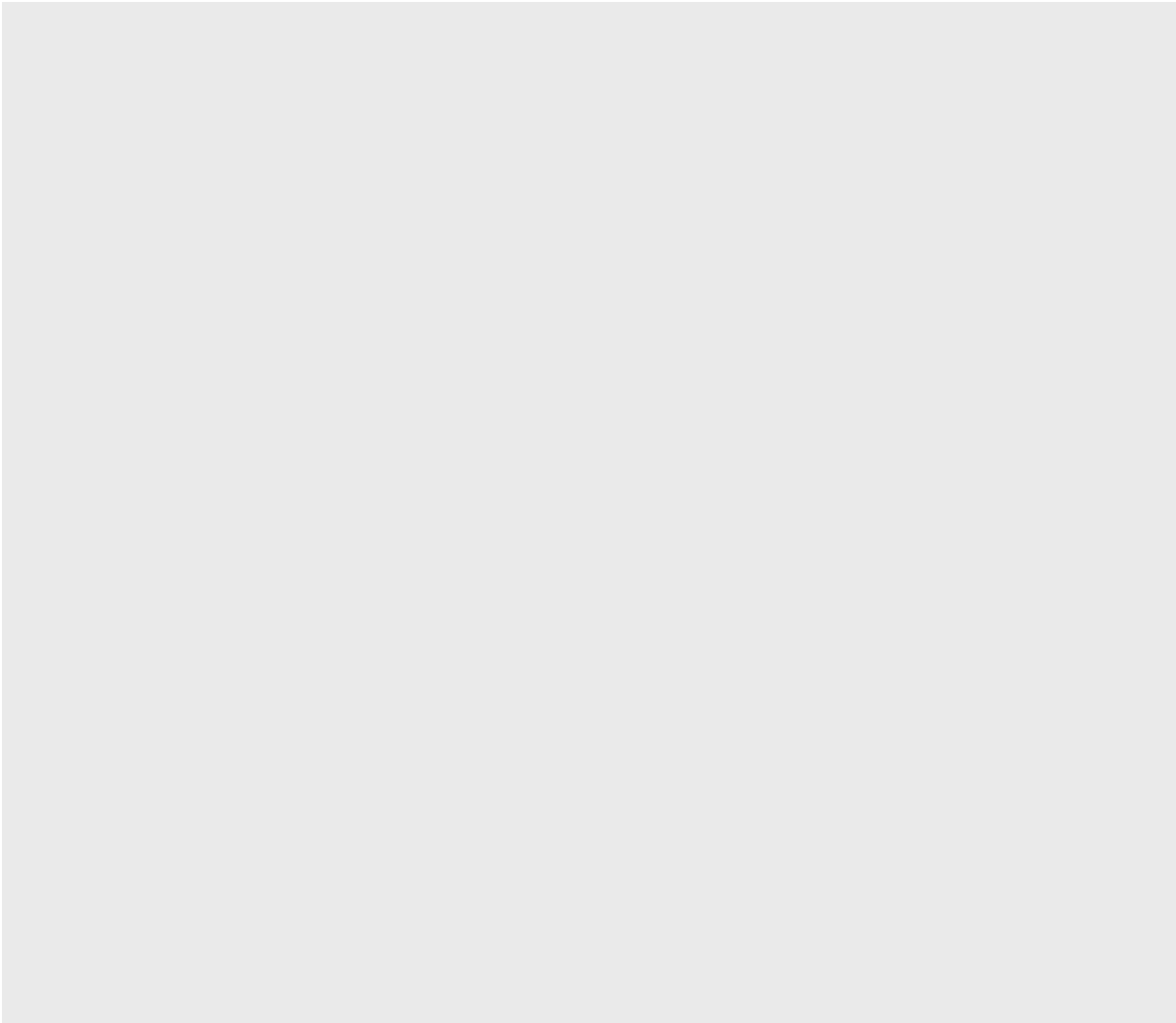


Figure 2. Screenshot of diabetes self-management game Packy and Marlon.

Okee

Okee is an application by The Royal Children's Hospital in Melbourne (The Royal Children's Hospital Melbourne, 2018). The app contains games to help children know what to expect when coming in for medical imaging appointments. The games provide healthcare communication through bright, cheerful graphics and simple interactions. For example, the player is able to practice keeping still for imaging by holding the device still to help a jellyfish hide from a shark. When the player does well, they are rewarded through visual and verbal praise from the happy character. This precedent provides useful inspiration when considering appropriate mobile game design elements to communicate healthcare information for children.

Precedent for criterion 4:

Healthcare communication should be personalized and directed to the child with age appropriate explanations, language and graphics.

Precedent for criterion 6:

The game should provide clear feedback to actions, including praise.

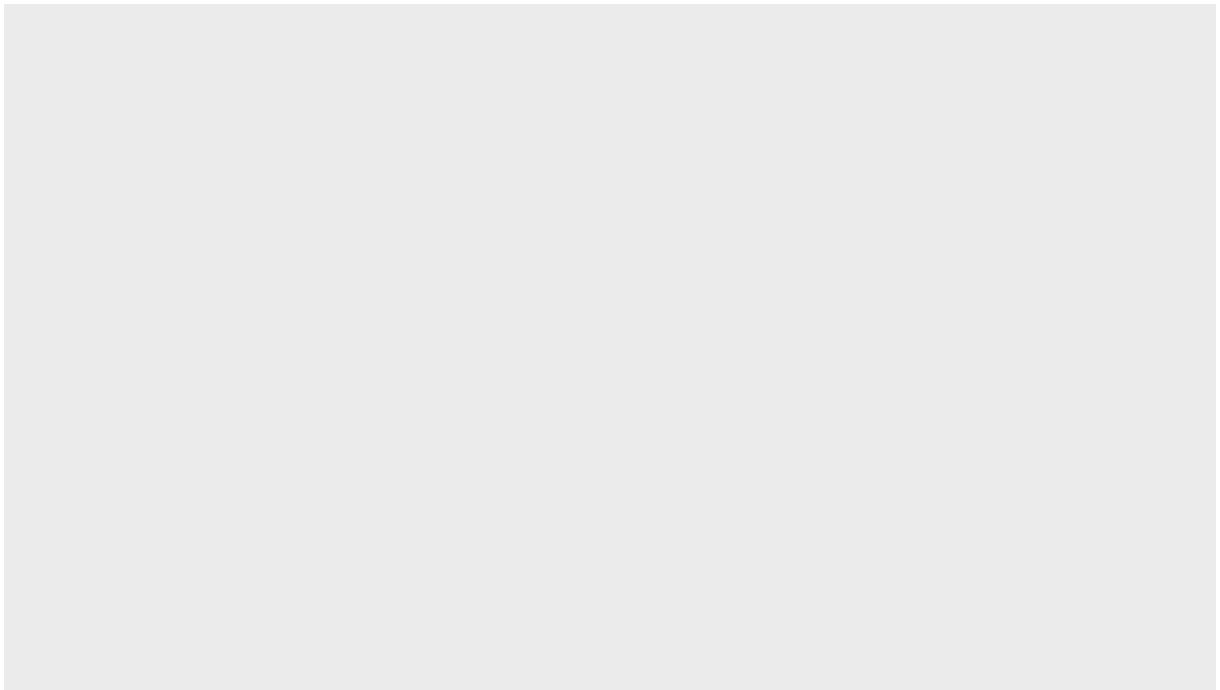


Figure 3. Screenshot of praise in the Okee in Medical Imaging application.

2.5 Conclusion

The existing literature and precedents show that game design can have a positive impact on health behaviours when designing with treatment factors in mind. There is a lack of precedents and literature for serious health games to address common ailments. Therefore, specific research would be valuable on how a game can be designed to improve engagement and facilitate education for skin sore treatment in children. The literature suggests it could be a successful approach and mobile gaming platforms allow games to be a solution easily available to large audiences. The criteria formed from the literature review should assist implementation of various strategies to improve education and engagement within a health game for common ailments.

3 Methodology

3.1 Theoretical Framework

Methods for design are often subjective and when using design in academic setting there needs to be a balance with more traditional objective research methods. This balance is met in this thesis by using mixed methodology to form a constructivist point of view (Rodríguez Ramírez, 2017, p. 24-25; Creswell, 2009).

3.2 Aims and Objectives

This thesis is structured to follow the Research Through Design Based on Design Criteria (Rodríguez Ramírez, 2017) model. There is no existing health game to engage and educate children around the treatment of skin sores. Therefore, research through design was necessary to find what a game aiming to do this should consist of, design the game, and test it to address the research question of “How could a mobile game be designed to facilitate education and improve healthcare engagement around skin sores in children?”.

The construction and review of criteria throughout the research and development guided the design of the final game output. This model is appropriate as it is structured to support research through systematic design. The criteria set was formed from the literature review and precedent analysis. Next, journey maps and user personas were formed from the background research and literature review to assist designing experimental sections of the game. These sections were then combined into a demonstration version of the game and tested for usability (Rubin, 2008), engagement and education through participant observation and short semi-structured interviews with questions designed for children. These results were thematically analysed and then used to refine the final output of the game which was then assessed against the criteria. Table 2 shows the research aims, their respective objectives and methods.

Table 2. *Research aims with respective objectives and methods*

<i>Aims</i>	<i>Objectives</i>	<i>Methods</i>
Create a set of criteria for serious game to improve healthcare engagement and education in children.	Describe what issues exist around health behaviours and engagement, and the current approaches to resolving them.	Thematic analysis (Alhojailan, 2012, p. 40-45) Background research and literature review (Cresswell, 2013, pp. 27-47, Martin & Hanington, 2012, p. 112)
	Situate the research within the current body of literature on serious game design. Focus on techniques for children that could be used to help them manage their own medical conditions. Look into persuasive techniques for education and engagement around medication and other steps of treatment.	Literature review (Cresswell, 2013, pp. 27-47, Martin & Hanington, 2012, p. 112)
	Define design criteria for developing a health game, by identifying suitable game design techniques to educate and engage children with their treatments.	Research Through Design Based on Design Criteria (Rodríguez Ramírez, 2017)
Design a serious game to improve to healthcare engagement and education around the treatment of skin sores in children between the ages of 5-7 years, primarily from New Zealand.	Discussion of current treatment regimes for skin sores and the issues affecting treatment completion in New Zealand children. Identify suitable game design techniques to address them.	Background research and literature review (Cresswell, 2013, pp. 27-47, Martin & Hanington, 2012, p. 112) Thematic analysis (Alhojailan, 2012, p. 40-45) User personas (Gothelf, 2013, p. 26, Curedale, 2016, p. 51) Journey mapping (Curedale, 2016, p. 39)
	Develop suitable game art and interactions to fulfil the criteria and create the design output of a mobile game.	Research Through Design Based on Design Criteria (Rodríguez Ramírez, 2017)
		Usability and enjoyment testing with children through adjusted usability testing methods (Andersen, Khalid, & Brooks, 2016) Semi-structured interviews with questions designed appropriately for children (Bell, 2007) Thematic analysis (Alhojailan, 2012, p. 40-45)

3.3 Methods

Qualitative and quantitative methods were used throughout the design process to meet the research aims and objectives. These methods are listed below with a description of why they were chosen and when they were used in the design process.

Research Through Design Based on Design Criteria

To begin this method involved the formation of criteria from the background research and literature review (Rodríguez Ramírez, 2017). This set of criteria was the starting point for the design process. In the design phase this methodology uses experimental prototyping around the criteria (Rodríguez Ramírez, 2017). In this thesis that consists of creating experimental sections of the game and critiquing a conceptual prototype created in previous research.

Thematic Analysis

This form of qualitative analysis is used by creating codes to pull themes out of the data (Alhojailan, 2012, p. 40). Data gathered from testing sessions and interviews was qualitative in the form of observations and transcripts so using a thematic analysis helped to point out key themes for the research. These themes could range from usability errors to highlighting areas within treatment steps that needed improvement. The process of thematically analysing results is detailed in Chapter 5.

User Personas

Personas are virtual user profiles created with information relevant to the product being designed (Gothelf, 2013, p. 26). This information is often drawn from previous research and can include topics such as demographic, needs and devices being used (Gothelf, 2013, p. 28, Curedale, 2016, p. 51). Personas are used to assist in making design decisions appropriate for the target audience throughout the design process. This was especially important during the designing phase of this thesis as frequent user testing was not always possible and personas were used to avoid decision making based off assumptions. The personas and development of them is detailed in Chapter 4.

Journey Maps

This method maps out a user's journey with a product from start to finish to find pain points where design could improve the experience (Curedale, 2016, p. 39). After the initial formation of criteria journey mapping assisted in finding areas where the design of a game could help within the skin sores treatment process. This journey map and how it was developed is detailed in Chapter 4 along with a simplified journey map to show how the gameplay experience fits alongside treatment. Another journey map can be found in Chapter 6 detailing the use of the final output and future concepts alongside the treatment of skin sores.

User Testing

It is necessary to test with children as they have different expectations than adults and therefore designing from an older viewpoint could lead to incorrect assumptions (Andersen, Khalid, & Brooks, 2016, p. 236). Standard user testing methods required adjustment as usability heuristics like the Standard Usability Scale (Brooke, 1996, p. 4) use language and structure unsuitable for children (Bell, 2007, p. 463) which could affect results. Observation (Curedale, 2016, p. 110) was the main method for playtesting alongside short follow up questions designed to suit the ages of participants. The participants, the procedure followed and adjustments made are discussed in depth in Chapter 5.

4 Design Phase One

4.1 Initial Starting Point

4.1.1 *Previous Research*

Some previous research and data collection had been done by the team before I joined the project. The data from this research had not been analysed and is not yet published at the time of completing this thesis. However, this research was useful to provide a starting point for my design process and provided some valuable insights for the creation of journey maps and user personas in this thesis.




Notes from interviews with children and parents conducted as part of the previous research provided useful insights when creating user personas in this thesis (see section 4.1.3).

These notes included:

- Children had limited access to devices for multiple reasons—no access as a punishment, or multiple children trying to borrow device.
- Some children were only allowed to use devices for a restricted hours.
- Often the only device available was the parent or caregiver's device so the device was only available when they were not using it.
- Limited access to WiFi
- Treatment can be forgotten when parents/caregivers are busy or other children need attention.
- Some people consider treatment as no longer needed if the condition appears to be healing/healed.

The previous research included the creation of a conceptual prototype of the game. This conceptual prototype had many issues and was limited in its graphics and interactions, as it was created in a short period of time and had not been user tested. Issues were identified by assessing the prototype against the criteria formed from the literature review, this can be seen in Table 3. These issues mean that the conceptual prototype does not fulfil the criteria. Therefore, further development and research was justified. The conceptual prototype did provide design inspiration and some assets were used to speed up the development in this thesis as discussed in section 4.3.

Table 3. Identified issues with the conceptual prototype from previous research from criteria assessment

Criterion Assessment and Identified Issues	
1. The game should provide education around why treatment is necessary as well as how to complete treatment steps.	
Issue: Missing explanations of why the treatment steps were necessary. An example is the bleach bath game which included a voice over telling the player that they were going to help wash the creature's sores, but not that this was done to get rid of germs.	
2. The game should remind the player to complete each of their treatment steps on the required days.	
Issue: Games related to treatment steps were unlocked on set days of treatment, however some games were needed earlier than when they were able to be unlocked.	
	3. If the player is prescribed medicine the game should remind them to take the correct dose with parent/caregiver assistance.
	Issue: The player is reminded through a visual to not forget their antibiotics but not that they need the correct dose with parental supervision.
	4. Healthcare communication should be personalized and directed to the child with age appropriate explanations, language and graphics.
	Issue: Some assets not being recognizable or suitable for children. An example can be seen in the screenshot, where a hand and nails are represented by geometric forms.
5. The game should remind the user to continue treatment even once they feel and appear to be better, along with an explanation of why this is necessary.	
Issue: There is no reminder and explanation to continue treatment when the player feels better.	
6. The game should provide clear feedback to actions, including praise.	
	6. The game should become more or less challenging over time to adapt to the players skill.
	Issue: Games could become repetitive when played throughout treatment. An example is the game for changing a dressing. This was a memory game to order the treatment steps, yet the order does not change so once the player has learnt it the game becomes very repetitive.

4.1.2 Skin Sores Research

Criterion 1 dictates that education around why treatment is necessary and how to complete treatment steps should be included. This meant that research into the different treatment regimens for skin sore was necessary to determine what the game should simulate to educate players.

Research into treatment steps for different skin sores conditions found common steps that were applicable across multiple conditions, a summary of this research can be seen in Table 4. Finding common steps provided areas to focus on when designing that would be beneficial to a multitude of users with different conditions.

Studies show the incidence of skin infections requiring hospitalisation in New Zealand is higher in Māori and Pacific Island children (Williamson et al., 2013, p. 924-925; O'Sullivan, Baker, & Zhang, p. 1800). Designing with these sociodemographic factors in mind was valuable to meet the criteria by personalizing healthcare communication with appropriate explanations, language and graphics.

Table 4. *Common treatment steps for skin sores and the conditions where applicable*

<i>Common Treatment Steps</i>	<i>Conditions</i>
Antibiotics <ul style="list-style-type: none"> • Prescriptions are usually liquid • Must finish prescription even if feeling better • Take every day 	Impetigo Cellulitis Infected cuts, scratches and grazes Infected eczema
Cover sores with dressings <ul style="list-style-type: none"> • Change dressings everyday to keep clean 	Impetigo Cuts, scratches and grazes Cellulitis
Check and clean infected skin <ul style="list-style-type: none"> • Wash with warm water • Check infection is not worse 	Cellulitis Cuts, scratches and grazes Eczema (with soap-free products) Impetigo
Keep nails short and clean <ul style="list-style-type: none"> • Stops damage to the skin if sores are itched • Prevents spreading germs 	Impetigo Eczema Chicken pox Cellulitis Insect bites
Taking regular bleach baths <ul style="list-style-type: none"> • 2 - 3 times a week • Approximately the same amount of bleach that would be in a swimming pool • 2ml bleach for every 1 litre of water 	Cellulitis Impetigo Eczema
<i>Resources Used</i>	
Parents and families guide for skincare and treating skin infections (Workbase Education Trust, 2012) Ministry of Health information page on impetigo (Ministry of Health, 2017) Journal article on the diagnosis and treatment of impetigo (Cole & Gazewood, 2007) Journal article on managing skin infections in Māori and Pacific children (Tilyard & Harris, 2012) Bleach bath instructions (The Paediatric Society of New Zealand and Starship Foundation, 2018) Discussion with research advisor Dr Lance O’Sullivan from iMoko	

4.1.3 Personas

User personas (Gothelf, 2013, p. 26; Curedale, 2016, p. 51) were created to assist in designing a game appropriate for the target audience. These personas helped to make the findings from the literature review, previous research (Section 4.1.1) and skin sores research (Section 4.1.2) more relatable so the needs of the target audience could be understood. This was important to fulfil Criterion 4; personalizing and directing healthcare communication to the child with age appropriate explanations, language and graphics. The use of personas also helped avoid decision making based off assumptions by providing a representation of user when frequent user testing in person was not possible.

