Journal of Marketing and Information System (JMIS)
ISSN:
www.readersinsight.net/jei

Designing a Persuasive Application for Behaviour Change with Children: A Design Thinking Approach

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Abstract

Persuasive technology is a technology that is designed deliberately to change user behaviour without coercion and deception. This study demonstrates the design of a persuasive mobile application aiming to encourage children below 12 years old to take care of their teeth and increase their awareness towards the importance of dental care. We applied a design thinking approach which comprised of five different phases: empathize, define, ideate, prototype, and test. A total of 13 children participated in this study. The findings show that children found that the application informs them how to brush their teeth properly and increases their awareness about the importance of dental care. This indicates that the design thinking approach is indeed useful for the designer to design a persuasive application aiming to change children's behaviour.

Keywords: *Persuasive Technology; Behaviour Change; Design Thinking; Children; Mobile Application; Dental Care.*

ARTICLE INFORMATION

Received: 10-Oct-2019
Revised: 28-Oct-2019
Accepted: 05-Dec-2019

INTRODUCTION

Persuasive technologies are technologies associated with changing an individual's behaviour through persuasion and social influence (Caraben et al. 2014). Today, there is a growing interest in creating a technology that would encourage individuals to observe good dental care. Multiple initiatives have been introduced to engage children in changing their behaviour towards better dental care such as developing tasty toothpaste, using colourful toothbrushes and capitalizing on technology. Most children do not place a great value on dental care because they are unaware of the infections and damage resulting from poor oral hygiene practices (Soler, Zacarias and Locero, 2009). Not taking care of one's oral hygiene might also affect people psychologically by leading to low self-esteem and lack of confidence to socialize. Hence, creating awareness is highly important to motivate children to take care of their dental and oral cleanliness habits to prevent negative consequences in the future. This paper highlights the design of a persuasive mobile application for children aged 6 to 12 years to increase awareness on the significance of having healthy dental care. A design thinking process as originated by Plattner and Hasso (2010) was applied. This paper is organized into several sections. First, the paper presents the overview of persuasive technology in the context of changing children behaviour towards dental care. Next, the paper reviews the relevant literatures, followed by step-by-step procedures of conducting design thinking phases with children in methodology section. After describing the final phase of design thinking, the paper then presents the results and findings of the evaluation. The paper concludes by offering suggestions for future work.

LITERATURE REVIEW

Persuasive Technology

In recent years, persuasive technologies have gained a lot of attention primarily aiming to change an individual's behaviour to encourage them towards a healthy lifestyle. According to Fogg (2011), persuasive technology can be defined as "technology that is designed to change attitudes or behaviour of the users in a predetermined way". There is also a growing number of technologies to encourage individuals to change their behaviour particularly towards a healthy lifestyle such as increase physical activity (Mohadis & Ali, 2016), healthy diet intake (Rahman et al. 2018), smoking cessation (Bascur et al. 2018) and weight reduction (Vlahu-Gjorgievska, Unnikrishnan & Win, 2018).

Persuasive technology also has been utilized to change the attitude or behaviour of children. For example, Almonani, Wahidah and Ying San (2014) developed a mobile game approach to prevent childhood obesity (MACO). This application was designed purposely to persuade children to practice healthy lifestyles by eating the right food and to be physically active. The game attempts to solve childhood obesity by organizing meal times and providing information on the food intake and encourage children to increase their physical activity. Another study on persuasive technology for children was Skiada et al. (2014) which aimed to improve children's learning behaviour. Their study involved the development of a mobile application called EasyLexia, which was designed to help children to overcome learning difficulties while at the same time encourage the learning process.

Design Thinking Method

Design thinking is frequently used to describe the problems designers are trying to solve. Dam and Siang (2018) defined design thinking as a design methodology that provides the solution for a specific problem where it helps to understand human needs by generating many ideas during the brainstorming session. There are five phases of design thinking which are; empathized, define, ideate, prototype and test.