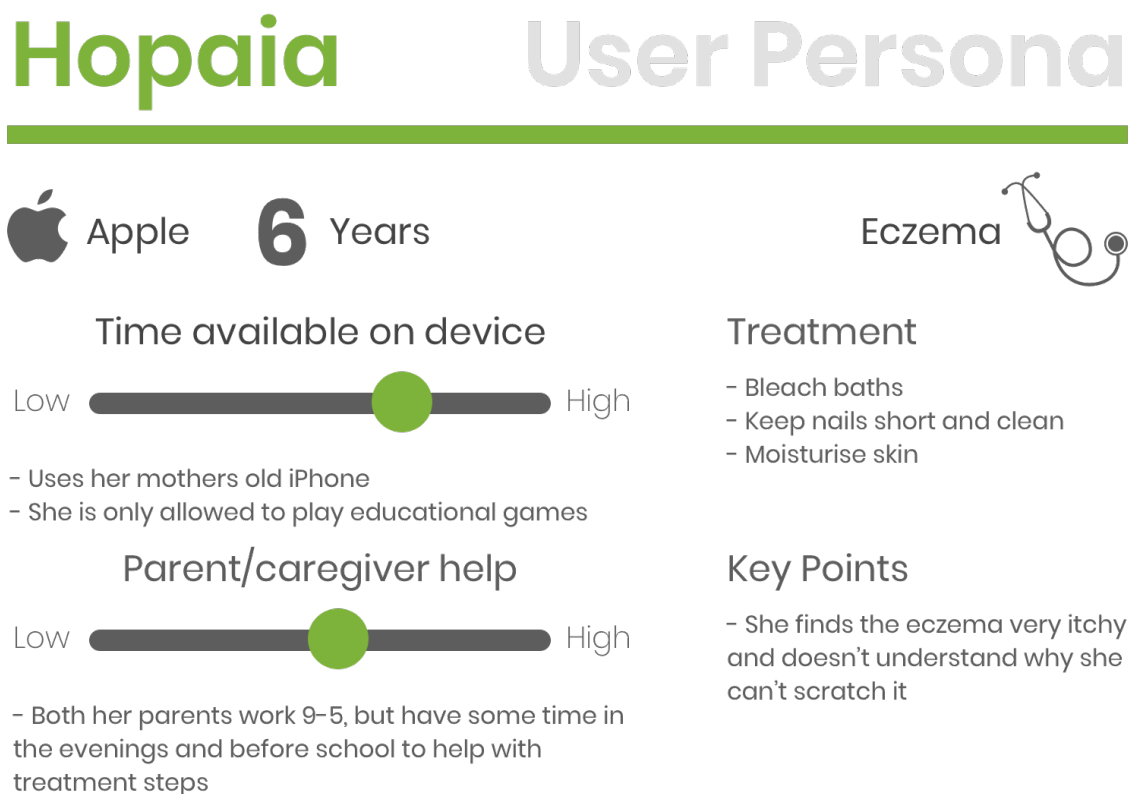


Figure 4. User persona - Hopaia

James

User Persona



Android

5 Years



Time available on device



- Shares a tablet with his 3 other siblings
- Has restricted hours of tablet time

Parent/caregiver help



- He has a stay at home mother, however she can be busy with housework and caring for his other siblings

Treatment

- Bleach baths
- Keep nails short and clean
- Cover with dressings
- Antibiotics

Key Points

- He doesn't like taking medicine

Figure 5. User persona -James

Tipene

User Persona



Android

7 Years



Time available on device



- Only has access to his fathers phone so device time is limited

Parent/caregiver help



- His dad can see the that the sore appears to be getting better so considers the treatment no longer needed

Treatment

- Bleach baths
- Keep nails short and clean
- Cover with dressings
- Antibiotics

Key Points

- He is interested in how to use medicine properly

Figure 6. User persona - Tipene

4.1.4 *Treatment Journey Maps*

A journey map was created of an average treatment regime for skin sores using the findings from the literature review, previous research (Section 4.1.1) and skinsores research (Section 4.1.2). Journey mapping highlighted pain points in the treatment regime that design could address and displayed these beside treatment steps in a chronological order, this was useful when designing the flow of the game. An additional journey map was created to understand how the issues around education and engagement with treatment can result in recurrence of skin sores or further health complications. These two journey maps can be seen in Figure 7 and 8 on the following pages.

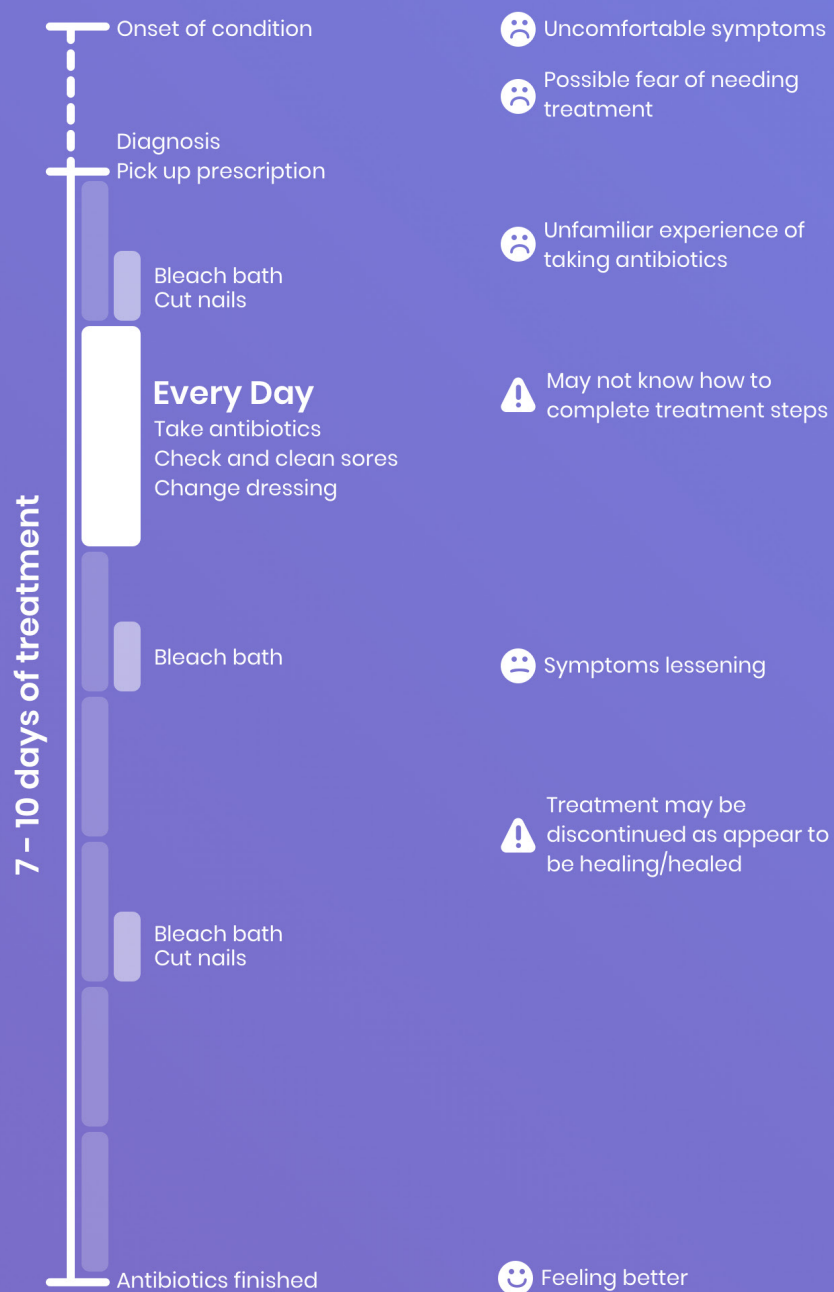


Figure 7. Journey map of completed skin sores treatment regime

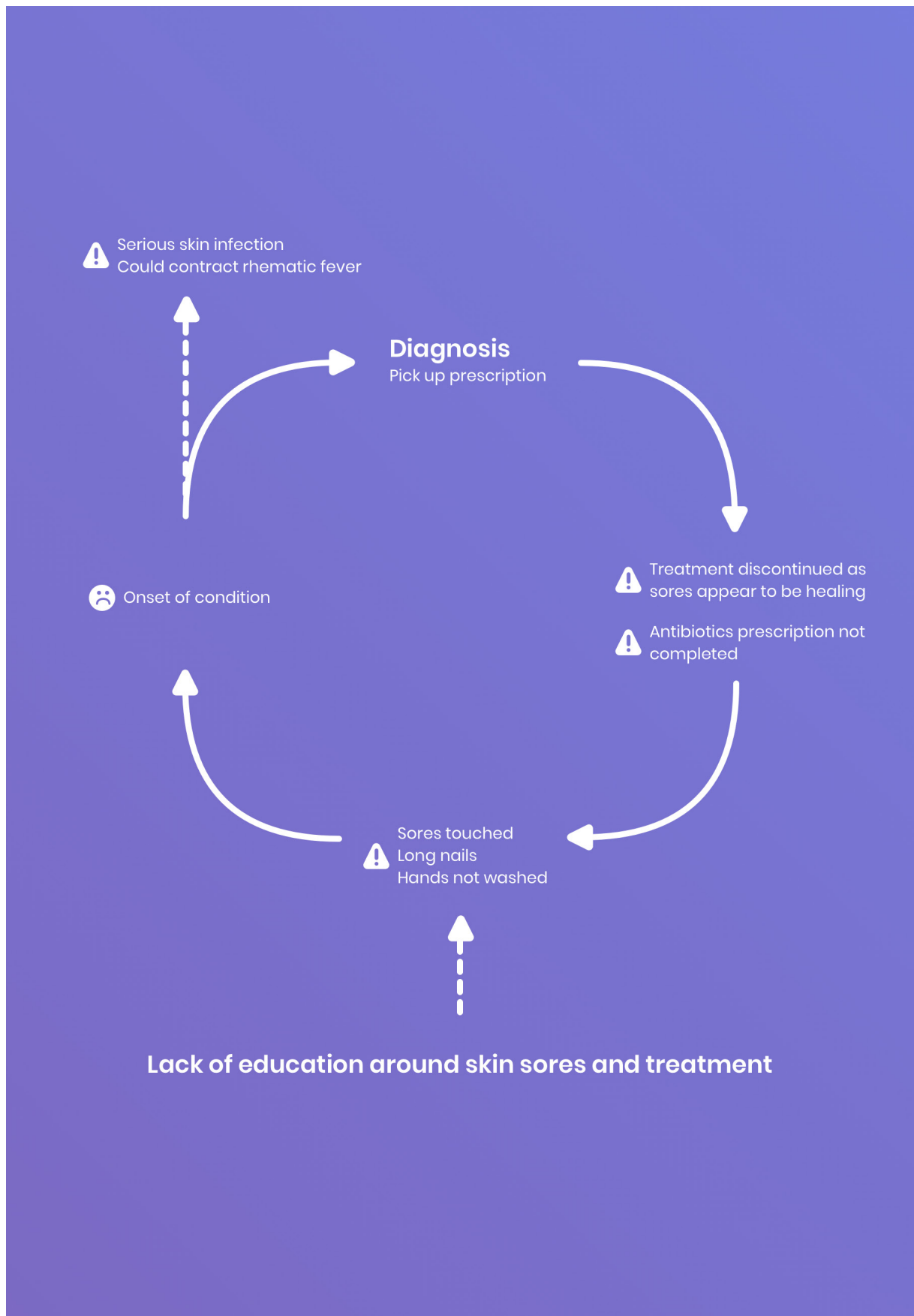


Figure 8. Journey map of current issues when treating skin sores and resulting cycle

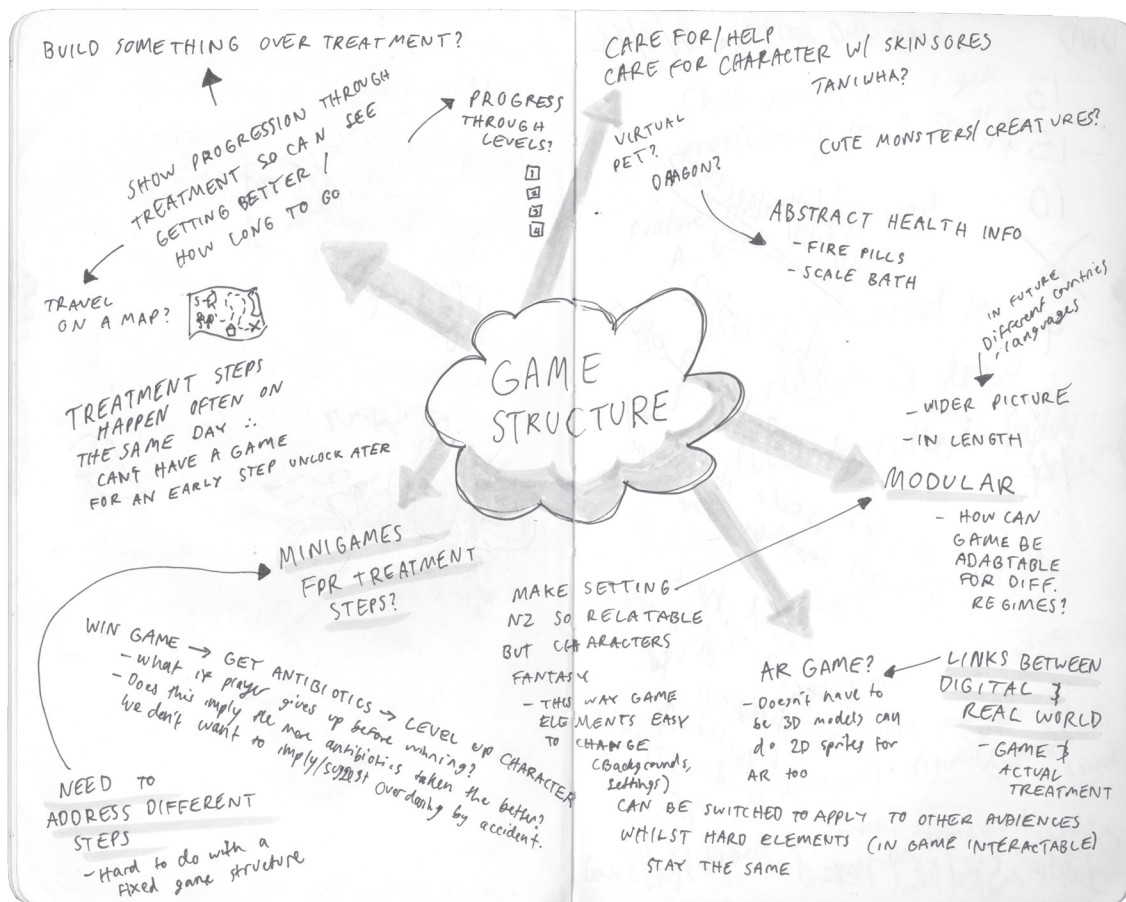


Figure 9. Mind map of game structure ideas

4.2 Game Structure

4.2.1 *Idea Generation*

Using the criteria, personas and journey maps, a mind map began the ideation of the game structure. It was clear that the game needed to address multiple treatment steps, however this would be difficult to achieve well without different sections of the game focused on an individual step.

The sections for each step would need to be available to be played each day the step was required. In some cases this would mean two or more sections being played in one day, for example changing dressings and taking antibiotics. The game structure needed to be adaptable for different treatment regimes as some skin sores conditions contained treatment steps not present in others. These considerations led to the idea of a modular game structure with minigames for each treatment step.

Ideas of how healthcare communication could be made less clinical to be age appropriate for the player were also explored. The minigames needed to be tied together to show progression through treatment, a storyline of the player helping to care for a character with skin sores addressed this.

4.2.2 *Game Journey Map*

A simplified version of the treatment journey map was made to show how the game could be played alongside treatment. This included detailing what the game could address in each stage of treatment and considering how it could fit within the iMoko program. This map can be seen in Figure 10.

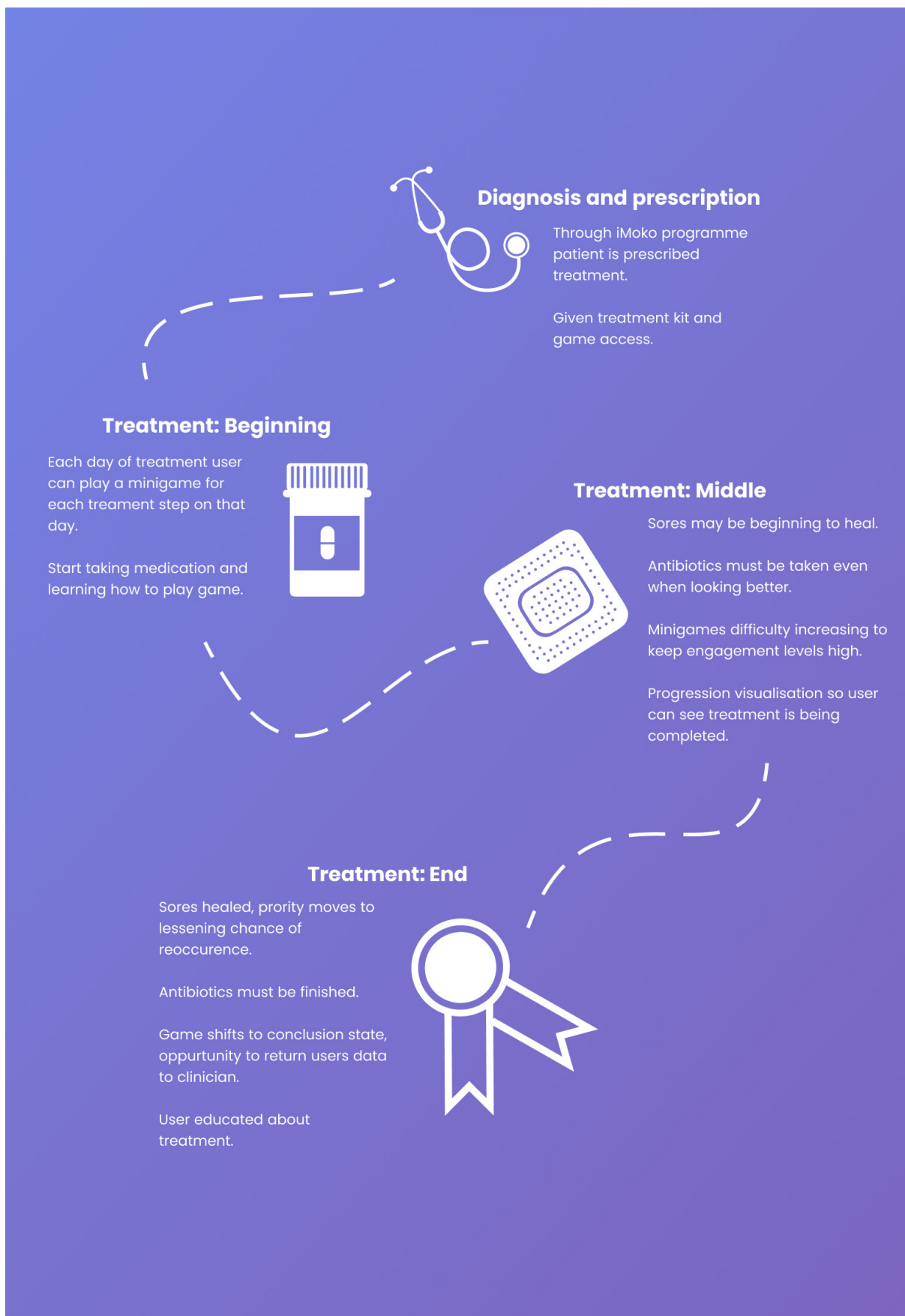


Figure 10. Simplified journey map of treatments with game use

4.3 Nail Cutting Minigame

The first treatment step of cutting nails was chosen to be the first to design a minigame for, as it was necessary in almost every skin sore treatment regime. It is an important step to reduce the spread of germs and it helps prevent damage to the skin if sores are itched (Workbase Education Trust, 2012; Cole & Gazewood, 2007, p. 859).

The design process began with a mind map of some possible game mechanics and interactions to include, which can be seen in Figure 11. Inspiration was taken from the previous research conceptual prototype nail cutting minigame (seen in Table 3, section 4.1.1) where players had to tap the nails to keep them short for the duration of a timer. This inspiration formed the basis of the minigame with some additional ideas generated in the mind map. The additional ideas included showing the nails getting covered in germs and dirt as they grew longer and swiping instead of tapping to cut the nails.

Criterion 1 was met in this minigame idea by the simulation showing the player that germs get on long nails, where in reality the player may not know that this happens as germs cannot be seen without a microscope. The minigame can be made more difficult by changing the speed the nails grow and moving the hand around to make it harder to swipe them. This meets criterion 7 as the challenge to keep the nails short within the timer can adapt to the player's skill.