During the empathize phase, the design thinker needs to fully understand the problem that they are trying to solve. This step is vital to have an in-depth understanding of the issues and areas of concern. In the define phase, the designer starts putting together all the information gained during the empathize phase. The collected information and observations need to be analyzed in order to define the main problems. This phase will help designers to resolve issues with least difficulty. The third phase – the ideate phase involves the designer brainstorming for the widest range of ideas, which involves generating multiple sketches of potential solutions, or asking for opinions or ideas from the target user through exploratory studies. During the third stage, designers can start generating their ideas. From the compiled ideas, designers can start building a prototype where it can be tested to identify the best solution for each of the problems identified during the first three stages. The prototype helps the designers to gain better ideas and understand how the users will feel when using the final product. The final stage is the testing process where designers will conduct a testing session of the prototype with the users. During this final stage, alterations and refinements are possible depending on the users' comments in the testing stage.

Numerous studies have reported on the use of the design thinking approach to design persuasive application. Petersen and Hempler (2017), for example, utilized the design thinking method to develop a persuasive diabetes health mobile application. They concluded that the design thinking approach did indeed help them to design the right application. This is because the users perceived that the application helps them to be aware of their health. In another study by Khindri (2018), a technology company called *Net Solutions* implemented the design thinking approach to develop a supply chain mobile application for their client. The approach helped them to develop an effective application for the target users further suggesting that design thinking approach is indeed a key element that enables researchers or designers to build a usable mobile application. However, it is important to emphasize that the design thinking approach applied in these studies only involved adult participants. To the best of our knowledge, there has yet to be a study reporting on the use of the design thinking approach with children. Thus, as designing for children is challenging, we were intrigued whether the design thinking approach is effective for designing applications targeted at children.

Children Dental Care

Health is one of the most significant domains in persuasive technology. Most of the mobile applications available in the market that teach proper dental care focus on children as it is usually difficult for parents to educate their kids regarding the value of having healthy oral and dental hygiene (Caraben et al. 2014). That is why many researchers have sought to develop tasty toothpaste, colourful toothbrushes and even opted for technology to engage the children in changing their behaviour towards better dental care (Caraben et al. 2014). The main reason children do not place a great value on dental care is that they are unaware of the many infections resulting from poor oral hygiene practices (Soler, Zacarias and Locero, 2009).

Having bad oral and dental care habits could lead to severe problems. Dental care issues refer to insufficient effort to maintain good dental habits. If children are oblivious about the consequences of poor dental care, they will experience many issues in the future such as cavities, gum infection, and tooth loss (Soler, Zacarias and Locero, 2009). These diseases are very painful, and children could be traumatized (anxiety and fear) (Viswanath, Kumar & Prabhuji, 2014). Other than that, many studies have found that, there is a relationship between oral diseases with heart disease, diabetes, cancer, dementia, and stomach ulcers (Beaudeate et al., 2017). Therefore, oral diseases should be prevented in early childhood in order to avoid more serious diseases during adulthood.

Thus, it is vital to create awareness or motivate children to improve their dental and oral cleanliness habits in order to prevent such grave consequences in the future. To this end, we attempt to design a persuasive mobile application using the design thinking approach that would engage children to care more about their dental hygiene and create awareness on the significance of healthy dental care.

METHODOLOGY

This study designs a persuasive application targeting children's awareness of dental care and to evaluate the effectiveness of the application at encouraging the children to improve their dental care. This section presents the methodology of the study.

Participant Recruitment

The participants of the study comprised of a group of students from an elementary school in Gombak, Selangor. The number of participants involved differs based on the stage of the study. We selected participants from this elementary school because the location is strategic and it is convenient to recruit the targeted participants there as compared to searching for individuals aged 6-12 years elsewhere. Besides, school is an effective and resource-efficient method of researching young people, as school enrolment is compulsory and high among our age group of interest. The process of recruiting participants started by securing permission from the school to conduct the study. We sent a letter detailing the series of interviews and usability test that will be conducted and requested to conduct the sessions at a suitable time. We also requested a voice recording and clarified beforehand that the identities of the participants would be kept confidential. Upon receiving approval from the school, a representative from the school then informed us of the date and time that is appropriate for the study to be conducted. All of the participants involved in this study participated voluntarily.

Design Thinking Procedures

A design thinking approach which comprised of five different phases: empathise, define, ideate, prototype and test phase is adopted in the study. The following paragraphs will describe in detail the activities that were conducted in each of these five phases.

1) Empathize: During this phase, an exploratory interview was conducted to gather and learn about the children's requirements and the needs of having a mobile application for their dental care and their perception towards it. Eight (8) students were interviewed to understand their dental care routine and their awareness towards the importance of dental care. A random sampling technique was used during this phase, where eight female students from a group of students aged 7 to 12 years volunteered to participate in this interview. The following are some of the questions asked during the empathize phase:

- How often do you brush your teeth?
- Do you brush your teeth after you eat?
- What do you use for your teeth cleaning?
- In what direction do you brush your teeth?
- How many times do you change your toothbrush?
- Do you think brushing teeth is important?
- How did you learn to brush?
- What do you think would happen if you do not brush your teeth?

2) Define: Based on the interview, a problem statement was formulated to address the children's needs and requirements. During this phase, we used personas and scenarios to define all information and features required within the app.

3) Ideate: Based on our understanding on the children's needs and requirements in the define phase, we then proceeded with the ideation

phase by conducting a brainstorming session to generate as many creative ideas and potential solutions as possible. These ideas were translated in the form of sketches, which is a form of low fidelity prototype. Figure 1 below shows an example of the sketches:

Fig. 1. User interface sketches generated during the brainstorming sessions.

In order to get the children's feedback on these sketches, we asked the children that we previously interviewed for their opinions and suggestions for improvement. The following Table 1 shows the crucial feedback received from the children on our sketches and the corresponding design implications.

Table 1. Participant Feedback and Design Implications

Participant Feedback	Design Implications
"I like these sketches because it looks interesting for me to use it" *(P1)* "I like these sketches because they are colourful" *(P3)*	A design that is appealing to users. The look of an app is important as it has a large impact on how users perceive experience. Colours and images can invoke positive emotional reactions and affect the excitement of users hence producing a quality user experience.
"I like these sketches because I understand how all the buttons in the sketches work" (*P2)*	Design for a usable experience. The app design should be understandable, easy to learn and easy to use. If the design has difficult functionalities, the chances are that users will not use it.
"I like this drawing because it provides instruction on how many times to brush in a specific area to prevent bacteria growing" *(P5)* "The drawing reminds me of when I have to brush my teeth" *(P1)*	Design an engaging, productive and enjoyable user experience to enhance utility. When the app provides users with features of design that are useful, important and interesting to users, users will most likely feel motivated to use the app again.
"I like these sketches because it shows me the correct way to brush the teeth" *(P2)* "These sketches show me the proper way to brush teeth which will indirectly increase awareness on dental care" *(P4)* "It helps me if there is an indicator that will show me the teeth is finally clean without bacteria and germs" (*P4)*	Design for the persuasiveness of users. This feature is one of the most important design considerations as the purpose of the app is to encourage and promote user behaviours towards dental care. Having a picture of an after-effect of brushing teeth and a reward will provide satisfaction to the users once the action is completed.

4) Prototyping: After getting feedback from users on the sketches, ideas were developed, and a high-fidelity prototype was then built. We named the prototype the 'Ali and Friends Superteeth' app. Once the app is launched, the user will be automatically transferred to a profile page to insert their name and age as well as choosing a character they would like to use as their profile. Once a profile is created, the user will be directed to the homepage, where four (4) different buttons are displayed. The user can select the bulb icon for tips regarding dental care or settings icon to adjust volume, text size, set an alarm as a reminder or to change a profile character as shown in Figure 2. The user also has the option to select the toothbrush icon on the homepage to see a demonstration on teeth brushing as shown in Figure 3. The video will display the correct way of brushing teeth, and a timer is available to indicate the duration needed to brush teeth. Once the tooth brushing session is completed, a compliment will pop up on the screen as the teeth have been clean. Lastly, the user has the option to select the 'fork and spoon' icon to record or keep track of their daily food intake as shown in Figure 3. This food intake will have an effect on the duration of the teeth brushing.

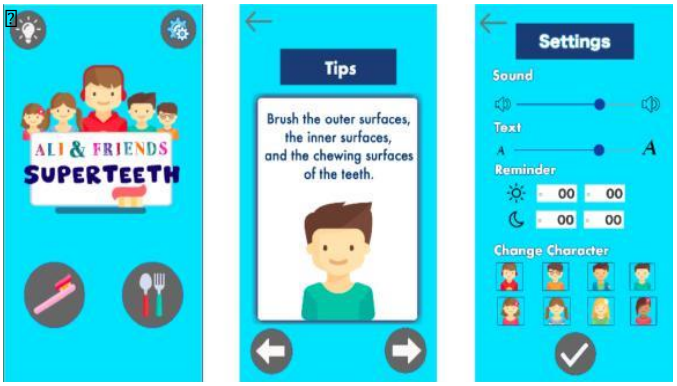

Fig. 2. Homepage, Tips and Settings User Interface of the app.