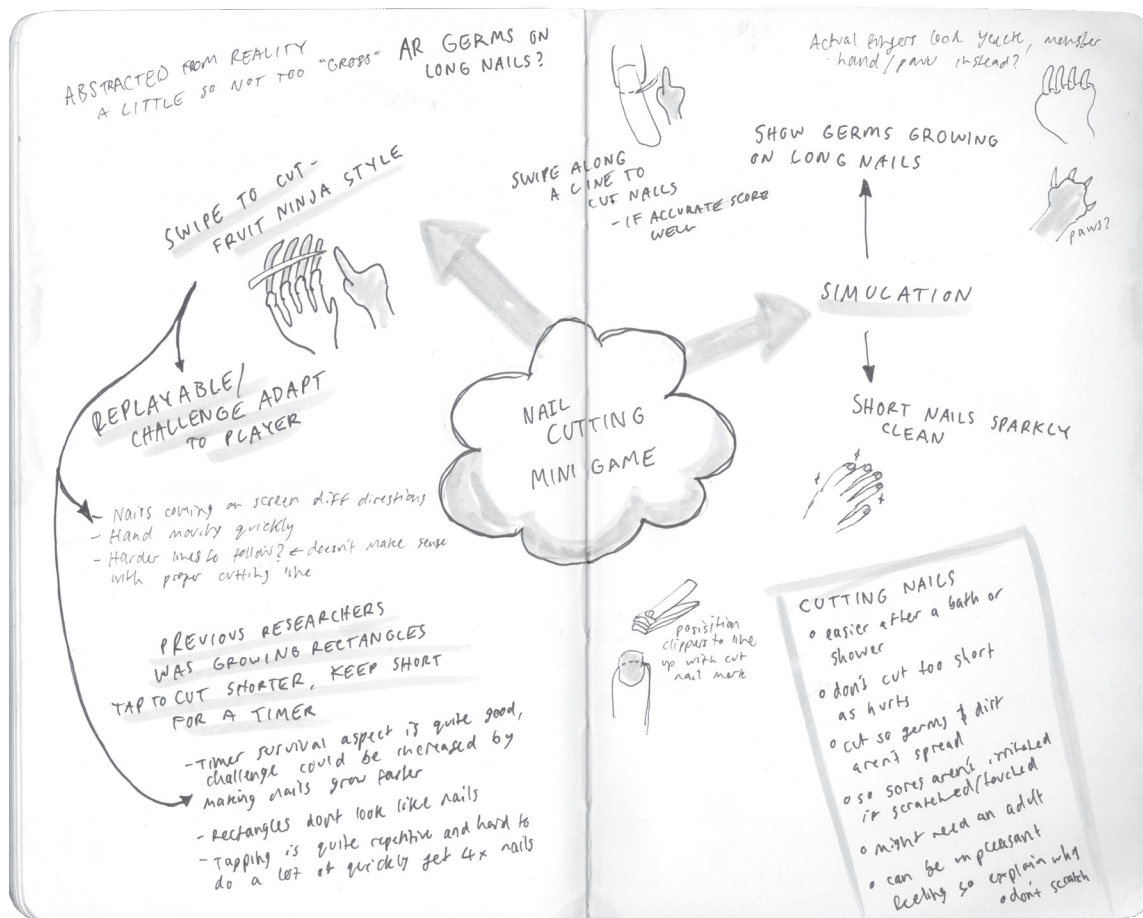


Figure 11. Nail cutting minigame idea mind map

Development and Asset Design

Some of the old assets from the previous research conceptual prototype were used with a little modification to aid in fast development. These consisted of buttons, a kiwi character, beach ball asset, and voice recordings of why nails should be cut. A few modifications were made to these assets such as rounding edges on button icons and changing the kiwi characters eyes to look friendlier.

Additional assets were created including; bacteria inspired germs, more realistic nails and a timer (see Figures 12 and 13). These were created with consideration of criterion 4 in mind, making imagery recognizable yet appropriate for 5-7 year olds. The nails had many iterations which can be seen in Figure 12. Initially they were designed to appear to grow from a human hand, however this looked quite creepy. The final version has four nails appearing to grow from the characters paw/hand, this unrealistic version is less unpleasant whilst still having the appearance of nails.

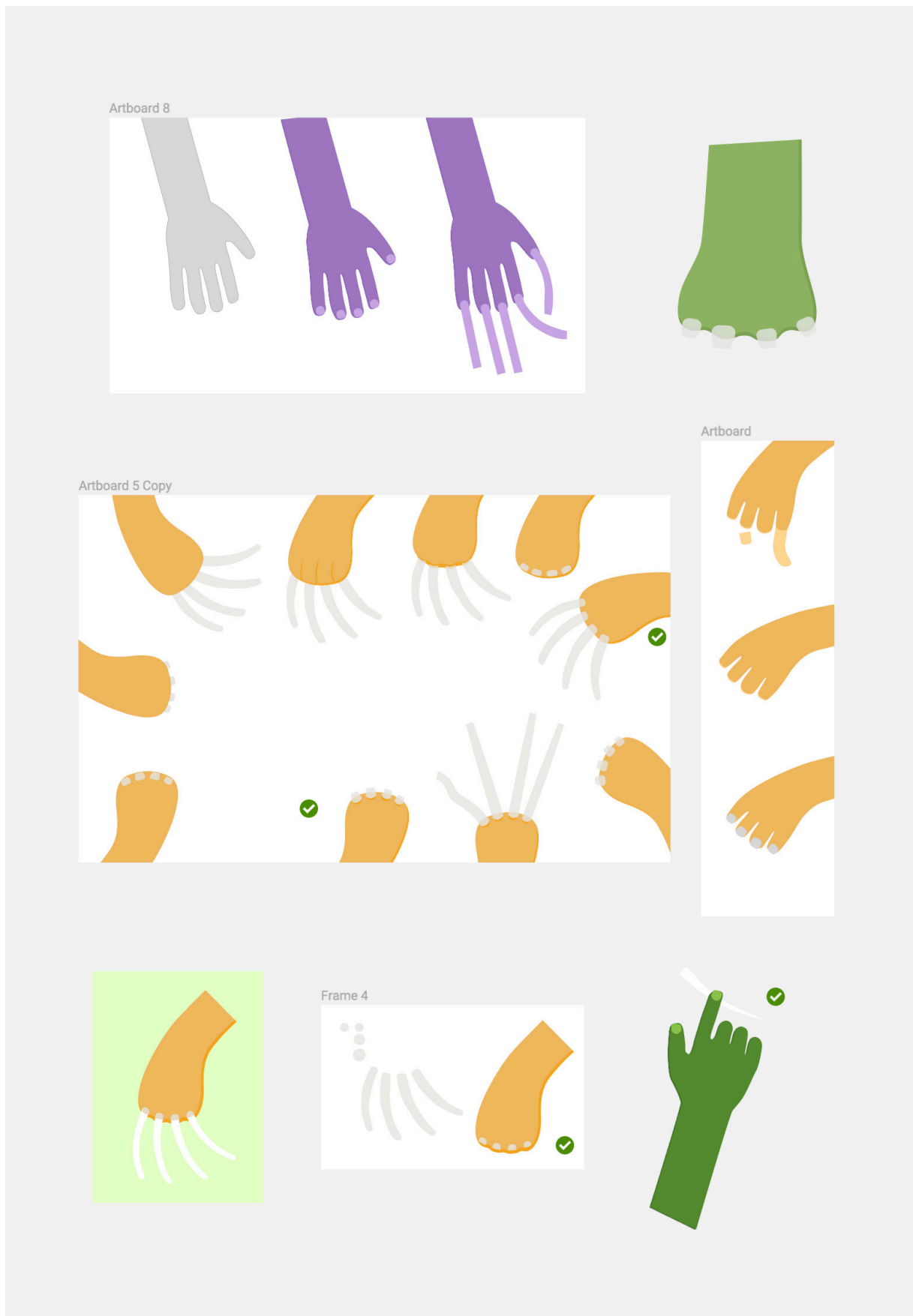


Figure 12. Creating nail cutting game vector assets (1)



Figure 13. Creating nail cutting game vector assets (2)

The design of the character for the player to help care for happened after the creation of the nails. The character was designed to look cute and friendly with a simple graphic style. Inspiration was taken from drawings by the children who had been interviewed in the previous research, particularly how many of the characters they drew had simple forms, with the face, arms and legs on a round body with no head. Some of the character design process can be seen in Figure 14.

Simulating nail growth was an interesting challenge to develop in Unity. Problem solving through sketching found a solution where nail pieces were hidden within a mask (see Figure 15). These pieces would move downwards within the mask to create the illusion of a nail growing. Each piece grows germs and gathers dirt as it moves and detects when the players swipes through it. Each nail piece below a piece which has been swiped through is deleted to “cut” the nail.

An introduction and conclusion (see Figures 16 and 17) was added to minigame explaining to the player why the nails were being cut and how it would help the treatment outcome, this ensured criterion 1 was met. To address criterion 6 feedback to the player is provided through sound effects when nails are cut and voice overs and text praising the player when they win the minigame. If the player loses they are given the option to play again and with a voice over explanation of why they lost the minigame.

Exploratory Testing

Some informal play testing of the game was carried out with colleagues, family and friends to find usability issues within the first nail cutting game build. Information from these play tests is not attributed or used in a formal sense - it merely aided in finding obvious usability issues quickly. An example of a usability issue discovered in this testing was a replay button not being recognized and having to be pointed out before it was tapped. This led to buttons being mostly avoided or explained with voice overs and instruction graphics in future iterations.

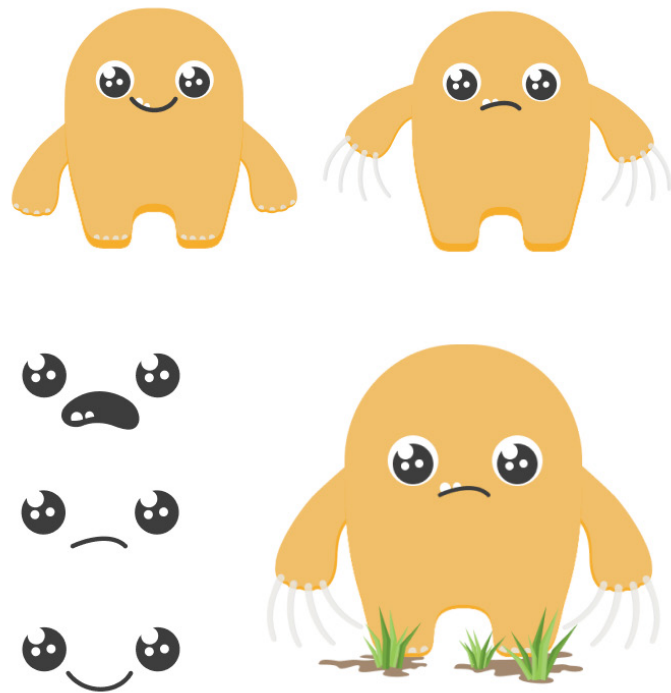
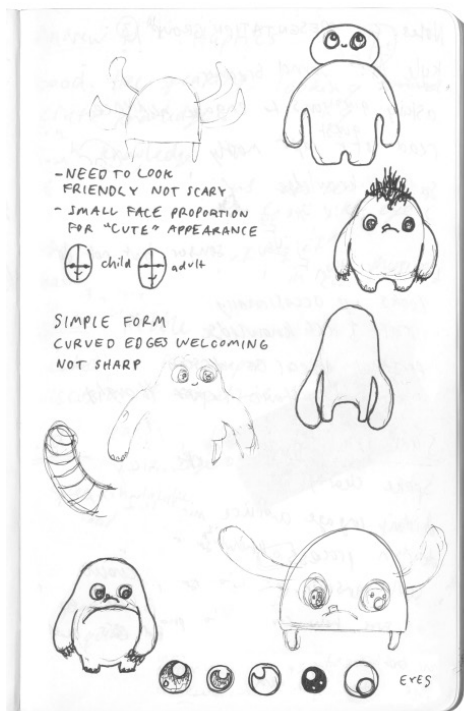


Figure 14. Character design process

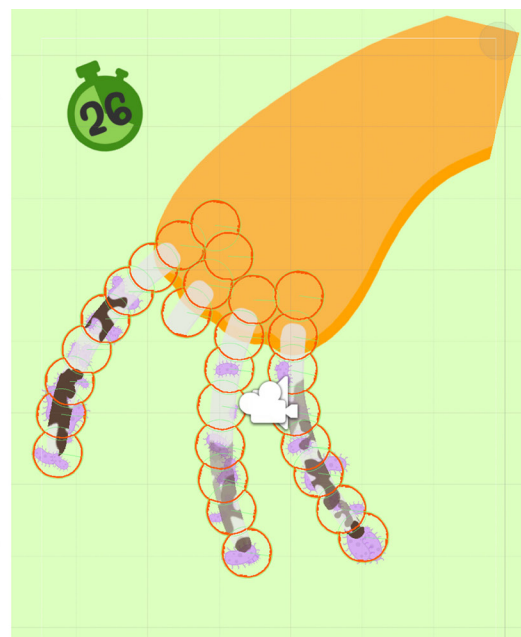
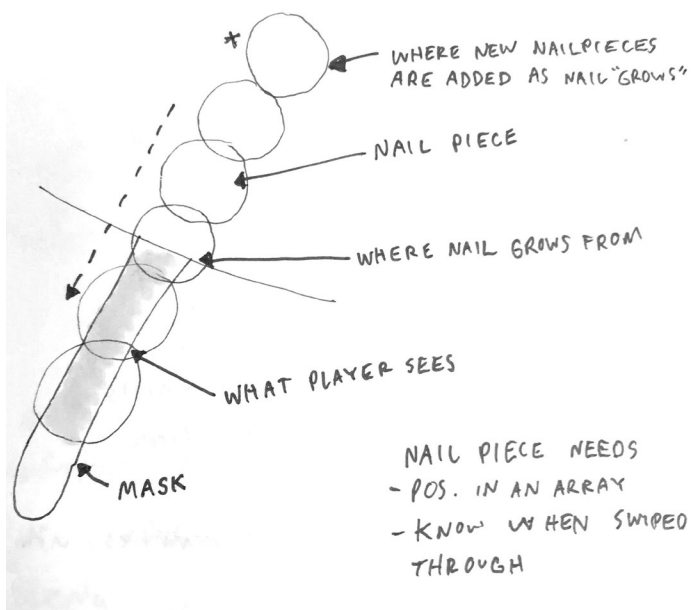


Figure 15. Nail growing simulation development sketch and implementation in Unity

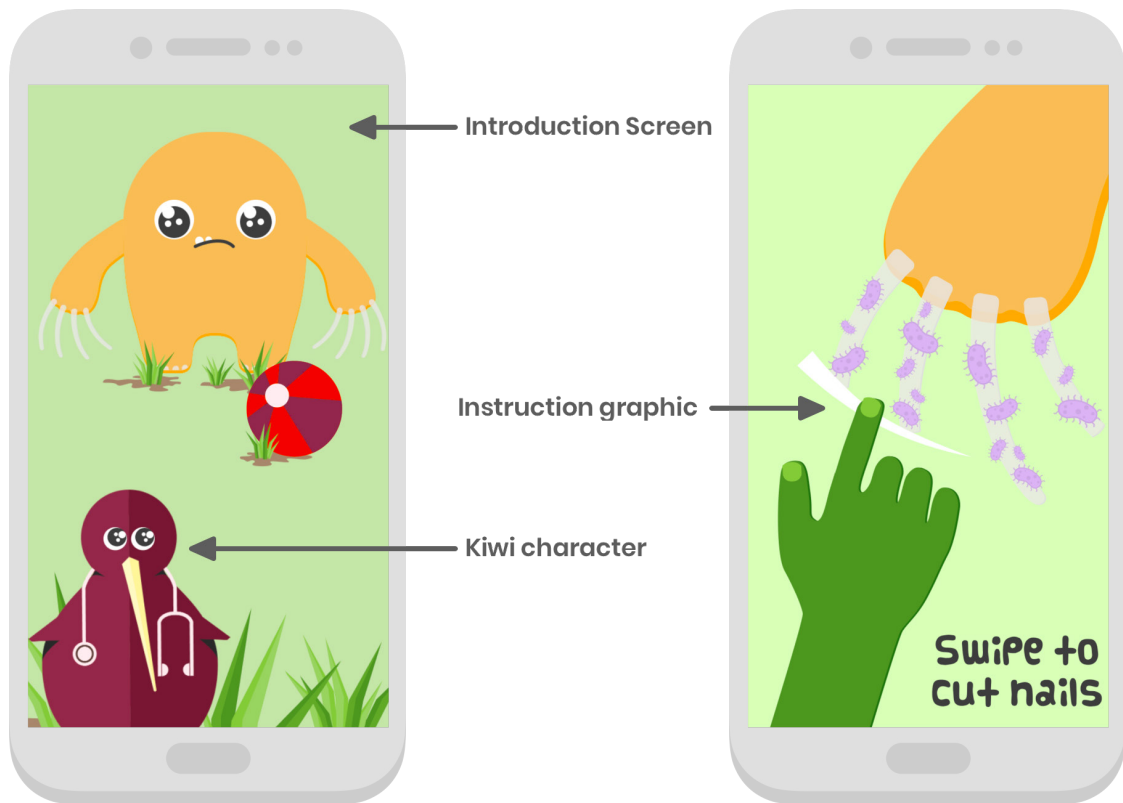


Figure 16. Screenshots of the nail cutting minigame introduction and instruction screens

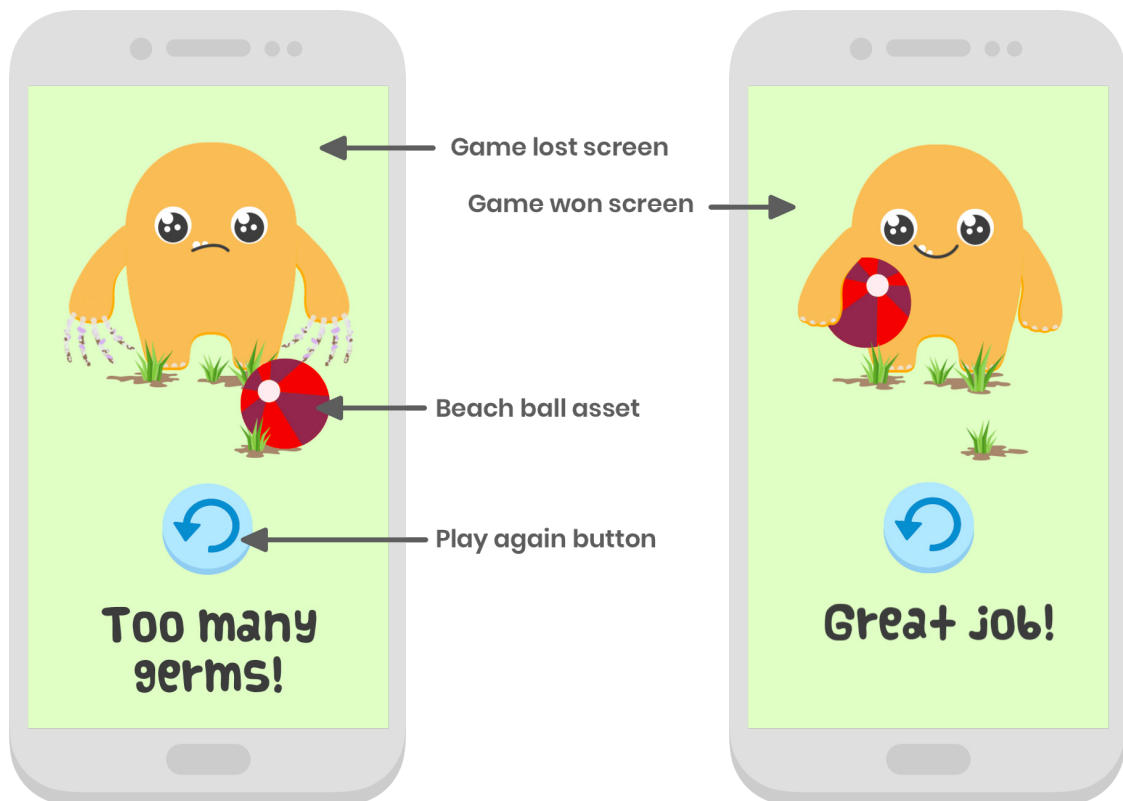


Figure 17. Screenshots of the nail cutting minigame conclusion and play again screens

4.4 Dressing Minigame

The design of the second minigame began with addressing the common and repeated treatment step of changing dressings covering sores (Workbase Education Trust, 2012). The design process began with a mind map of some possible game mechanics and interactions to include, which can be seen in Figure 18. Interactions and mechanics represented the physical process of the treatment steps. The ideas from the mind map that addressed the design criteria best were then chosen to combine to develop the minigame.