Fig. 3. Tooth Brushing Demo and Food Intake User Interface of the app.

The prototype of the application developed is integrated with several persuasive principles defined by Oinas-Kukkonen and Harjumaa (2009), which is summarized in Table 2 below:

Table 2. Persuasive Principles Integrated into the Prototype

Persuasive Principle	Definition of the Principles	Application Features
Personalisation	A personalised content or services that has a greater capability for persuasion.	The duration of teeth brushing is personalised based on the food intake.
Self-monitoring	Self-monitoring provides simulations to persuade by enabling users to observe the link between cause and effect.	Food intake page allows users to update and monitor sweets, snacks and other unhealthy foods taken.
Rehearsal	Rehearsal provides a way to rehearse a behaviour that enables people to change their attitudes or behaviour in the real world.	Video tutorial on how to brush teeth enable the user to follow the proper techniques of brushing.
Praise	The Praise acts as a reward for target behaviours, which may have great persuasive powers.	Compliment user after teeth brushing session.
Reminders	Reminding users of their target behaviour will more likely make the users achieve their goals.	Notify user after teeth brushing session.

Suggestion	Users that are offered suggestions to carry out behaviours will have greater persuasive powers.	Provide tips on dental care.

In addition to these persuasive principles, we also incorporate guidelines on designing a mobile application for children as identified in the literature. Those guidelines are:

1. The use of text should be minimised unless the application software is made for reading or writing as a goal (Hourcade, 2007).
2. Texts are most likely placed on buttons or headings, and it is important to use fonts that are clear and readable by children (Wängberg & Högskola, 2012).
3. Navigation of menus should be designed in the most visible way, and pull-down menus should be avoided (Hourcade, 2007).
4. Colours play an essential role in the design process of an app. Children respond well to bright colours. In creating a learning tool for children, the app can strive to use a bright blue colour aimed at a shorter but exciting and focused session (Wängberg & Högskola, 2012).
5. Designing a playful and appealing app will more likely engage children in a prolonged period as compared to an app that focuses mainly on information presentation (Caraben et al. 2014).
6. Reduce the number of components when designing an app interface to enable children to focus (Aziz et al., 2013).
7. The selection of icons or images should be designed so that they represent actual usage in the real world as children relate to image or items on the app based on what they usually see in the real world (Hourcade 2007, Aziz et al. 2013).
8. The arrangement of components should be simple and consistent within the app. If the main buttons are placed at the bottom of the interface in the beginning, it should remain the same for another interface and not be complex (Aziz et al. 2013).
9. When designing the settings option, designers should consider from which perspective it is being used, either by children or adults. If the settings are intended to be used by children, it should be made easily understandable and do not have too large of an impact on the app to avoid any disastrous changes (Wängberg & Högskola, 2012).
10. Children aged 5 to 12 years have no problem using a lot of gestures on the interface. Gestures may include tap, flick, slide, drag and drop, rotate, pinch and spread (Aziz et al. 2013).

5) Test: Finally, the children tested the high-fidelity prototype built. During this phase, five (5) children aged 9 volunteered to participate in the usability testing session. We decided to conduct the usability testing at the elementary school, which we considered as a natural setting rather than in a usability lab. This is to ensure the children are not pressured or feel uncomfortable with the test. The purpose of the test is to determine whether the application achieves the usability goals and to discover any difficulties faced by users when using the application. The mobile devices use screen recorder software to capture the user interaction with the application such as navigational choices and typing process while completing the task given. The following are the tasks that the children were asked to perform during the usability testing session:

- Complete the profile information by inserting your name, age and choose your character.
- Use settings to adjust sound volume to up and enter notification time to 7.50 a.m. and 9.00 p.m.
- Find a toothbrush and watch the brushing teeth video.
- Use settings to choose a different character.
- Insert your food intake of candy to 2, chicken to 1, milk to 2.
- Find tips to improve dental care.