The first idea involved the player changing a dressing by touching the screen to drag and drop the dirty dressing into the bin and replace it. In the second idea, a puzzle was created for the player by providing them with plasters to arrange to cover sores, this would be replayable with different layouts of sores and shapes/numbers of plasters. The third idea

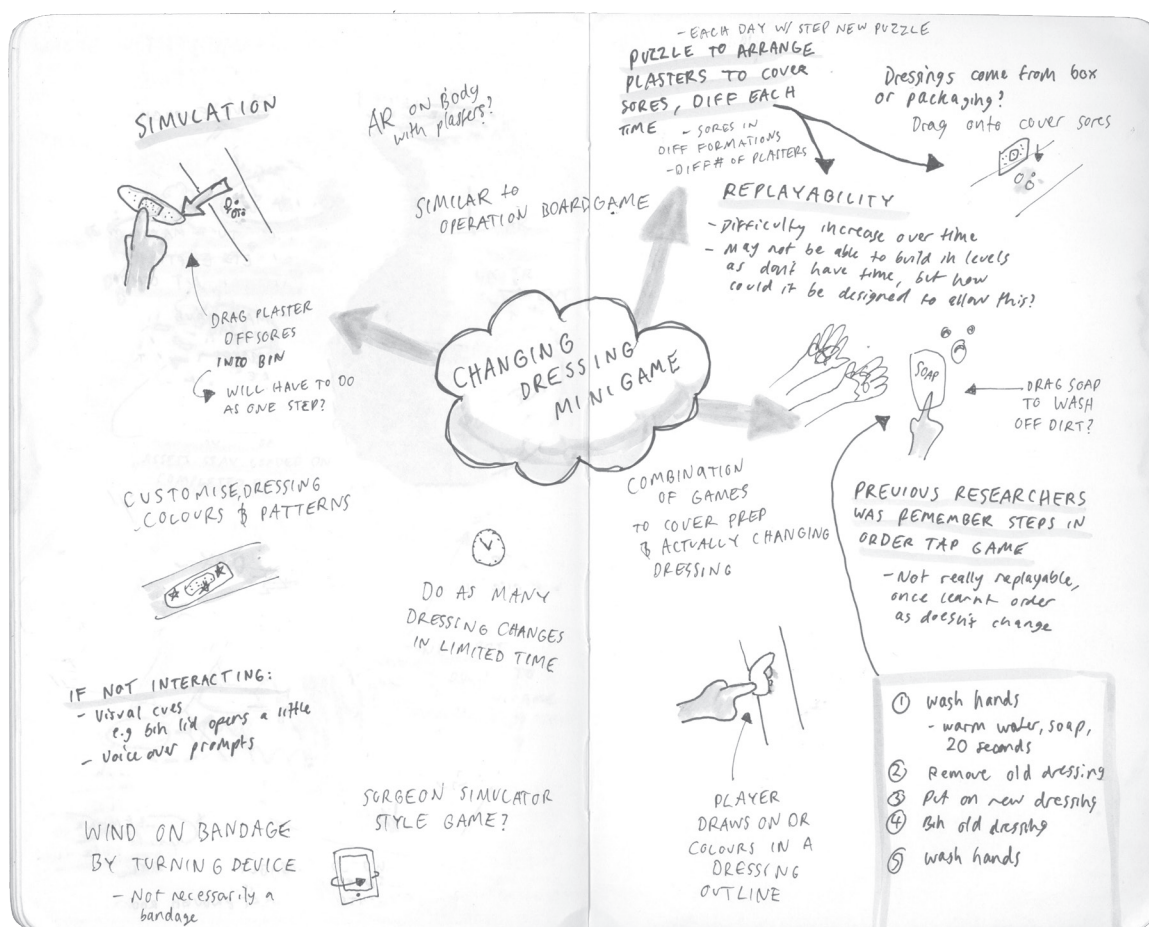


Figure 18. Changing dressing minigame idea mind map

simulated hand washing before and after replacing a dressing, with the player dragging soap around to scrub germs off hands.

These ideas were combined by creating a plan for a minigame with 4 stages for the player:

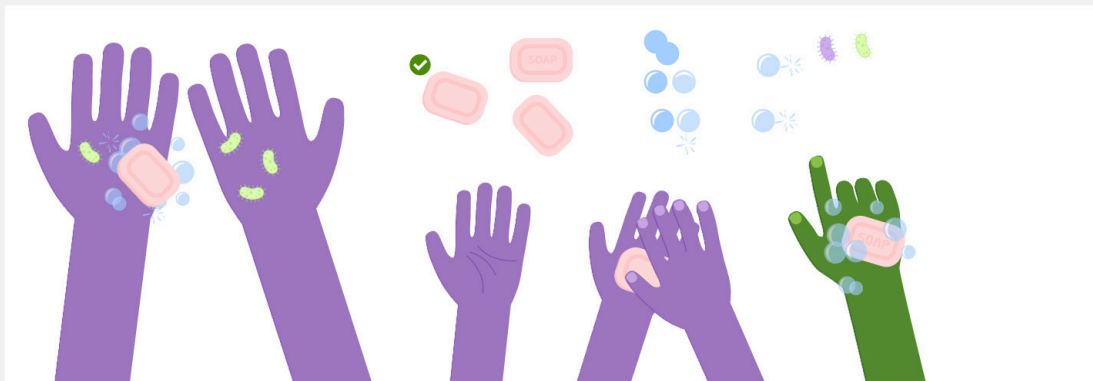
1. Wash the germs off the hands for twenty seconds.
2. Drag the old plaster/s into a bin.
3. Complete the puzzle by arranging the new plaster/s on the sores.
4. Germs appear on hands again to represent touching contagious sores. Wash the germs off the hands for another twenty seconds.

This minigame idea fulfilled criterion 1 by simulating each part of the treatment step with time for voice overs explaining why each stage was necessary. Criterion 7 is addressed by the ability to increase the challenge over time with more complex puzzle arrangements of sores and plasters.

Development and Asset Design

In regard to criterion 4, assets for the dressing minigame were created as vectors whilst looking at reference imagery to make recognizable forms. Colours for skin and plasters were carefully considered so that they were not relatable to only one skin colour, this can be seen in Figure 19 and 20 where the hands are purple and the final plaster is translucent. Plasters were chosen instead of bandages as they are a more common dressing.

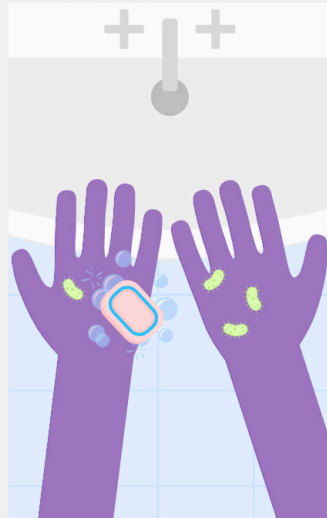
Frame 3



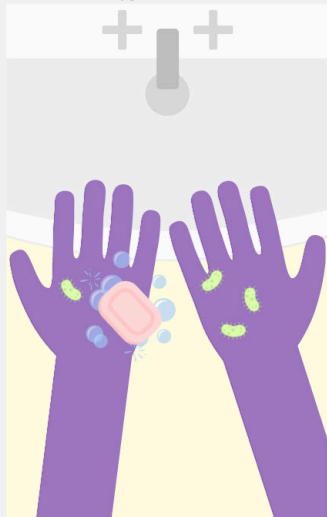
Lenovo TB3 710F Copy 13



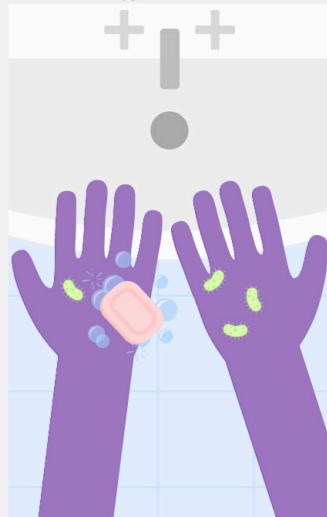
Artboard 13 Copy 5



Artboard 13 Copy 4



Artboard 13 Copy 3



Artboard 13 Copy 6

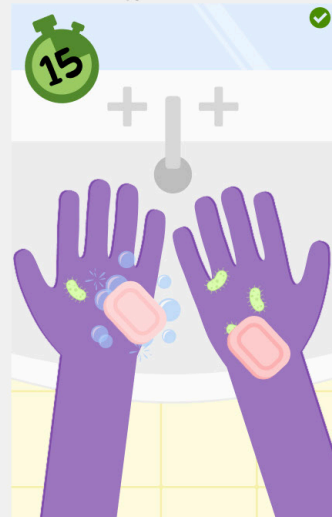


Figure 19. Creating dressing game vector assets



Figure 20. Creating dressing game vector assets

Development of the minigame included coding a script to allow a game asset to be dragged around the screen when the player is touching it. This script was coded to be reusable in case draggable assets were needed for other minigames and included an ability to toggle the draggability of an asset. To switch the assets needed between each state of the minigame a pair of reusable scripts was created to slide assets in and out of the screen. The first script was called a “set piece” and this allowed an in and out position to be specified when added to an asset. The asset could then be told to slide between the position with an eased animation. The second script was called a “set” and it could be given a list of set pieces to slide at the same time whenever needed by the main code of the minigame, a set sliding out can be seen in Figure 5. This pair of scripts was also reusable for use in the other treatment step minigames so that any time an asset needed to appear on or off screen the animation was consistent and expected by the player.

Each stage of the minigame was mapped to a progress bar (see Figure 21) to provide feedback to the player on their actions as required by criterion 6. Particle systems (Unity Technologies, 2018) were used to make bubbles appear and pop when washing hands (see Figure 21) and to make the clean plaster sparkle when it covers the sores (see Figure 22), this form of feedback indicates to that player that they are interacting correctly.

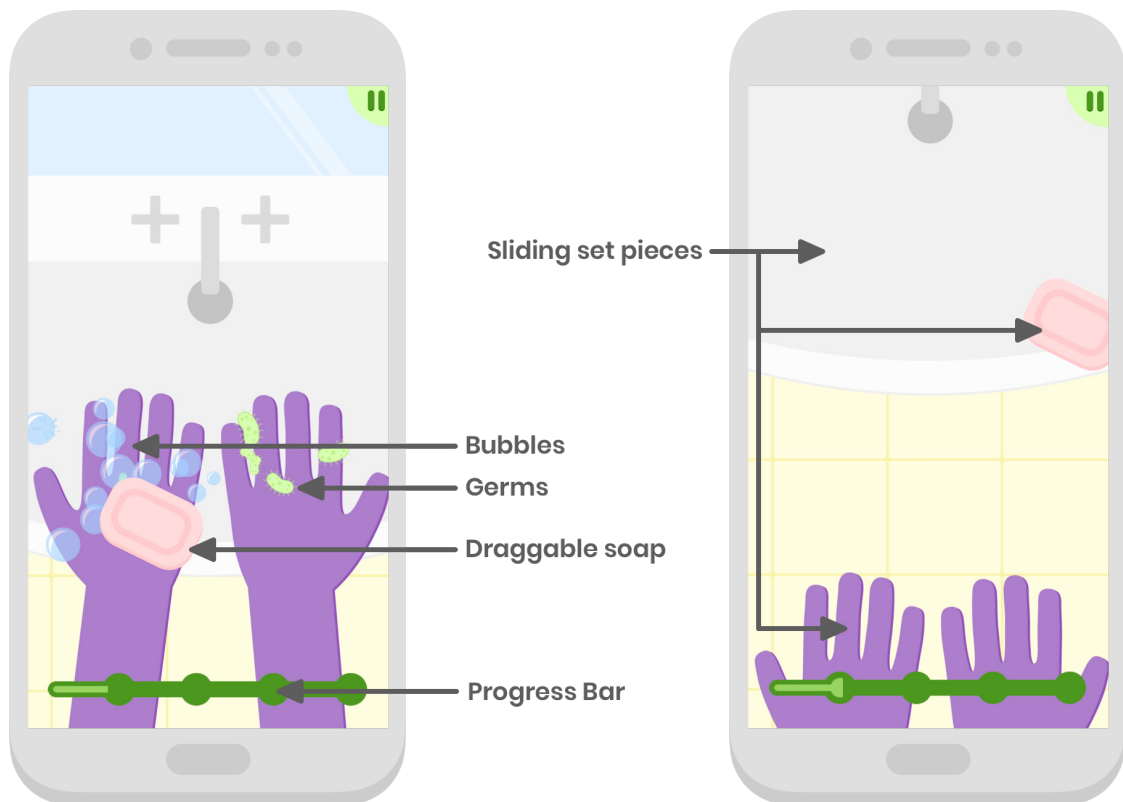


Figure 21. Screenshots of the first washing hands stage

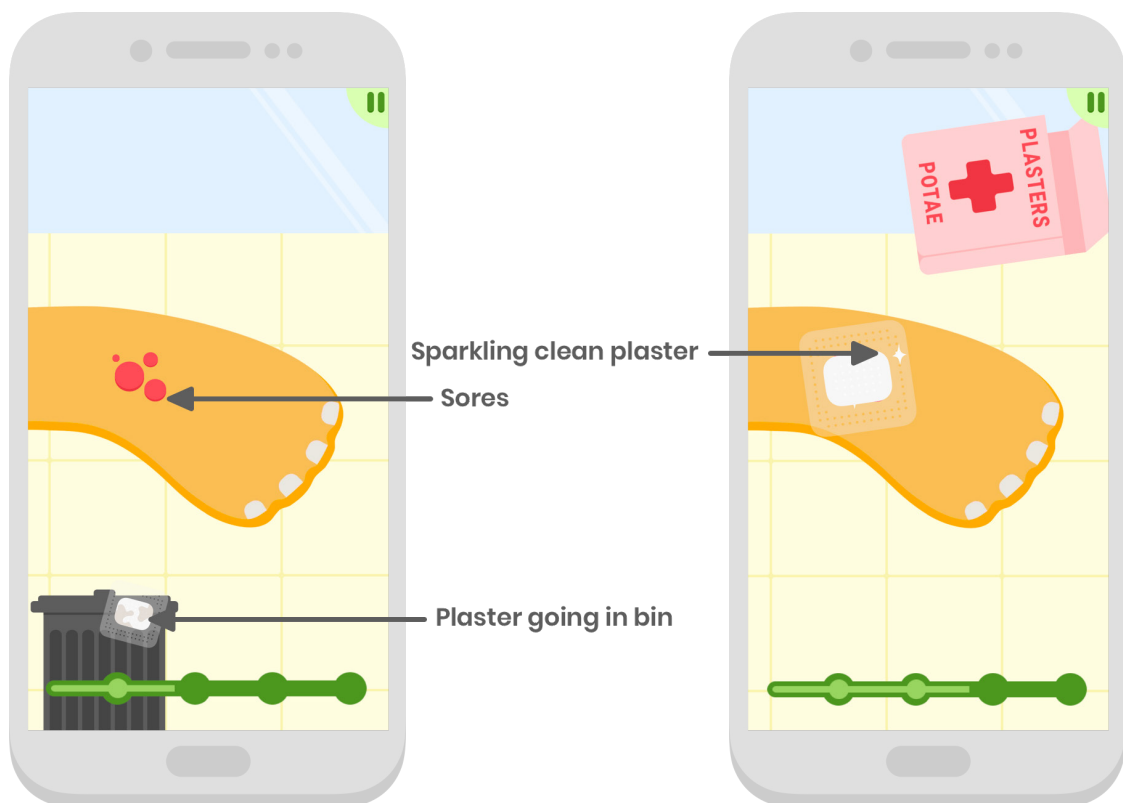


Figure 22. Screenshots of the changing dressing minigame

Table 5. *AR platform comparison*

<i>Platform</i>	<i>Positives</i>	<i>Negatives</i>
<i>ARKit</i> (Apple Inc., 2018)	Surface recognition Marker recognition Free	Exclusively Apple Runs on Apple devices iOS 11 or later (including iPhone 6S and above)
<i>ARCore</i> (Google Inc., 2018)	Surface recognition Image recognition Free	Runs on newer upmarket model devices only including: Google Pixel all models Samsung Galaxy S7 and above LG V30 Runs on Apple but only on ARKit supported devices
<i>Easy AR</i> (VisionStar Information Technology (Shanghai) Co., Ltd., 2018)	Image recognition Free	No surface recognition (at the time of developing the output)
<i>Vuforia</i> (PTC Inc., 2018)	Well supported in Unity Marker recognition Surface recognition Free to develop and test	Watermark on free version Paid to deploy

4.5 AR

“A technology that superimposes a computer-generated image on a user’s view of the real world, thus providing a composite view.” (Oxford Dictionaries, 2018)

Creating a game for a mobile platform provided an opportunity to include augmented reality (AR) technology. Some examples of existing application using AR technology include; the popular Pokemon GO mobile game (Statt, 2016) where Pokemon characters are visualised in the players surroundings, the IKEA app where users can place furniture around themselves (Lee, 2017) and the messaging app Snapchat has camera filters which augment the users appearance (Hern, 2015).

AR was relevant to the project as it provides a relatively easy to develop, yet powerful way to relate the game to the players real world and their treatment. Other technologies that could have been used included Virtual Reality which immerses the user in a virtual environment, however this would not provide the direct link between the game and the real world. Some simple experimentation was used to gauge how valuable use of AR would be in the final output.

There are two types of AR available; marker recognition looks for a specific image to load the AR visualisation on, whereas surface recognition detects flat surfaces in the room which AR visualisations could be mapped to. Platforms allow developers to build AR functionality into apps, games and other software. A comparison of different AR platforms was done to find the benefits and downfalls of each. As seen in Table 5, most platforms supported marker recognition, however surface recognition was only available on the more recently released devices. The game should not be restricted to use only on newer devices so the platform of choice was Vuforia. Vuforia works most devices, supports marker recognition and has good documentation in Unity. Unity was the game engine used to make output this meant less time could be spent on development. Vuforia is also free to develop and test with which is all that was needed within the scope of this project.

Initial tests were done to gauge what the marker size needed to be in order to be reliably detected by the camera on a lower end Lenovo tablet. A lower end device was used to ensure the technology would work on a wide range of devices and not be restricted to a limited audience with newer devices. These tests determined design possibilities with the marker, for example whether the marker could be small enough to be placed on a medicine bottle cap.

The results of these test can be seen in Figure 23 where a marker could be as small as approximately 3 cm and still register on the device. However the marker was registered most stable at the larger sizes over 5 cm. The next step of experimentation was seeing how AR could be used for a treatment step minigame where the player would be using AR and touching the screen simultaneously. I adapted the nail cutting minigame to use AR to project the growing nails to look as if they were growing from the players hand when a marker was placed on the skin (see Figure 24).



Figure 23. AR marker size testing results with NZ ten cent coin for reference

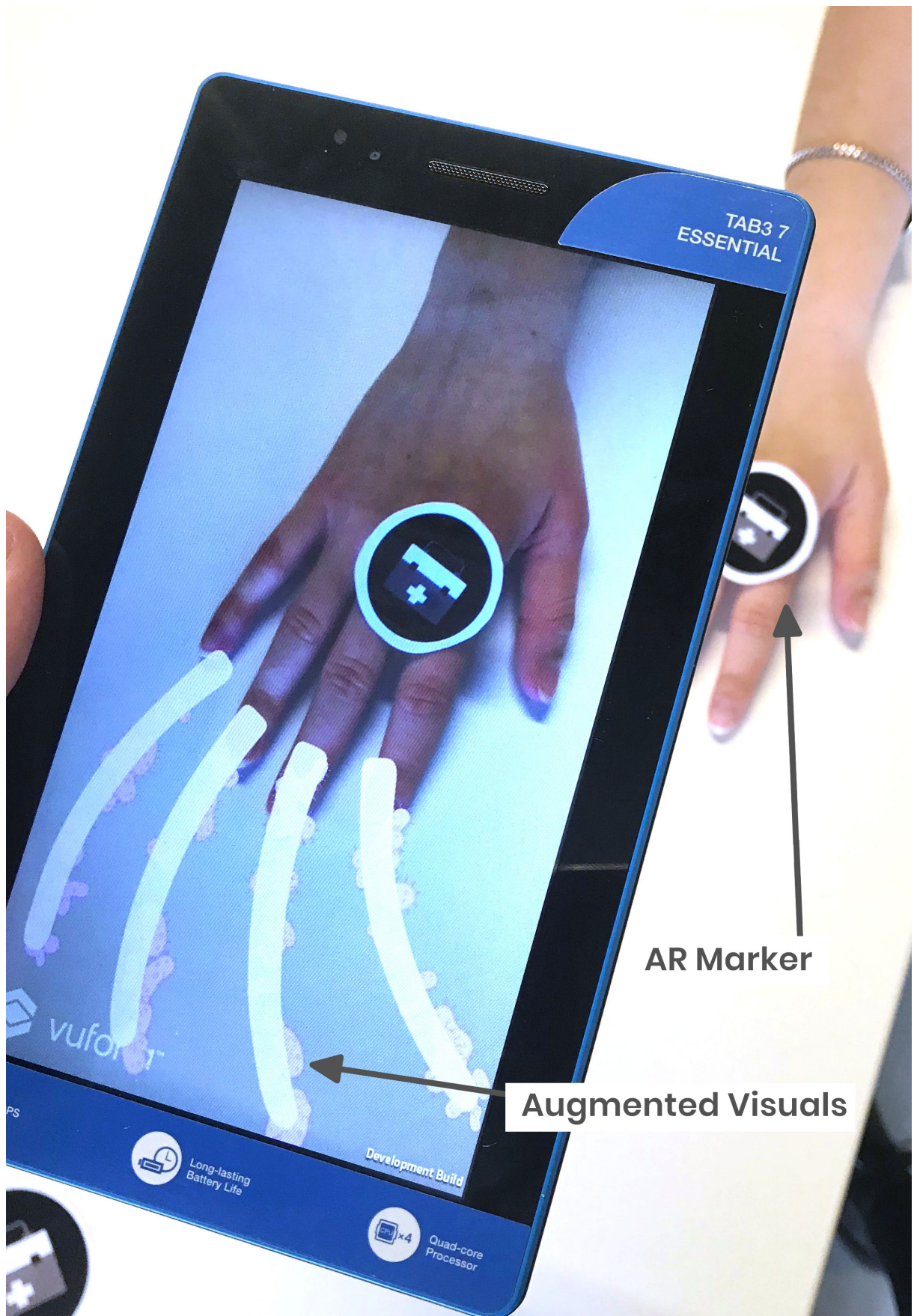


Figure 24. AR in game experiment in nail cutting minigame

This experiment showed how AR could be used to create a link between the virtual game and the player's physical body. There were many issues with using AR in this way and the experimentation showed that AR would need to be used in a simplified manner if it was to be implemented in my final output.