After completing the usability testing, the children were also interviewed about the usability of the application and their perceptions of the application as a support tool. The System Usability Scale (SUS) was adapted to measure the usability (Brooke, 1986). The purpose of this questionnaire is to measure the satisfaction of users towards the application as a whole. However, instead of using the Likert scale to identify the children's level of agreement towards each statement, we used a Smileyometer. A Smileyometer rating scale, which is based on a 5-point Likert scale tool and pictorial representation was used during this phase to capture children's perceptions of statements regarding the usability of the app. We used a Smileyometer because it is widely adopted and applied in research to measure the satisfaction and experience of children (Sim & Horton, 2012). It is also assumed to be easy to use, as it requires no writing on behalf of the children. By using the Smileyometer, the children were asked to point their finger towards any of the smileys that best represent their level of agreement. The following Figure 4 shows the Smileyometer used to identify the children's level of agreement in exchange for the traditional Likert scale.

Fig. 4. The Smileyometer

The purpose of the SUS questionnaire is to address the usability of the application. However, it did not address the question of whether the application could raise awareness on the importance of dental care. In other words, the study wanted to determine whether the application is persuasive enough to change the participant's behaviour, which is done by conducting a short interview with only four (4) questions. The following are the questions asked:

- Do you think the application would be able to change your behaviour? Why or why not?
- What do you like most about the application?
- What do you dislike most about the application?
- Do you have any recommendations on how this application could be improved?

This usability evaluation session consisting of usability testing, post-test SUS, and subjective questions lasted from 30 to 45 minutes.

RESULTS

This section presents the findings of this study in terms of participants' demographic information, post-test usability questionnaire and post-test subjective questionnaire.

Demographic Information

Table 3 displays all of the five children's demographic information.

Table 3. Participant Demographics

Participant	Gender	Age	Smartphone Usage (Daily)
P1	Female	9	1 hour
P2	Female	9	2 hours
P3	Female	9	Less than 1 hour
P4	Female	9	2 hours
P5	Female	9	1 hour

Table 3 shows that this study involved five children participants. Nielsen (2000) asserted that conducting a usability evaluation with three to five users is sufficient. This is because 85% of the usability problems can be identified with only five participants as by the time it reaches to more than three users, the study would only discover redundant problems and would only waste valuable time and resources

(Nielsen, 2000). Hence, the authors can argue that five participants are more than enough to conduct usability testing for the application developed for this study. It must be noted that the respected teacher taught all female students in her class. Therefore, we are only able to recruit female participants. Furthermore, all the participants were recruited from the same class which is why all of the participants are aged 9 years. With regards to daily smartphone usage, two participants spent two hours whereas another two spent one hour. Only one of the five participants spent less than one hour.

Post-test Usability Questionnaire

In order to evaluate the usability of the mobile application in this study, a post-test questionnaire using a System Usability Scale (SUS) was conducted. The purpose of this questionnaire is to measure the satisfaction of users towards the application. Table 4 shows the resulting scores from each of the participants as well as the overall average score.

Table 4. System Usability Test Score

Statement	P1	P2	P3	P4	P5
I think that I would like to use this mobile app frequently.	5	3	4	3	5
I found this mobile application difficult.	4	1	1	2	5
I thought the mobile application was easy to use.	5	5	5	3	5
I think that I would need someone to help me to use the mobile app.	2	1	1	1	1
I found the various functions in this mobile app were well organised.	5	4	5	4	5
I thought there was too much inconsistency in this mobile app.	3	1	1	3	4
I would imagine that most people would learn to use this mobile app very quickly.	2	4	4	3	4
I found the system very complicated to use.	5	1	1	1	1
I felt very confident using the mobile app.	4	3	5	3	4
I needed to learn a lot of things before I could get going with this mobile app.	5	4	4	2	3
SUS Score	55.0	77.5	87.5	67.5	72.5
Average			**72**		

Table 4 above shows the calculation results of the System Usability Scale (SUS) questionnaire. The score indicates whether the application is usable or not. The values collected are put into an Excel spreadsheet, and the results are shown above. For statement three (I thought the mobile application was easy to use), the majority of the participants strongly agree with the statement whereas one child rated it as neutral. Other than that, four out of five participants strongly disagreed with statement 4 (I think that I would need someone to help me to use the mobile app) and statement 8 (I found the system very complicated to use). In terms of the score between the participants, the highest value for the SUS score is 87.5 whereas the lowest score is 55.5. The overall average score for the application as a whole is 72. Table 5 displays the percent value of agree (strongly agree and agree) for each statement.