The issues included:

- Trying to hold the tablet in place to view the AR whilst trying to tap the screen to interact was very cumbersome.
- Difficulty getting dimensions correct when using markers with the players body as hand size would be variable amongst players
- Devices have cameras in different places, creating unexpected holding positions that could get in the way of touch screen interaction

After the issues uncovered in this experiment it was clear it would be more valuable to try and implement AR in a situation where the user would only be focusing on holding the device to view the AR visualisation. The time needed to overcome the issues of using AR to create a game interaction for each treatment step would be disproportionate to the timeframe of the thesis, therefore a better approach was to implement AR in a single recurring area of the game. When considering what the game needed to include there was two obvious places in which an AR visualisation could be used. The first place was the introductions and conclusions of the minigames when how the treatment step helps the player get better is explained. The second place was the progress through treatment visualisation as required by the criteria.

Initially the introductions and conclusions were implemented in AR, beginning with the nail cutting minigame (see Figure 25). At this stage of the design process the minigames were being built out as individual games to allow for quick testing and iteration.



Figure 25. AR experiment initial implementation introduction (left) and conclusion (right)

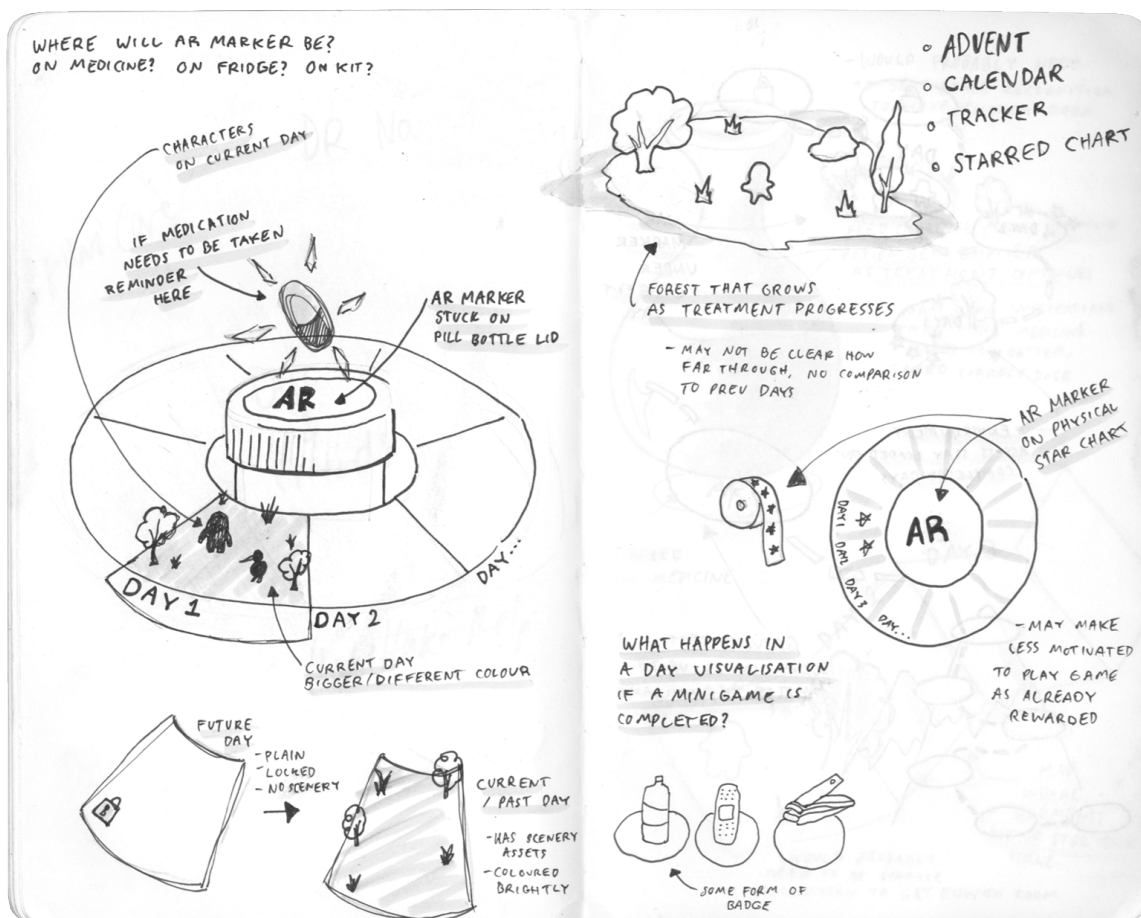


Figure 26. Idea generation of treatment progression visualisation in AR (1)

Traditional game level displays provided inspiration for the treatment progress visualisation. Some level displays took the form of a map, others had boxes that unlocked or a carousel of levels to look through. It was also key to consider that in this case a “level” was a day of treatment for the player so time could be represented.

After generating ideas through sketching (see Figure 26 and 27) a mock-up of two possible AR level maps was made to see how effective the idea would be when using the technology (see Figure 28). When evaluating the two different versions the map was a better representation of progression as it had a start and end point as opposed to the continuous round “disk” version (see Figure 28). This led to iteration and focus on the more common map approach to represent the players journey both through their treatment and the game.

When combining the different sections of the game into a single entity the use of AR in the minigames and map visualisations was merged. This meant that the player would only need to get the AR working for the map. The player can then see the characters play out the introduction on the map in AR before the minigame is played. After the minigame is completed the game switches back to the map in AR for the conclusion.

The use of AR in the game creates a link for the player between the themes and activities within the game and the real world. It was considered how AR could be used to make patterns in the players day to day life around their treatment. By using a marker instead of surface recognition the player has to seek out their treatment kit/medication that the marker is on in order to continue on and play the game. This means that the treatment steps the player is being taught about in the game can be completed right after the game is played, with the actual medication/treatment kit ready in front of the player as a reminder.

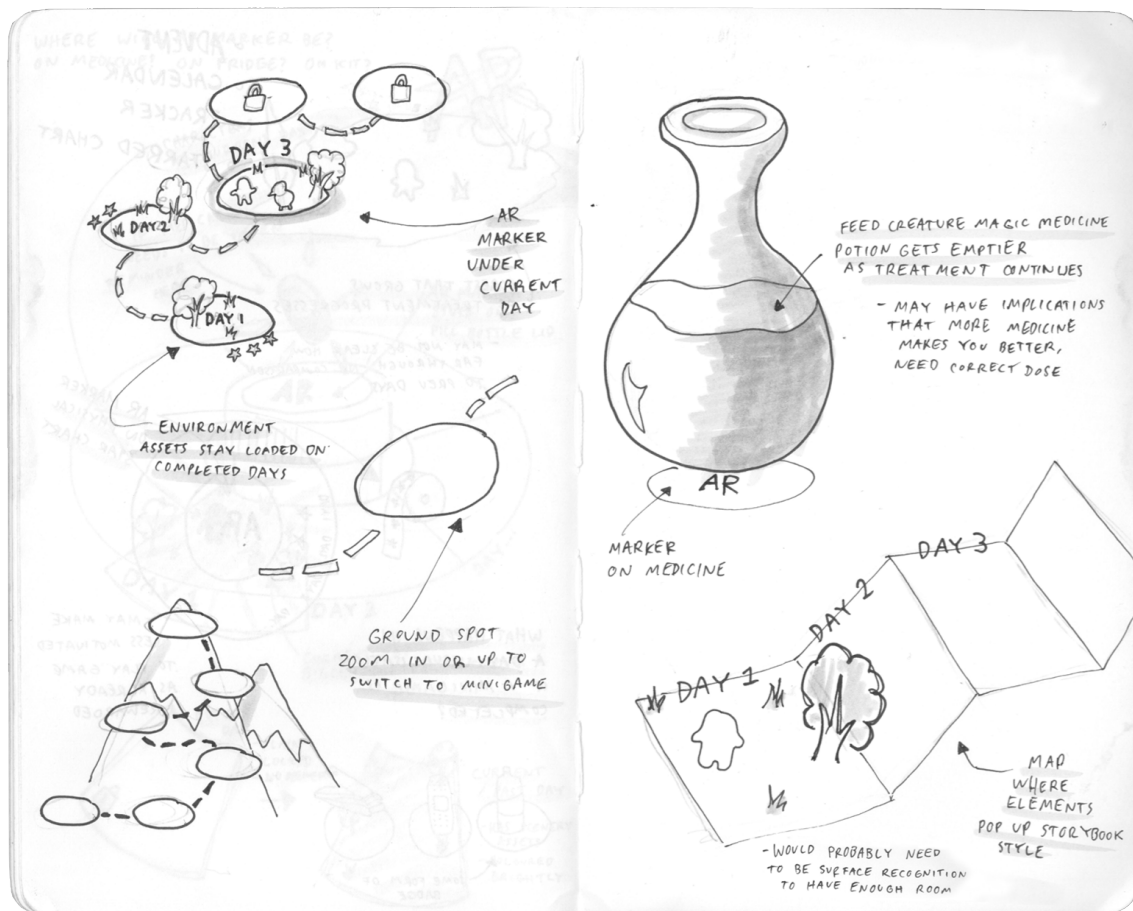


Figure 27. Idea generation of treatment progression visualisation in AR (2)

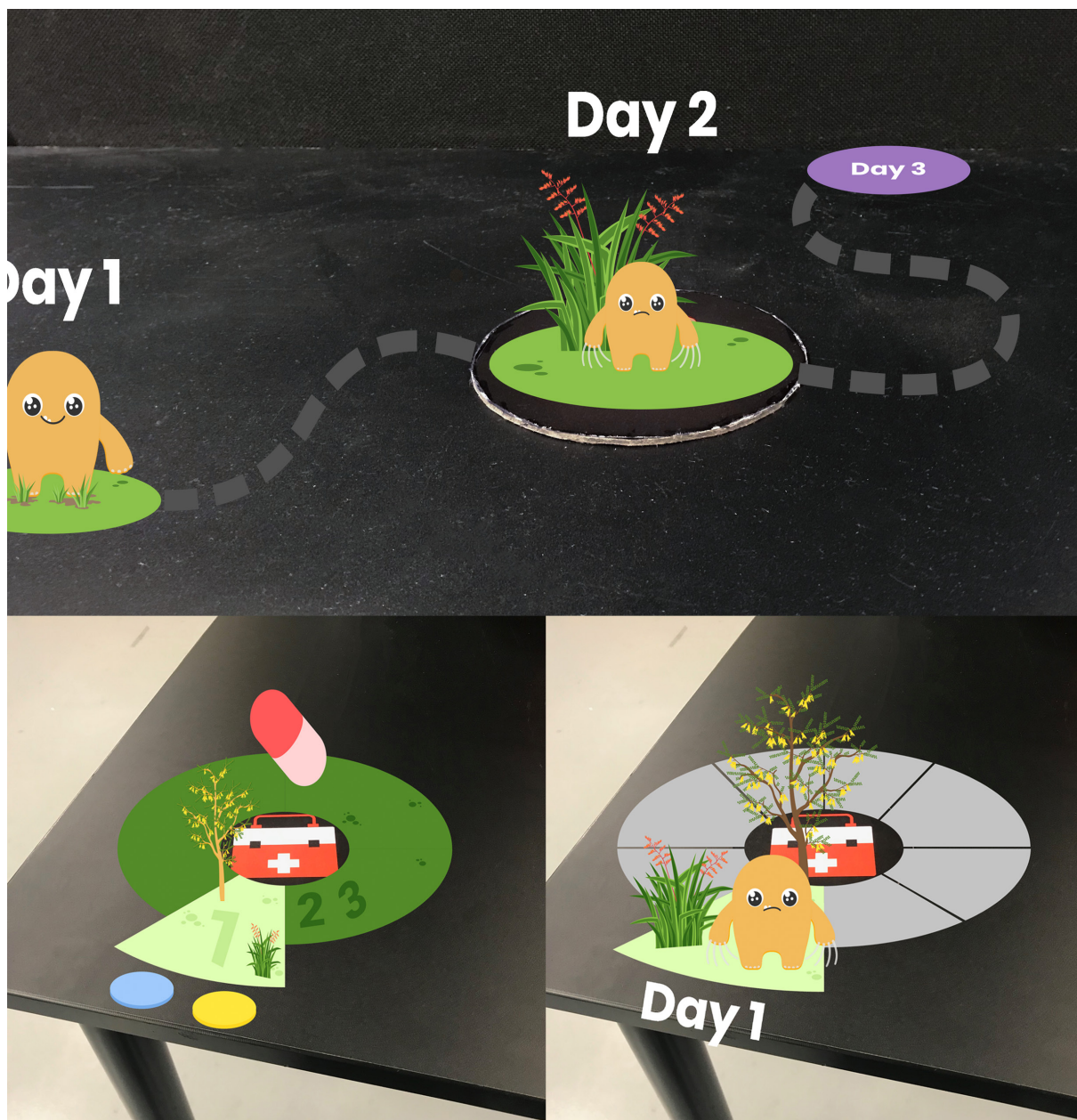


Figure 28. Mock-up of AR progress visualisations, map (top) and disk (bottom)

4.6 Iterations

The two minigames with the AR visualisation of treatment progress were combined into a demonstration version of the game that could be used for a play test. The introductions and conclusions to each minigame were updated to use the AR map as discussed in the previous section.

To create the modularity of the game a players treatment regime needs to be provided. The game was developed the game with this in mind by making settings within a data file to turn different minigames on and off. The game was coded to load this data file and save which day of a treatment the player is on as well as which minigames have been played. This data file could contain which treatment minigames should be played on certain days so that the iMoko team can enter different treatment regimes. For the demonstration version this data file loaded both the nail cutting minigame and the dressing game.

Other additions and changes to the game for the demonstration version included:

- A pause menu so the data file could be reset during testing sessions.
- Updating the nail cutting minigame to use the “set” sliding scripts from the dressing minigame.
- A tutorial for the AR functionality (see Figure 29).
- Transitions between the AR introduction and 2D minigames; increasing the size of the green current day ground patch asset and use of the “set” sliding scripts (see Figure 29).
- Detection of whether the current day on the AR map was on screen so that the introductions and conclusions of the minigames could be seen and the transition to the 2D minigame was visible.
- Background music and audio effects such as bubbles popping and New Zealand birdsong.

Screenshots of the demonstration version with the discussed updates above can be seen in Figure 29.

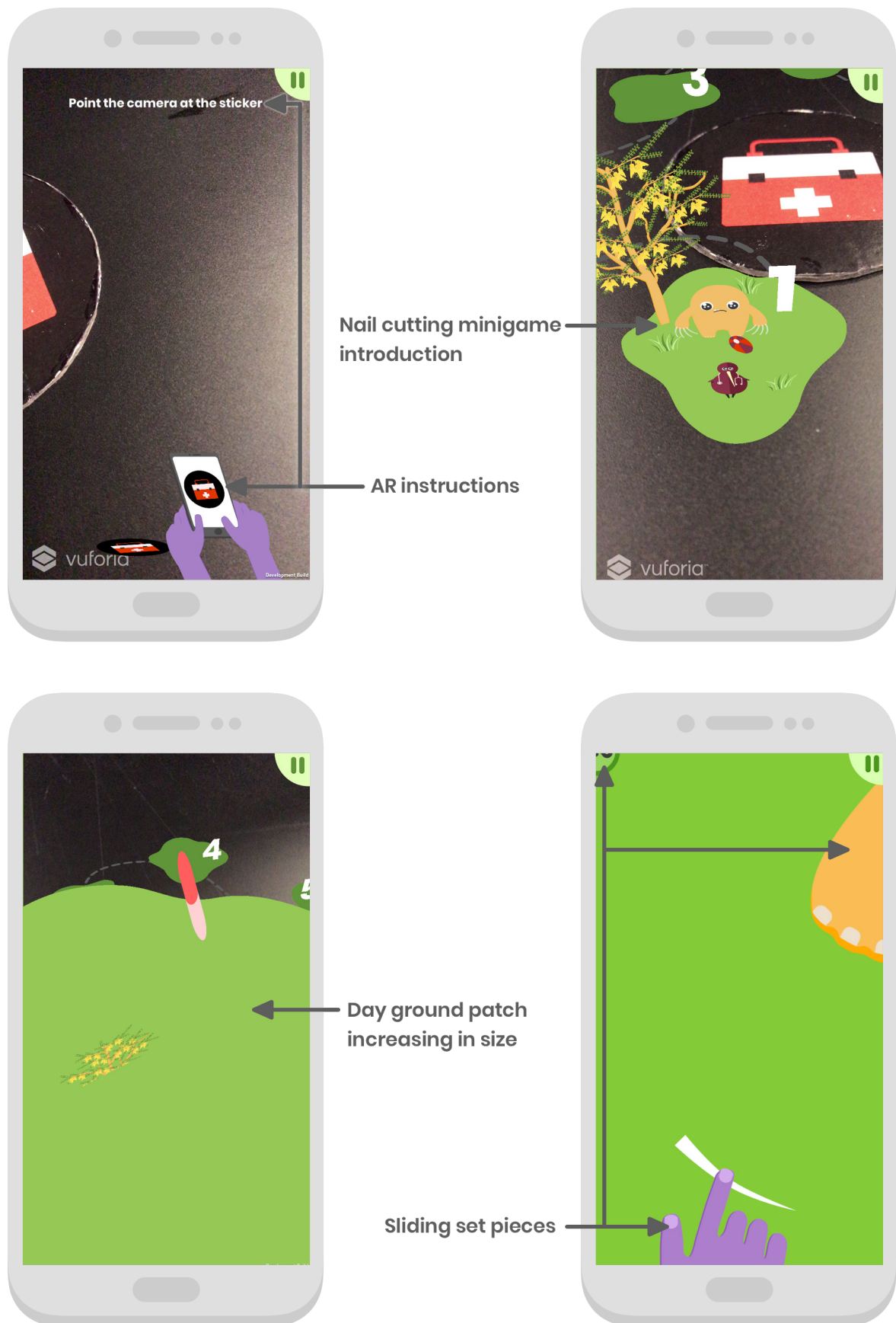


Figure 29. Screenshots of additions and changes in the demonstration version of the game

5 Testing

Testing was conducted to determine if the game was usable, engaging and educated the player around the treatment steps of skin sores through simulation. It was important to collect information from children to gain genuine opinions, attitudes and to observe the children's behaviour (De Leeuw et al., 2004, p. 409; Tisdall, Davis, & Gallagher, 2009, p. 5). Play testing the game with children was necessary to ensure the game was appropriate and usable for the target audience. Adult assumptions may not predict children's responses adequately (Andersen, Khalid, & Brooks, 2016, p. 236) and children may have different physical usability issues such as holding a device with smaller hands.