Table 5. Result of Agreement for each Statement in Percentage

Statement	Percentage of Agreement
I think that I would like to use this mobile app frequently.	40
I found this mobile application difficult.	20
I thought the mobile application was easy to use.	80
I think that I would need someone to help me to use the mobile app.	0
I found the various functions in this mobile app were well organised.	100
I thought there was too much inconsistency in this mobile app.	20
I would imagine that most people would learn to use this mobile app very quickly.	60
I found the system very complicated to use.	0
I felt very confident using the mobile app.	80
I needed to learn a lot of things before I could get going with this mobile app.	40

Based on Table 5 above, statement three (I thought the mobile application was easy to use); statement five (I found the various functions in this mobile app were well organised) and statement nine (I felt very confident using the mobile app) scored the highest with values ranging from 80 to 100. For statements two, four, six, eight and ten, the majority of the users scored them below 50 which means that they disagree with the statements that say that they need assistance to use the mobile application, or the mobile application is too complex to use, or that they need prior knowledge in order to use the mobile application.

Post-test Subjective Questionnaire

From the interview, the study identified that most of the participants believe that the application has enabled them to know the correct brushing technique. Three out of five children said that the application teaches them to brush their teeth correctly.

"I like this app because it informs me how to brush my teeth correctly," (P1)

"Now I know that I need to brush my teeth like this," (P4)

One child said that the application could be used as a reference while brushing their teeth.

"This is very helpful, I can refer to this app when brushing my teeth," (P3)

Another participant stated that the application could be used to teach her younger siblings as it visualises the proper way to take care of their teeth.

"I want to show this application to my younger sister so that she can learn how to brush her teeth correctly," (P2)

When asked which features in the application were their favourite, two of them felt that the reminder is useful because it can notify them when they should brush their teeth.

"I like the reminder function because this app can notify me when it is time to brush my teeth," (P1)

"The reminder is very good because I can set time when to brush my teeth." (P3)

The majority liked the video provided as it shows them the correct way to brush their teeth.

"The video shows me the correct way to brush my teeth," (P1)

"Because it shows me how to brush my teeth," (P3)

"I like the video because I can follow the steps to brush my teeth," (P4)

One participant liked the food diary/record as it helps her to keep record and monitor the kind of food she consumed.

"I can update those less healthy foods that I took, and I can monitor it," (P2)

Additionally, the participants proposed many recommendations such as the need to include background music to make it more enjoyable and make the picture of the teeth more realistic by putting some germs or dirt. This is to indicate that the teeth are full of bacteria.

"I like it when there is music because it is more fun," (P3)

"The teeth are too clean… why should I brush my teeth when it is already clean. The teeth should be dirty to show that I have to brush my teeth because it is full of bacteria," (P3)

One participant felt incorporating voice in the video would make it easier to understand and follow.

"The video has no sound… I like it when there is someone who tell me how to brush my teeth correctly," (P2)

DISCUSSIONS

Ali and Friends Superteeth is a mobile application developed to help children develop good dental habits. The app was tested, and subjective assessment data was collected. The data collected is to

identify the overall satisfaction of the children towards the application. The result shows that the highest value for the SUS score is 87.5. This indicates that the particular participant is very satisfied with the mobile application because the participant either strongly disagreed or strongly agreed with the statements given. For example, the participants strongly agreed with statements three, five and nine, which it is about the ease of use of the application.

The participants also strongly disagreed with statement four which it is about whether users need assistance to use the mobile application and statement six which it is about whether the mobile application contains a lot of inconsistency. Though the highest score is 87.5, one participant rated the application at 55.5. This shows that not all participants felt that the mobile application is easy to use. As a whole, the mobile application has an average score of 72. The average score for SUS survey is between 68 and 70 and a score below 68 is considered to have very poor usability (Bangor, Kortum, & Miller, 2009). Hence, it can be said that this mobile application can be considered to have good usability because the score received for the application is well above the SUS average value.

From the short interview, it was revealed that the majority of the participants felt that the application helps them to brush their teeth properly and care more about their teeth and gums. This means that the application is able to change the users' behaviour towards having good dental habits. Several studies show positive results when using technology as an education tool as it can inculcate good dental habits among children (Chen-Yu, Lo, Huang, & Hsieh, 2008). Similar to our findings, this shows that technology like mobile applications could act as a tool to help raise awareness about the importance of dental care. Other than that, the interview shows that videos and reminders are important means to help the children change their behaviour. The study followed the persuasive principle of rehearsal and reminder. The rehearsal principle means that the application must provide a way to enable the users to achieve the desired behaviour whereas the reminder is a way to remind the users their desired behaviour (Beaudette et al. 2015). This principle provides a means to enable people to change their behaviour. Therefore, having a video and reminder in this mobile application would help the children to be aware of good dental care.

In terms of the methodological perspective, this study used the design thinking approach that consists of five (5) phases –empathise, define, ideation, prototype, and test. Our study demonstrates the details of user-centred design activities that should be conducted at each phase. Using the design thinking approach enabled us to understand the children's needs and goals. This is in line with what has been proposed by Vetterli et al. (2013) in which the authors said that users' needs can be identified when design thinking is implemented as a methodology. This is because it engages the users at the early stage of development to gain insights by conducting the interview in the define phase. Other than that, the technique also helped us to refine the needed requirements as it allows us to look from the user's point of view. This is similar with Soledade et al. (2013) where the authors stated that using design thinking gave them the ability to enhance their requirements in building a Learning Management System (LMS). This, as a result, facilitated the design of the right application that addresses the users' needs accordingly. For this study, we presented a variety of sketches to users to receive extensive feedback. This is because the activities promote discussion among the users and the designers. Sketches are an essential tool that could facilitate communication between the related parties (e.g. designers and clients) (Rohmer et al. 2001).

As the result of our evaluation shows, the application designed based on this approach has good usability. We believe this indicates that design thinking was indeed relevant for the design of usable and persuasive mobile application for children.

RECOMMENDATIONS

Although this study can be said to be a success, the participants involved in this study were female children aged only 9 years. Therefore, future research could focus on a different participant cohort to ensure the mobile application is usable for all other children. In addition to this, when conducting the testing, the children were unable to understand the wording under the Smileyometer rating scale. In other words, the participants could not comprehend what the word 'Brilliant' and 'Awful' represent. They were more comfortable when the authors explained the terms using the standard five points of the Likert scale; strongly disagree to strongly agree. Children had substantial difficulties when presented with a scale that uses uncommon or unambiguous words (Borgers & Hox, 2001). Hence, it is suggested that researchers would take into consideration the verbal comprehension of the participants. This means that the labels and wording used for the questionnaire must be clear and understandable. This can be done by identifying what kind of words are familiar to the children beforehand which can then be used for the testing (Borgers & Hox, 2001). Previous studies also reported that children find it difficult to differentiate the differences between the smiley faces. Children find it hard to identify the distinction between "extremely happy" smiley faces and a "slightly happy" smiley faces (Airey et al, 2002). Therefore, each smiley face must be labelled accordingly. Appropriate labels are vital so that it can facilitate a more reliable response from the children (Borgers, Hox & Sikkel, 2001). Further, based on our experience using the design thinking approach with children, there are limitations discovered during the empathize phase. The empathize phase is where the interview is conducted to identify users' needs. However, interviewing children requires more effort as often the children are not expressive enough about their opinions. One reason could be that he or she is very shy. Therefore, an alternative method is that the researchers could implement the friendship-pairs method. This means that two children familiar with each other are put together so that they can share their experiences with regards to the application. This interview method was done by Jakob when conducting usability testing with children (Nielsen, 2010). Though the design thinking approach has its phase-by-phase structure, it is not restricted for researchers. In other words, researchers can always loop back to any phase after initial testing has been conducted in order to gain more valuable information (Gibbons, 2016). This is to make sure that the solutions provided address the users' problems.

CONCLUSIONS

The findings of this study are useful in identifying design requirements that shall be considered in developing persuasive physical activity applications targeting children below 12 years. A longitudinal study could be conducted to evaluate the effectiveness of this mobile application in encouraging children below 12 years to brush their teeth properly and take care of their teeth correctly. Further, future research could investigate the factors influencing the intention to use, adoption and continuance usage of the application. The design thinking technique is a worthwhile tool to develop a persuasive mobile application as it allows people to focus on solving the right problem. This technique also gives the capability to understand the users' needs to support the development of the mobile application.

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