The procedure began with an introduction section where the participants are welcomed with an explanation of the research and what they can expect during testing. This section was included to help to build a relationship with the participants and make them feel comfortable during the tests (Hafit, Razak, & Haron, 2011, p. 150; Hanna, Ridsen, & Alexander, 1997, p. 11-12). Next was the usability, education and engagement testing section of the procedure where instructions and questions were read out loud to participants for testing education and usability, and signs of engagement were assessed through observation. Reading instructions was necessary so that all participants understood what was needed from them (Hafit, Razak, & Haron, 2011, p. 150; Hanna, Ridsen, & Alexander, 1997, p. 13-14). Upon finishing the testing session the participants were thanked and given a small reward to make them aware of how valuable their participation was (Hafit, Razak, & Haron, 2011, p. 150; Hanna, Ridsen, & Alexander, 1997, p. 13-14).

Insights from the informal exploratory play testing (see Chapter 4, Section 3) included that answering questions was difficult for children and that questions must be worded carefully to avoid leading answers. Guidance during a play test should be allowed if the player asks for help or is unable to progress. If the player is not assisted they may become uncomfortable and usability findings for later parts of the game will be missed.

Table 6. *Original SUS compared to adapted SUS*

Original System Usability Scale	Adapted System Usability Scale
<p>Strongly disagree Strongly agree</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="border: 1px solid black; width: 40px; height: 20px; margin: 5px;"></div> <div style="border: 1px solid black; width: 40px; height: 20px; margin: 5px;"></div> <div style="border: 1px solid black; width: 40px; height: 20px; margin: 5px;"></div> <div style="border: 1px solid black; width: 40px; height: 20px; margin: 5px;"></div> <div style="border: 1px solid black; width: 40px; height: 20px; margin: 5px;"></div> </div> <div style="display: flex; justify-content: space-around; margin-top: 5px;"> 12345 </div>	<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <div style="border: 1px solid black; border-radius: 50%; width: 40px; height: 40px; line-height: 40px; margin: 0 auto;">1</div> <div style="color: red; font-size: 20px; margin: 5px 0;">👎</div> <div style="font-size: 8px;">I don't think so</div> </div> <div style="text-align: center;"> <div style="border: 1px solid black; border-radius: 50%; width: 40px; height: 40px; line-height: 40px; margin: 0 auto;">2</div> </div> <div style="text-align: center;"> <div style="border: 1px solid black; border-radius: 50%; width: 40px; height: 40px; line-height: 40px; margin: 0 auto;">3</div> </div> <div style="text-align: center;"> <div style="border: 1px solid black; border-radius: 50%; width: 40px; height: 40px; line-height: 40px; margin: 0 auto;">4</div> </div> <div style="text-align: center;"> <div style="border: 1px solid black; border-radius: 50%; width: 40px; height: 40px; line-height: 40px; margin: 0 auto;">5</div> <div style="color: green; font-size: 20px; margin: 5px 0;">👍</div> <div style="font-size: 8px;">I think so</div> </div> </div>
Participant marks a check in relevant box	Participant places sticker in relevant circle
<p>Statements</p> <ol style="list-style-type: none"> 1. I think that I would like to use this system frequently 2. I found the system unnecessarily complex 3. I thought the system was easy to use 4. I think that I would need the support of a technical person to be able to use this system 5. I found the various functions in this system were well integrated 6. I thought there was too much inconsistency in this system 7. I would imagine that most people would learn to use this system very quickly 8. I found the system very cumbersome to use 9. I felt very confident using the system 10. I needed to learn a lot of things before I could get going with this system 	<p>Statements</p> <ol style="list-style-type: none"> 1. I think I would like to play this game lots 2. I found the game hard to play 3. I found the game easy to play 4. I think I would need someone to help me play the game 5. I found that each part of the game worked well 6. I thought the game changed too often 7. I think other kids my age could play this game 8. I found the game uncomfortable to play 9. I felt like I could play the game well 10. I needed lots of help to play the game
<p>Readability Results</p> <p>Flesch Reading Ease score: 73.4 (fairly easy to read)</p> <p>Flesch-Kincaid grade level: 5.8 (sixth grade)</p> <p>Gunning Fog: 7.7 (fairly easy to read)</p> <p>Automated Readability Index: 4.3 (8-9 years)</p> <p>The Coleman-Liau Index: 7th grade</p>	<p>Readability Results</p> <p>Flesch Reading Ease score: 107.5 (very, very easy to read)</p> <p>Flesch-Kincaid grade level: 0.4 (kindergarten)</p> <p>Gunning Fog: 3.5 (easy to read)</p> <p>Automated Readability Index: -0.3(3-5 years)</p> <p>The Coleman-Liau Index: 3rd grade</p>

5.1 Participants

The game was tested with nine participants between the ages of five to seven from primary schools with the iMoko program. These participants were recruited through Dr Lance O’Sullivan from iMoko as the project ethics allowed and each participant had parental permission. The ethics application and other related documents can be found in Appendix B.

5.2 Usability Assessment

The Standard Usability Scale (SUS) (Brooke, 1996, p. 4) was adapted to be suitable for children (see Table 6). This adaption was needed as questions for children should use simple language, be short and have explanations if necessary (Bell, 2007, p. 463; Yáñez-Gómez, Cascado-Caballero, & Sevillano, 2017, p. 17).

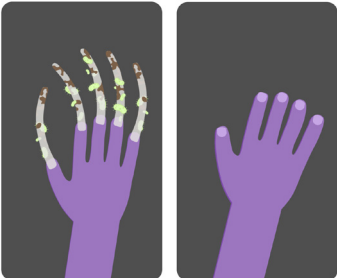
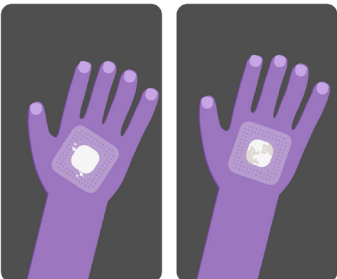
The SUS statements were analysed by using readability scales to find the readability of the original statements. These results were compared to the adapted statements which had been adjusted to use simplified language.

The process of completing the scale was also changed so that statements were read out loud to the participants and explained if necessary. The scale itself was modified to use stickers and visual cues to encourage the children to participate (Tisdall, Davis, & Gallagher, 2009, p. 18-20). The participant was also observed (Curedale, 2016, p. 110) during the play test to find usability issues.

5.3 Education Assessment

Open ended questions were needed to avoid leading answers when testing whether the participants had learnt how to do the treatment steps and why they are necessary. The solution to this was using flashcards and asking the participant what they could tell us about the pictures (see Table 7). Secondary prompts were used if an unrelated response was given or if there was no response.

Table 7. *Education testing questions and flashcards*

Open Ended Question	Prompt 1	Prompt 2	Flashcard Set
“What can you tell me about these two pictures?”	“Which picture has nails that won’t spread germs?”	“What can be done to stop the germs from spreading from this one?”	
	“Which picture has a dressing that needs changing?”	“Why does it need changing?”	

5.4 Engagement Assessment

Observation (Curedale, 2016, p. 110) was the main method for testing engagement, looking for body language, facial expression and verbal response. Observation was especially key for engagement as the data can be more reliable than responses where the child participant may give a positive answer to please the tester (Hanna, Risdén, & Alexander, 1997, p. 13-14). The “I think I would like to play this game lots” statement within the adapted System Usability Scale was also linked to engagement as it addressed how often the participant would like to play. At the end of the session the participant was asked if they would like to play the game again to see whether it was engaging enough to make the participant want a second turn. These observations and responses were thematically analysed to find themes within the results related to the engagement theories of flow and the persuasive strategies of simulation, personalization and reward.

5.5 Procedure

Consent forms and information sheets were sent to parents to sign before conducting the testing sessions.

1. **Introduction**

Welcome participant and check consent form is signed by parents. Read child friendly summary of project and what the session will involve. Remind participants that they can stop the session at any time.

2. **Warm up exercise**

Creative warm up exercise to build a relationship with the participant. Provide participant with pens and paper and ask if they can draw what they think a germ looks like.

“To start we have a drawing task, can you please draw what you think a germ looks like?”

3. **Play test**

Participant has one play through of game, filming with multiple cameras to capture body language and facial expressions as well as device interactions. Assist if participant asks for help or cannot continue in the

game for more than 15 seconds.

“Can you please play this game, if you get stuck and and can’t work it out you can ask for help”

Recording equipment:

- Over shoulder video camera
- Video camera facing participant
- Audio recorder

4. Follow up interview

Short interview about game experience with props: sticker scale and flash cards.

- System Usability Scale exercise, explain to participant and provide stickers for chart. Read questions out loud as well as the printed version with the scale on each bit of paper.

“Thinking about the game can you put a sticker on the scale on how much you agree with what I say? Closer to this end if what I said is what you think and closer to this end if what I said is not what you think.”

- Education questions, show participant set of flashcards and begin with open ended questions, prompting with follow up specific questions if the answer is unrelated or not given.

Ask participant if they would like to play the game again and offer them the device to use.

“Do you want to play the game again?”

If the participant wants to play again continue filming and provide assistance if needed.

6. Conclusion

Thank the participant and offer reward of a small sheet of stickers. The participant is not told they will receive a reward before the session ends to ensure answers are not affected.

“Thank you so much for your help! It will be very useful to help us to finish the game. Would you like some stickers?”

5.6 Limitations

The testing was limited as recruitment was only possible through Dr Lance O'Sullivan as the ethics application allowed. This meant the research team had travel to the recruited primary schools in a different city and only two sessions were possible within the thesis scope. The usability testing guidelines for children suggested that a pilot test would be conducted before hand to refine the process (Hafit, Razak, & Haron, 2011, p. 150) however this was not possible with the limited number of participants.

Minor adjustments were made during the sessions instead of conducting a pilot test, this is discussed with the results in section 5.7.1.

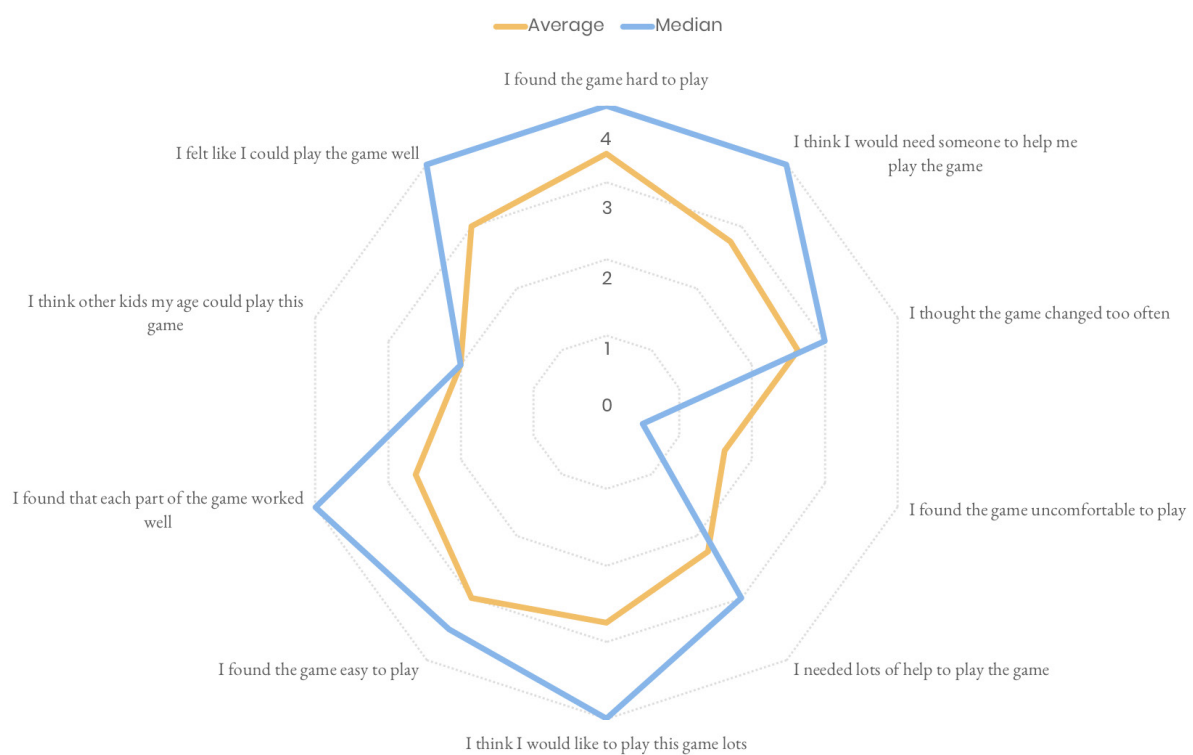


Figure 30. Average and median scores for each SUS statement (high score is a better result, not that the participant agrees with the statement)

5.7 Results

Majority of the testing sessions produced useful findings and were completed without significant issues. The first primary school had invited a parent/guardian to be present for the testing which caused some unexpected interference, however some children seemed comforted by their presence. We chose to not conduct the session for one of the participants at the second school as they were not answering any questions and looked very uncomfortable.

5.7.1 Usability

During the first lot of testing sessions the SUS was adjusted having to rating negative statements highly to agree with the statement was confusing participants. Each individual statement was explained how it related with the scale; for example the “I think other kids my age could play this game” was explained as “all kids my age could play the game” when pointing at the higher end of the scale. After the second testing session the “I found the game hard to play” statement was removed as it was too similar to the “I found the game easy to play” statement and was confusing participants as one came directly after the other. This was also to remedy the issue of participants had been getting restless as the SUS section of testing was quite long. After the third testing session the “I found the game uncomfortable to play” statement was also changed to be explained as the device being tricky to hold or use. The results for the “I found the game easy to play” were duplicated for the removed “I found the game hard to play” statement so the SUS total scores could be calculated.

Figure 30 shows a radar chart of the average and median responses for each SUS statement. This chart was used to show clearly what areas need improvement. The results show that some participants found that using or holding the device was uncomfortable or tricky. Most participants did think that they would want to play the game often and that they could play it well. Interestingly the results show that most participants found the game a suitable level of difficulty yet did not think all children their age could play it. Most participants thought that they could play the game without help.

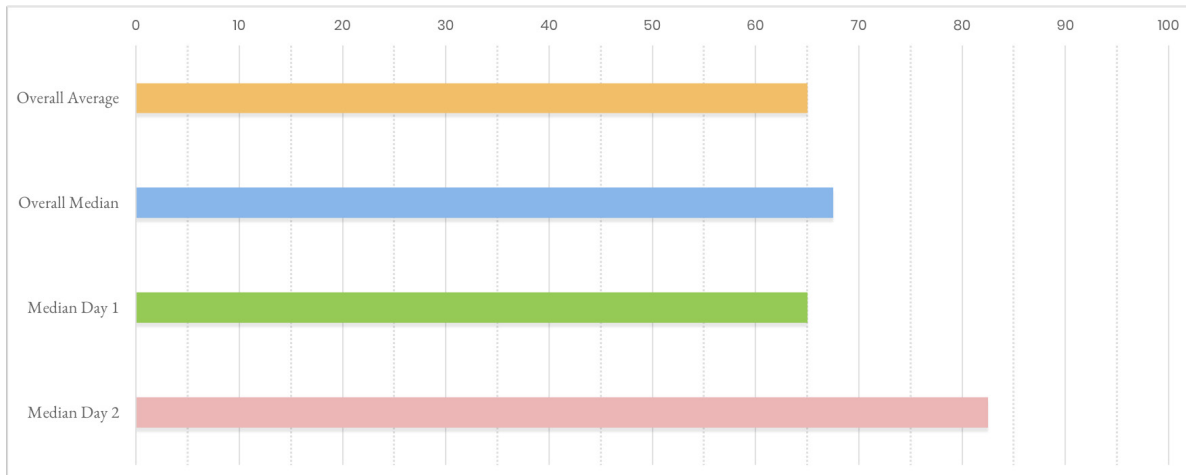


Figure 31. Overall median, overall average, day 1 median and day 2 median for the SUS total scores.

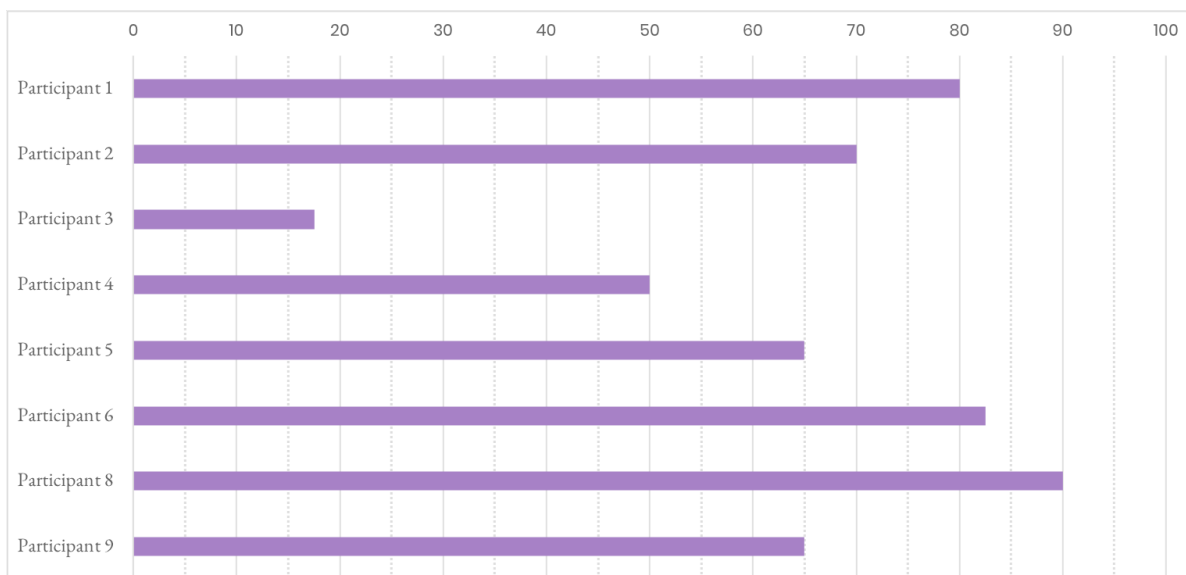


Figure 32. SUS score totals for the individual participants.

The first day of testing returned a median SUS score of 65. Between the two days of testing some usability issues were fixed within the game, particularly around participants not swiping more than once to play the nail cutting game properly. This issue was fixed by a voiceover prompting the player to swipe the nails again whenever two or more nails grew too long. This appeared to have a positive impact on the median SUS score which rose to 82.5. The average and median SUS scores overall and for each day of testing can be seen as a bar chart in Figure 31.

Observations from the video recordings of the play test were thematically analysed (see Figure 33) to find the areas where usability issues were common. This was done in addition to the SUS as children may not verbalise issues they discover in usability testing (Markopoulos & Bekker, 2003, p. 235).

It was also important to discover any usability issues specific to different parts of the game as well as the overall usability. The usability themes and example observations can be seen in Table 8. The dressing minigame was found to be very usable in its current state whereas the nail cutting game had a few issues around unclear instructions. The AR usability needed improvement as some participants found the initial relationship between the marker and the camera hard to understand.



Figure 33. Process of grouping notes into themes for the thematic analysis of usability observations

Table 8. Usability themes and example observations

Theme	Example Observations
<p>It is unclear that players must swipe more than once after following initial instruction in the nail cutting minigame.</p> <p><i>This was fixed in between the two testing days by adding prompts to keep swiping.</i></p>	<p>Participant 4 kept losing the minigame and tapping replay as they did not swipe to cut the nails multiple times. When shown to swipe more they completed the game.</p> <p><i>Once fixed each participant on the second day of testing worked out how to play the minigame without assistance.</i></p>
<p>Some areas of the game need more voiceovers or clarification of what is happening when in loading states.</p>	<p>“What’s going on?” - Participant 1 when game was in a loading state without explanation.</p>
<p>The dressing minigame is very usable in its current state.</p>	<p>Each participant was able to complete the minigame without assistance.</p>
<p>The day numbers on the AR map visualisation are not a clear representation of time by themselves.</p>	<p>“I’m on number two” - Participant 2 when the AR introduction for the second minigame was playing.</p> <p>Participant 8 tried to tap number 2 after the nail minigame and number 3 after the dressing minigame.</p>
<p>The AR needs a better tutorial and explanation for some players.</p>	<p>AR marker was placed in front of the camera for Participant 1 but the tablet was held so close to it that they could not see the augmented visuals.</p>
<p>Some players can get the AR working from the in game instructions.</p>	<p>Participant 4, 5, 6, 8 and 9 got the AR working without assistance.</p>
<p>Once the AR is explained or the player has got it working once the player can get it working when it loads again.</p>	<p>When game returned to the AR state for the dressing game conclusion Participant 2 immediately moved the tablet so the AR marker was in view.</p>
<p>The current day should be centred in the AR view as the characters are not always visible.</p>	<p>“He doesn’t have arms or legs?” - Participant 6 mistaking the AR marker graphic for a character.</p> <p>Participant 8 had the augmented visuals showing but the characters were offscreen.</p>



Figure 34. Process of grouping notes into themes for the thematic analysis of education testing results

Table 9. *Example quotes and related themes of the education interview*

Example Quote	Related Theme
<p><i>"Have to take the plaster off cos it's dirty and yucky"</i> - Participant 8</p> <p><i>"Keep it clean"</i> - Participant 3</p> <p>Participant 1, 2, 5, and 8 pointed at dirty plaster in response to "Which picture has a dressing that needs changing?" prompt.</p>	Some players know to change the old dressing.
<p><i>"That one doesn't got germs"</i> - Participant 2 points at cut nails flashcard.</p> <p><i>"They're dirty"</i> - Participant 4 points at long nails flashcard.</p>	Players know that long nails are dirty/have germs whilst short nails are clean after playing the game.
<p><i>"Get the pinchy things and cut them off"</i> - Participant 5 whilst gesturing cutting nails.</p> <p><i>"This one needs cleaning, cut the nails"</i> - Participant 1</p>	Most players know to cut nails to get rid of germs after playing the game.
<p><i>"Um I dunno"</i> - Participant 4 in response to the <i>"What can be done to stop the germs from spreading from this one?"</i> prompt.</p>	Some players don't know what to do to long/dirty nails after playing the game.
<p><i>"That pictures right because the sore is healing, I see no germs on that one"</i> - Participant 5 pointing at the clean plaster flashcard.</p>	Players know which dressing is clean and which is dirty/has germs.
<p>Participant 3, 6, and 9 pointed at the clean plaster graphic in response to the <i>"Which picture has a dressing that needs changing?"</i> prompt.</p>	Some participants are confused by the dressing graphics.
<p><i>"Cos your plasters dirty"</i> - Participant 9</p> <p><i>"Plasters"</i> - Participant 3</p>	Participants are unfamiliar with the word dressings, plasters is more understandable.

5.7.2 Education

The semi-structured interview was selectively transcribed (Davidson, 2009, p. 38) to only record behaviour and quotes relevant to the education questions. The thematic analysis of the transcription (see Figure 34) was used to find out what the participants knew about the treatment steps after playing the game. The common themes found and example key quotes can be seen in Table 9.

After playing the game participants knew that the long nails had germs or could point out that they were dirty. The majority of participants understood the treatment step of cutting the nails. However, some of the participants were unable to answer prompts, whilst others gave unexpected solutions such as to wash or wipe the germs off.

“Have to take the plaster off cos it’s dirty and yucky”

- Participant 8

Participants knew that the plaster should be changed to keep it clean or if it was dirty but some recognized the wrong graphic as being dirty. An important insight linked to the design criteria was that participants were more familiar with the word “plaster” than “dressing”.

5.7.3 Engagement

When coding the play test video recording attention was given to nonverbal behavior as movement behaviour is more common for younger children (De Leeuw et al., 2004, p. 426) and children may not respond honestly to questions about how much they liked a system (Hanna, Risdén, & Alexander, 1997, p. 13-14). Body language and facial expression such as smiling, laughing and holding the tablet closer to the participant were coded as signs of engagement. Observations of frowning, closed body language and playing the game with as little effort as possible were coded as signs of disengagement. A thematic analysis (see Figure 35) was used to find common themes of engagement.

Themes found and example observations can be seen in Table 10. A common theme was that participants found the dressing game engaging enough to create unnecessary interactions. When completing the washing hands step, participants were observed interacting to simulate steps that were not part of the game, such as dragging the soap back to beside the sink and tapping the tap to turn it off.

“Oh yay!” (upon winning a minigame)

- Participant 5

A common theme was that participants wanted to play the game multiple times. The SUS statement “I think I would like to play this game lots” was agreed with by the majority of the participants (5 out of 8) with one participant giving a neutral answer and two participants disagreeing. When asked if the participants wanted to play the game again at the end of the session the majority wanted another turn (7 out of 8).

“I want to play it lots of times!”

- Participant 6



Figure 35. Process of grouping notes into themes for the thematic analysis of engagement observations

Table 10. *Engagement themes and example observations*

Theme	Example Observations
Players were engaged enough in the dressing minigame that they created unexpected interactions	<p>Participant 1 dragged the soap back to beside the tap once hands were washed.</p> <p>Participant 4 tapped the tap when hands were washed.</p>
Players were engaged in the dressing minigame, particularly the washing hands step.	<p><i>“Eww, germs”</i> - Participant 6 whilst smiling and washing hands.</p> <p>Participant 9 began to wash hands by dragging the soap in circles faster and faster.</p> <p>Participant 8 moved to hold tablet closer and did each step very carefully.</p>
Players were engaged in the nail cutting minigame.	<p><i>“Get off, they’re gonna spread everywhere”</i> - Participant 5 on second turn of game whilst leaning in close, swiping and grinning.</p> <p><i>“2, 1, Yay!”</i> - Participant 6 counting down with timer at the end of the minigame.</p>
Engaged players experimented with different techniques to cut the nails.	<p>Participant 2 began to drag finger up each nail to cut it and celebrated by dancing when they won.</p> <p><i>“Hey!”</i> - Participant 1 when swiping faster to cut nails by using more fingers.</p>
Most players want to play the game multiple times.	<p><i>“I want to play it lots of times!”</i> - Participant 6</p> <p>Participant 9 gave a big nod and grinned when asked if they wanted to play again.</p>
Some players found the AR engaging.	<p>Participant 5, 6, 8, and 9 either smiled or laughed whilst looking at the AR visualisation.</p>
Not every player will find the game engaging.	<p>Participant 3 played the game with disinterested body language and did not want a second turn.</p> <p>Participant 3 and 4 rated the SUS “I think I would like to play this game lots” statement a 0 (did not agree with the statement at all)</p>

5.8 Testing Insights

Insights gained after completing the two testing sessions included a need to resolve issues with the adapted SUS statements as the format used was not immediately understandable by some participants. Explaining each statement to the participant helped however, the scales could be visually adapted further. Replacing numbers with imagery or verbal labels which children are more likely to interpret correctly (Bell, 2007, p.465) would be beneficial. The sets of two statements to balance for positive and negative valence within the SUS is suitable for adults, however some guidelines suggest avoiding negatively phrased questions with children completely (Borgers, de Leeuw, & Hox, 2000, p. 65). After testing the adapted set, it is clear that further adaptation for children, or research into alternative usability measures that avoid negative phrasing would be valuable.

Other insights included the importance of defining clear guidelines of when to assist during play testing and establishing a rapport with the participant before beginning the test. The testing procedure for education of a semi-structured interview using open ended questions and flashcards was a successful way to assess whether participants were educated around the treatment steps. The preparation of additional prompts that do not lead answers would be useful for unresponsive participants. These testing insights are valuable findings to consider in other research conducting tests with children for usability, education and engagement.

6 Design Phase Two

6.1 Expert Review

The demonstration version of the game was reviewed by research advisor Dr Lance O’Sullivan. This review was to confirm that treatment steps were correct and find what additions would be most valuable to the game in the future.

Suggestions from the review included:

- An introduction section should be added to the game with an explanation of what a germ is.
- The player should be reminded to wash their hands before eating, after using the toilet and if they touch their skin sores.
- A conclusion section should be added when the game is completed to remind the player if the treatment steps are followed they can avoid getting skin sores again.
- The player should be reminded every day to take their medicine, even when they are feeling better as it is important that antibiotic prescriptions are finished.
- Taking photos of the sores to send to iMoko at the start and end of treatment would be useful to confirm treatment was completed.

6.2 Medicine Minigame

An additional minigame was added to the final game output of this thesis to reflect how the findings from the user testing and the recommendations from the expert review would be implemented. Two mind maps (see Figure 36) were used to generate minigame ideas for the skin sores treatment steps of taking antibiotics and having bleach baths. The medicine minigame was chosen to develop as it is a treatment step that occurs in other common ailments. Findings from the literature review showed that some children were interested in learning about taking medicine, and that others may have a fear of medicine (Hämeen-Anttila et al., 2005, p. 429-433) that education could lessen.

The form of the medicine game that was chosen to develop was a visualisation of treatment progress through a medicine bottle. The player feeds the character a spoonful of medicine each day. The device is tilted to simulate pouring out a spoonful of medicine before dragging the spoon

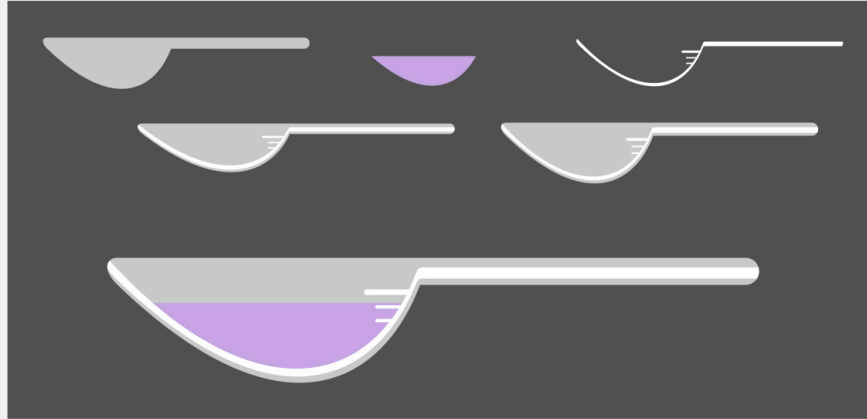
to feed the character. If the spoon is not filled up, they are prompted to keep pouring.

The game fulfils criterion 3 by teaching the player about their medicine through a voice over. The voice over explains that medicine helps fight the germs when you take the right amount. The conclusion of the mini game reminds the player to have an adult help them take their medicine. The game reminds the player to continue taking their medicine in the later days of treatment, this fulfils criterion 5. A voice over in the minigame explains that germs are still around even when the sores are looking better. The player can also see their progress each day as the level of liquid in the medicine bottle gets lower.



Figure 36. Mind map of medicine and bleach bath minigame ideas

Frame 7



Frame 2.1

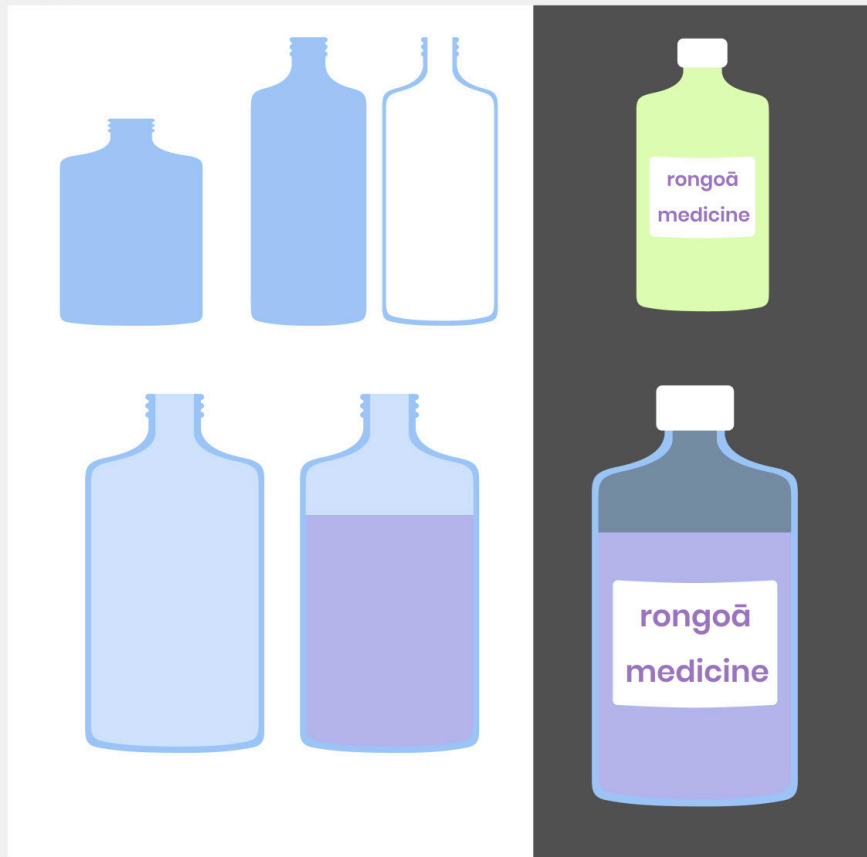
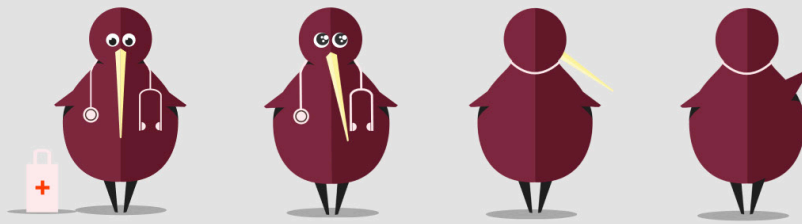
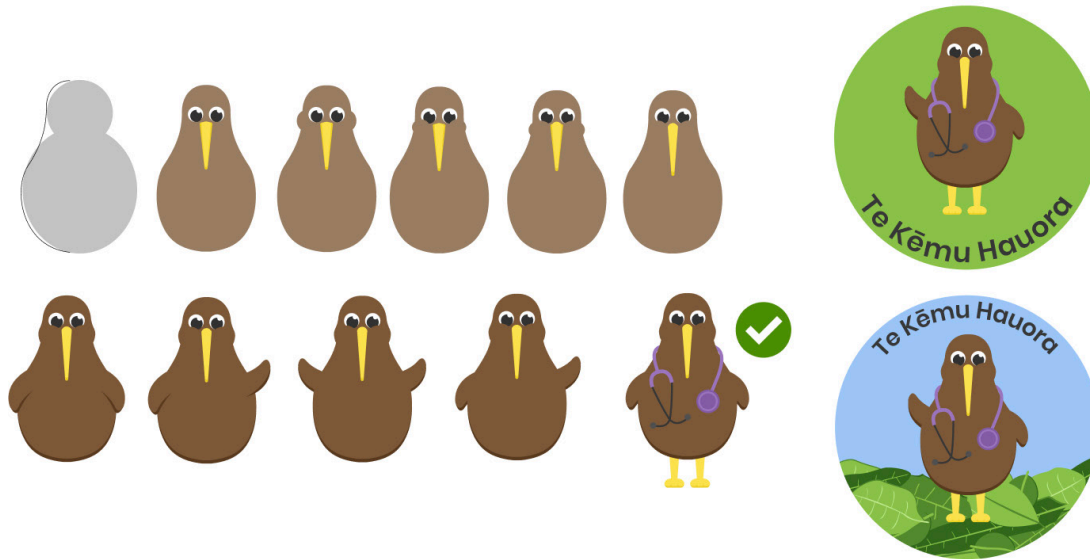


Figure 37. Creating medicine bottle and spoon assets



Frame 5.1



Frame 5

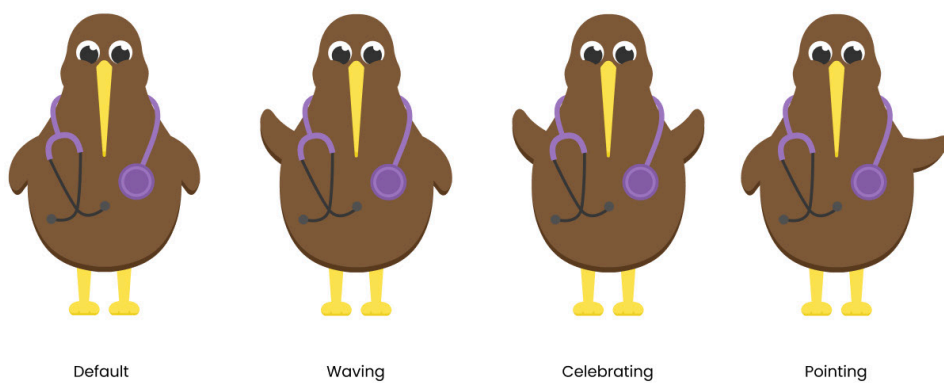


Figure 38. Kiwi character “Doc” design process

6.3 Final Game Output

In addition to adding the medicine minigame, some other refinements were made to the final game output. These refinements included fixing usability issues found during testing which can be seen in Table 11. As seen in Figure 38, the kiwi character was redesigned as the asset used in the testing build was from the previous research prototype and did not match the aesthetics. The new character “Doc”, was designed to look cheerful and friendly, the kiwi resemblance was kept to make the game relatable to New Zealand children. After discussion with research advisors the game was named Te Kēmu Hauora which means “the health game” in Māori. This name is not specific to skin sores so that future development could include other common health ailments. The AR marker sticker was redesigned to display the name of the game as well as the redesigned kiwi character. More voice overs were added to create an initial introduction and final conclusion section of the game as suggested in the expert review. The character the player looks after was given the Māori first name “Tuiti”, which doesn’t have alternate meanings as a word, except for the English translation to “Sweet”.

Table 11. Usability issues found during testing and respective fixes for the final game output

Usability Issue	Fix
The current day should be centred in the AR view as the characters are not always visible.	The current day spot loads centred on the sticker.
The AR needs a better tutorial and explanation for some players.	Additional voice overs were added to tell the player to hold the camera closer or further away from the sticker.
The day numbers on the AR map visualisation are not a clear representation of time by themselves.	The numbers now have the word day in front of them. The introductory voice over tells the player they will be helping over 7 days and at the end of a day the kiwi character says “see you tomorrow”.
Some areas of the game need more voiceovers or clarification of what is happening when in loading states.	Voice over praises were added at the end of each minigame to show the player the minigame is over before set pieces slide out to show loading state.

6.4 Future Concepts

The final game output was scoped to focus on designing a representation of what a health game for children should include. Three minigames were implemented, as well as the introduction and conclusion. However, concepts of how the game should be improved and what needs to be added for the final build of the game to work with the iMoko program were considered. These changes can be implemented in the future with more development time and assistance from technical experts.

The journey map in Figure 40 on the next two pages shows what was implemented in the final game output in colour, the concepts to be added in the future are depicted as line drawings.

Journey Map of Treatment

with Final Game Output and Future Concepts

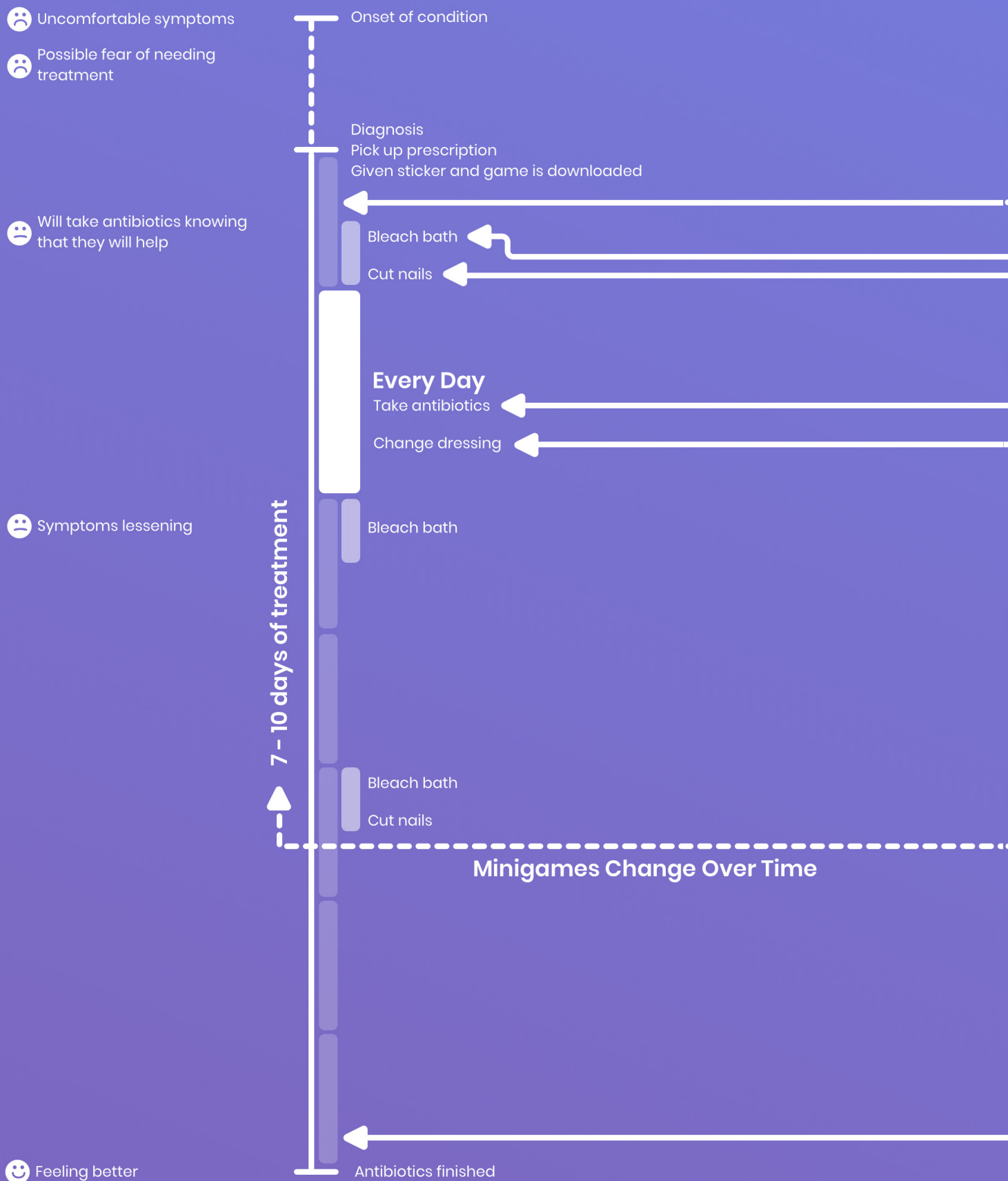
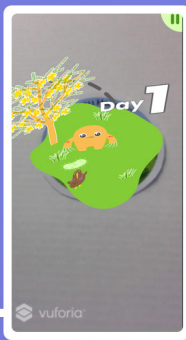


Figure 40. Final journey map



Game Introduction

- ✓ Learns about germs and washing hands after toileting and before eating
- ✓ Game explained



Take Photos

- Takes photos of sores and nails with parents help
- Sent to iMoko



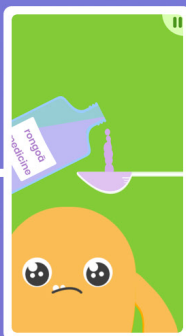
Bleach Bath Minigame

- Learns to wash sores
- Learns how to take bleach baths to get rid of germs



Nail Cutting Minigame

- ✓ Learns to cut nails so germs don't spread
- ✓ Learns that long nails get dirty with germs
- ✓ Learns that short nails are cleaner



Medicine Minigame

- ✓ Learns to continue antibiotics
- ✓ Learns that medicine fights germs
- ✓ Learns to take right amount with parental supervision



Dressing Minigame

- ✓ Learns to change dressings
- ✓ Learns to cover sores so germs aren't spread
- ✓ Learns to not scratch sores so germs aren't spread
- ✓ Learns to wash hands after touching sores



Medicine Minigame

- ✓ Medicine amount in bottle goes down each day as a visualisation of actual antibiotic prescription



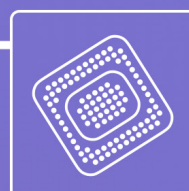
Nail Cutting Minigame

- Becomes more or less challenging: nail growth speed changing and hand moving



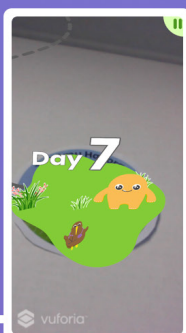
Bleach Bath Minigame

- Becomes more or less challenging



Dressing Minigame

- Becomes more or less challenging: puzzles of different sore arrangements to cover



Game Conclusion

- ✓ Reminded to continue steps to not get skin sores again



Take Photos

- Takes photos of sores and nails with parents help
- Sent to iMoko

7 Discussion

Skin sores are a common health ailment in New Zealand that when left untreated can result in serious health issues. Treatment is highly effective and reasonably simple for children, families and medical practitioners to administer. However, children lack education around health topics, and engagement with healthcare treatments is low in communities with little access to healthcare. Literature shows that serious game design is a viable solution to address education and health behaviours. However, there was a gap in the research of how to design a game for improving education and engagement around common health ailments such as skin sores. This justified the research question of this thesis: “How could a mobile game be designed to facilitate education and improve healthcare engagement around skin sores in children?”. Design criteria were formed from the findings of the literature review and refined throughout the design process to address the research question. The design output produced from the criteria was a mobile game to be played whilst completing treatment for skin sores.

As seen in Table 12, majority of the criteria are met when the final output of the mobile game is compared to the final design criteria. The design process envisages how each criteria could be met and the final output either has the full application of this or the early stages of implementation.

This research shows that it is valuable to consider simulation as an engaging form of education as it can be used to show players how to do their treatment steps in a virtual environment. An example in the design output of *Te Kēmu Hauora* is the nail cutting minigame. Players are challenged to cut the nails of Tuiti as they grow long, dirty and get covered in germs. When the players win the minigame they see Tuiti happy with clean, short nails and a voice over explains that germs won’t be spread. The results from testing show simulation was engaging to some participants who created unexpected interactions when immersed in game tasks. Flow theory appeared to be engaging as some participants were focusing in on the game and improving their interactions after a second turn. The findings from the thematic analysis of the education testing show that most participants were informed about how to complete treatment steps and why they were necessary after completing the minigames where treatment steps were simulated.

Implications for game design aiming to address healthcare in communities with limited access to healthcare include how children can

Table 12. *Assessment of final output to final design criteria*

<i>Usability Issue</i>	<i>Fix</i>
1. The game should provide education around why treatment is necessary as well as how to complete treatment steps.	Minigames for each treatment step simulate completing a treatment step, with dialog and visualisations explaining how the step helps the player's health improve.
2. The game should remind the player to complete each of their treatment steps on the required days.	In order to play the minigames the player has to seek out the AR marker. The marker should be placed on their medication/treatment kit to provide a physical reminder. The minigames available each day are for each of the treatment steps required that day, reminding the player that they should do them and how to complete each step.
3. If the player is prescribed medicine the game should remind them at the to take the correct dose with parent/caregiver assistance.	Medication treatment step minigame highlights the importance of administering the correct dose with parent/caregiver assistance through visualisation and dialog.
4. Healthcare communication should be personalized and directed to the child with age appropriate explanations, language and graphics.	Language used in the game is simple and explanations are short and clear. The color scheme is bright and graphics have curved edges to create a welcoming effect. The game is in English to accommodate all testing participants with commonly used Māori language in appropriate places. Voiceovers can be easily replaced if the iMoko programme is used in Māori immersion primary schools.
5. The game should remind the user to continue treatment even once they feel and appear to be better, along with an explanation of why this is necessary.	When the player completes a minigame step the conclusion segment explains why the step was necessary and that they should continue even if they are feeling better to stop the condition returning.
6. The game should provide clear feedback to actions, including praise.	The game has visual and auditory feedback for player interactions, including praise where appropriate. Interaction within minigames includes feedback to the player relating to the treatment step.
7. The game should become more or less challenging over time to adapt to the player's skill.	Development time was limited so the final output provides a demonstration version of the game to play alongside a basic treatment regime, this included three treatment step minigames. To address the criteria these minigames were designed with consideration of how they could adapt to the players skill over time (see Chapter 4 and 6) however, implementation of this was outside of scope.

be engaged and educated around their treatments through simulation without having to continually see a clinician in person.

This research will be applied in a real-world context as findings will assist in building Te Kēmu Hauora into a fully functional mobile game to be delivered via the iMoko programme. The criteria will be used to design sections of the game to address the additional treatment steps and features suggested by Dr Lance O’Sullivan in the expert review. Figure 40 in Chapter 6 depicts a treatment journey map with use of Te Kēmu Hauora. The sections produced during this thesis are depicted in colour and what will be added using the research and design process from this thesis is depicted with line drawings.

The design process could be improved by a pilot run of the testing to allow refinement of the methods used in the procedure and ensure results would not be affected by minor issues. The testing process would have been improved further by refining the SUS questions to gain more usable answers from child participants. The final output could be improved by addressing all the possible treatment steps for the skin sores treatment regime as some steps such as the bleach bath were not present.

Future research opportunities include exploring how the criteria could be applied to improve engagement and education around other common child health conditions such as strep throat, head lice and oral health issues. The designed modularity of the game provides a framework for these conditions to be added in a update. Modularity also means that the game could be modified for alternate locations including other countries. In the expert review of the game Dr Lance O’Sullivan suggested an extension to involve a parent/caregiver role in the child’s treatment. This could include the parent/caregiver confirming that the child has completed treatment steps. Another way of involving the parent/caregiver would be to assess health data provided by the child when playing the game (such as photos taken of skin sores) to send back to iMoko. At the time this thesis was produced the project does not have ethics approval to test with children who have the condition however there is an opportunity to conduct a clinical trial to see if treatment outcomes are improved with use of the game.

Recruitment of participants for testing was restricted by the time frame of the thesis as well as travel to the location of the available participants from the projects approved ethics application. The participants had to be recruited through Dr Lance O’Sullivan from schools with the iMoko

programme. There was a of total nine participants over the two testing sessions. Both sessions were both in Auckland with primarily English speaking schools therefore results may have differed in other locations where Māori was the dominant language.

Suggestions were made to refine the testing procedure from the insights gained after completing the two testing sessions, these can be found in Chapter 5 Section 8. These suggestions can be applied in future approaches to user testing within this project and other research looking to test usability, education and engagement with children.

8 Conclusion

Skin sores are a healthcare issue for many children in New Zealand (O’Sullivan & Baker, 2012, p. 70-77) and it is important that they are treated correctly to avoid complications (Workbase Education Trust, 2012, p. 2). Correct completion of treatment regimens for skin sores after early diagnosis can prevent hospitalisation (Gray et al., 2013, p. 2).

This thesis answers the research question “How could a mobile game be designed to facilitate education and improve healthcare engagement around skin sores in children?” in two parts: the criteria and how it’s applied.

First, the construction of criteria to design health games for common ailments. These criteria were formed from literature findings around serious games, persuasive strategies and children’s attitudes to healthcare. The criteria consider use of game design elements including simulation, flow theory, personalization and reward to engage and educate children.

Second, the application of the criteria to design a mobile game addressing the treatment of skin sores. The criteria and background research on skin sores was used to create user personas and journey maps to guide the design process of an output specific to New Zealand children between the age of five and seven. There was a particular focus on Māori and Pacific Island children, as the incidence of skin infections requiring hospitalisation is higher in these groups (Williamson et al., 2013, p. 924-925; O’Sullivan, Baker, & Zhang, p. 1800). Initial experimental sections of the game were combined into a demonstration version for user testing. The user testing results showed that the game provided education around skin sores treatment steps and was engaging for most participants.

Te Kēmu Hauora was refined from the usability testing insights and expert review before being assessed against the criteria. Children can be engaged and educated about their health care by experiencing simulation of their treatment steps, through helping Doc to care for Tuiti over the length of their treatment. Te Kēmu Hauora fulfilled all of the criteria, either by actual implementation, or through concepts to be added in the future.

This research shows that serious games can be designed to facilitate education and improve healthcare engagement in children.

9 List of Figures

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Figure 2. Screenshot of diabetes self-management game Packy and Marlon.

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Screenshot retrieved from:

<https://gamefaqs.gamespot.com/snes/588555-packy-and-marlon/images/218>

Figure 3. Screenshot of praise in the Okee in Medical Imaging application.

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Screenshot taken in application

All other figures generated by the author,
Sophie May Price

10 References

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11 Appendix

Appendix A

This thesis is accompanied by a mobile game. An Android device with a back facing camera is required. The game can be downloaded from the URL below. Load the URL from your device to download the application directly to the device for easy installation.

https://drive.google.com/drive/folders/1MqUKHjmTqn6I2WQPTCcFIn_NvckN-3Ma?usp=sharing

To install it you may need to enable developer settings on your device, instructions can be found here:

<https://developer.android.com/studio/debug/dev-options>

The graphic below is an AR marker that is needed to play, hold the device so it is in view of the camera.

The application is a demonstration of the first day of playing Te Kemu Hauora alongside skinsore treatment.



Appendix B

The projects Human Ethics approval notice and application. The consent form and information sheets given to the participants before testing are also included here.

Phone

Email

MEMORANDUM

TO	Mr Edgar Rodriguez-Ramirez
COPY TO	Mailin Lemke, Gillian McCarthy
FROM	AProf Susan Corbett, Convener, Human Ethics Committee
DATE	9 November 2016
PAGES	1
SUBJECT	Ethics Approval: [REDACTED] The design of a digital app to help children engage with their healthcare

Thank you for your application for ethical approval, which has now been considered by the Standing Committee of the Human Ethics Committee.

Your application has been approved from the above date and this approval continues until 31 October 2019. If your data collection is not completed by this date you should apply to the Human Ethics Committee for an extension to this approval.

Best wishes with the research.

Kind regards

Susan Corbett

Convener, Victoria University Human Ethics Committee



Design of a System for helping children engage with their healthcare

CONSENT TO INTERVIEW

This consent form will be held for 2 years.

Researcher: *Dr Edgar Rodriguez, School of Design, Victoria University of Wellington.*
Sophie Price, Masters Student, Victoria University of Wellington.

- I have read the Information Sheet and the project has been explained to me. My questions have been answered to my satisfaction. I understand that I can ask further questions at any time.
- I agree for me and my child to take part in a (video/audio) recorded interview.
- I have read the explanation in the information sheet to my child and he/she assents (agrees) to take part in the study

I understand that:

- I may withdraw from this study up to *four weeks* after the interview, and any information that I have provided will be returned to me or destroyed.
- The information I have provided will be destroyed 2 years after the research is finished.
- Any information I provide will be kept confidential to the researcher and the supervisor. I understand that the results and a summary of the results may be used in academic reports and/or presented at conferences.
- My name or my child's name will not be used in reports, nor will any information that would identify me. I agree that pseudonyms may be used to refer to our responses.
- I would like a summary of my interviews Yes ☐ No ☐
- I would like to receive a copy of the final report and have added my email address below. Yes ☐ No ☐

Signature of participant: _____

Name of participant: _____

Name of child: _____

Date: _____

Contact details: _____



Design of a System for helping children engage with their healthcare

INFORMATION SHEET FOR PARTICIPANTS

Thank you for your interest in this project. Please read this information before deciding whether or not you and your child want to take part. If you decide to participate, thank you. If you decide not to take part, thank you for considering our request.

Who am I?

My name is *Sophie Price* and I am a masters student at Victoria University of Wellington. This research project is work towards our research in the design of apps and games that help children engage with their healthcare. I am working on this project with Dr Lance O'Sullivan from Navilluso, Dr Edgar Rodriguez, our research assistants Gillian McCarthy, Mailin Lemke and summer scholars.

What is the aim of the project?

This project investigates how the design of a game can help educate children and engage them in the treatment of their skin sores, headlice or sore throats. We are trying to find out what can be improved so that we can design a better system. This research has been approved by the Victoria University of Wellington Human Ethics Committee [approval number: XXXXXXXXXX].

How can you help?

If you agree to take part we will interview you and your child. ~~We will ask you questions about your experience treating skin sores, headlice or sore throats.~~ The interview will take *approximately 30-45 minutes*. We will record the interview and write it up later. You can stop the interview at any time, without giving a reason. We will also ask your child to play with the game we design and give us feedback about their preferences. The results from this study will inform our design of a new app and game for children. You can withdraw from the study up to four weeks after the interview. If you withdraw, the information you provided will be destroyed.

What will happen to the information you give?

This research is confidential. We will not name you in any reports, and we will not include any information that would identify you or your child. Only the people named above will read the notes or transcript of the interview. The interview transcripts, summaries and any recordings will be kept securely and destroyed 2 years after the research ends.

What will the project produce?

We may also use the results of our research for conference presentations, and academic reports. We will take care not to identify you or your child in any presentation or report.

If you accept this invitation, what are your rights as a research participant?

You do not have to accept this invitation if you don't want to. If you do decide to participate, you have the right to:

- choose not to answer any question;
- ask for the recorder to be turned off at any time during the interview;
- withdraw from the study up until four weeks after your interview;
- ask any questions about the study at any time;
- read over and comment on a written summary of your interview;
- agree on another name for me to use rather than your real name;
- be able to read any reports of this research by emailing the researcher to request a copy.

We will read the following explanation to your child and ask you to confirm in the consent form that your child assents to take part in the research:

We are doing a research study about ***designing games to help children learn more about their health***. A research study is a way to learn more about people. If you decide that you want to be part of this study, ~~you will be asked some questions about times that you have had to see the doctor and take some treatments.~~ We will show you a game and it would be great if you could play it and tell us what you think about it. We will make a video of you playing it so that we can see what parts you like and what parts you don't like. ***We may show the video and your responses to other people we work with, but we will not show them your face or tell them your name.***

When we are finished with this study we will write a report about what was learned. This report will not include your name or that you were in the study.

You do not have to be in this study if you do not want to be. If you decide to stop after we begin, that's okay too. Your parents know about the study too.

If you decide you want to be in this study, please tell your parents so. Thank you!

If you have any questions or problems, who can you contact?

If you have any questions, either now or in the future, please feel free to contact either:

Researcher:

Name: Sophie Price

Role: Masters Student

School: School of Design

Email: [REDACTED]

Name: Dr Edgar Rodriguez

Role: Associate Professor Industrial Design

School: School of Design

Phone: [REDACTED]

[REDACTED]

Human Ethics Committee information

If you have any concerns about the ethical conduct of the research you may contact the
Victoria University HEC Convener: Associate Professor Susan Corbett. Email

[REDACTED] or telephone [REDACTED]

Appendix C

Sound Credits

Throwing Trash Away

by btherad2000

Link: <https://freesound.org/people/btherad2000/sounds/328081/>

Licence: <https://creativecommons.org/licenses/by/3.0/legalcode>

Changes: Cropped to use small part of clip.

Bubbles Popping

by AryaNotStark

Link: <https://freesound.org/people/AryaNotStark/sounds/407614/>

Licence: <https://creativecommons.org/licenses/by-nc/3.0/legalcode> Noncommercial

Fast Swipe

by ParadoxTheSock

Link: <https://freesound.org/people/ParadoxTheSock/sounds/412595/>

Licence: <https://creativecommons.org/publicdomain/zero/1.0/legalcode>

Weapon Swipe

by Yap_Audio_Production

Link: https://freesound.org/people/Yap_Audio_Production/sounds/219005/

License: <https://creativecommons.org/licenses/by/3.0/legalcode>

Human Clipping Nails

by 170048@virtualwindow.co.za

Link: <https://freesound.org/people/170048@virtualwindow.co.za/sounds/408043/>

Licence: <https://creativecommons.org/licenses/by-nc/3.0/legalcode> Noncommercial

Changes: Cropped into multiple individual clips

Running Tap

by FractalStudios

Link: <https://freesound.org/people/FractalStudios/sounds/363097/>

Licence: <https://creativecommons.org/publicdomain/zero/1.0/>

Splat

by jameswrowles

Link: <https://freesound.org/people/jameswrowles/sounds/248253/>

Licence: <https://creativecommons.org/publicdomain/zero/1.0/>

Asset Credits

Bottle Liquid Simulation

<https://assetstore.unity.com/packages/3d/props/potions-with-liquid-simulation-87014>

Tutorials Used

Touch Swipe

<https://code.tutsplus.com/tutorials/create-a-fruit-ninja-inspired-game-with-unity--cms-22145>

Progress Bar

<https://xinyustudio.wordpress.com/2015/08/06/unity3d-progressbar-using-new-ui-system/>

