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Design, Implementation and Evaluation of a Serious Game for Obesity Prevention among Preschool Children

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Abstract

This paper presents the design, implementation and evaluation of a kindergarten based prevention on childhood obesity among preschool children. The prevention applies motivational game-based learning and behaviour change theories during design. Preschool children are the main target group for this study because preschool childhood obesity has been found correlated to obesity in later years of childhood, thus preventing and treating preschool obesity are particularly important. There have been few prevention and interventions that have targeted game based strategies in the kindergarten to promote health outcomes in preschool children and especially in Asian countries. To our knowledge, Fight Obesity 2.0 is the first mobile application in Southeast Asia. In this study, it shows a positive way for the content experts and subject experts to collaborate with each other to design and develop digital mobile games for preschool children, we discuss in detail the challenges faced while designing and implementing this trial. Finally, we present the evaluation results from the three-scope validation strategy.

Keywords Serious games; Preschool children; Health prevention; Behaviour change; Obesity

Introduction

Obesity has become a global epidemic since year 2000 reported by World Health Organization, particularly in developing countries. Childhood obesity is associated with a higher chance of obesity, premature death and disability in adulthood [1]. Thus preventing and treating preschool obesity are particularly important. According to some systematic reviews [2, 3] to compare the effectiveness of primary care-based childhood obesity prevention against treatment intervention, only one effective (out of 31) study was prevention study, as opposed to seven effective treatment intervention studies. Another systematic reviews [4] about the effectiveness of health professional-delivered interventions to prevent overweight/obesity in children, there is only four interventions (out of 180) were effective on a primary (adiposity/weight) and secondary (behavioural) outcome measure. In other words, most existing prevention and treatment intervention did not yield the desired positive effects, thus failing to stop the rising number of children who face overweight or obesity problems. So, novel approaches, as revealed by Dias et al [5] in preventing and treating childhood overweight and obesity, are urgently sought after. These approaches involve the use of behavioural treatment with contemporary computing technologies [6]. There are indeed games designed for tackling obesity issues, but those games are generally meant for teenagers or adults, and those games lack validation from the content experts. Treating adult obesity is different from treating childhood obesity due to the differences in physiological and psychological characteristics [7]. As a result, designing game content to prevent and treat obesity would also be different between adults and children. The potential of games, particularly games for health, has been recognised by researchers as being an efficient and effective means of childhood obesity prevention [8, 9, 10]. However, as elaborated by Thompson [11], the key challenge of using games in preventing childhood obesity was to identify the right balance between "serious-ness" of components that promote behaviour change and "fun-ness" of components that entertain children. In fact, this was a research gap encountered by most of researchers who attempted to design and develop games for childhood obesity prevention, hence this paper aims to fill in the research gap.

Game Design and Development

Game idea

The initial game idea was sketched and proposed as a board game that involved playing cards. In the first iteration, a paper-based prototype tabletop game was created to test the playability of Fight Obesity 2.0, which was created to assure that all game contents required in the obesity prevention were feasible to be included in game-like activities. Despite being a feasible multiplayer game, the tabletop version of Fight Obesity game needed to be improved to cover all three types of content knowledge for childhood obesity. In the case of this research, some of the features were discarded after evaluating the paper-based prototype by a subject expert and a content expert. The features discarded include calculation and some questions, for example, all calculation of calories were omitted in the mobile game because the concept of calories was not required for preschool children to build conception of childhood obesity, all question cards were

transformed into drawings of recognizable scenarios of children' daily living. Also, a digital mobile game would further attract children's attention than a physical tabletop game. After going through the game idea and paper-based prototyping, the mobile version of Fight Obesity 2.0 has been predetermined as a single-player game on mobile devices, which was produced by a team of people, including the game programmer, game graphic, subject expert and content expert.

Game Design and Development Model

The game design and development model proposed by Tan [12] was adapted as the game creation and research methodology (see Figure 2). This model supported the provisional game-based childhood obesity prevention by turning gamifiable components into game features. It supposed that there should be game features that support the development of a healthy lifestyle in childhood. Particularly, the game should highlight the importance of a healthy diet and physical activities. The game should also contain the consequences of childhood obesity. Apart from the game designer mentioned, the production team of Fight Obesity 2.0 consisted of two game-based learning specialists, and two game programmers. The two game-based learning specialists were selected based on their experience in completing at least two R&D projects in gamification and game-based learning, while the programmers were chosen based on their credential and experience in developing serious games. In particular, the programmers took part in the production of two educational games before joining the production team of Fight Obesity 2.0.

The subject matter expert of the game presented the requirements of the game to the game production team at the pre-production stage through face-to-face meetings and discussion. The game designer developed game ideas based on the content knowledge supplied by the subject matter expert. It is important to stress that in the creation of serious games, the needs and requirements of the subject matter experts would be prioritised as opposed to the targeted players, when they examined the differences between serious games and games for entertainment. Also, preschool children may know what features of a game they want to play, but they generally do not know the features of a serious games they need to play in order to acquire knowledge on childhood obesity. Thus, this serious game for health presumed that only the subject matter experts should supply knowledge content, as opposed to preschool children, parents or kindergarten teachers. This in turn omitted the need to involve preschool children, parents or kindergarten teachers in the game content and design validation process.
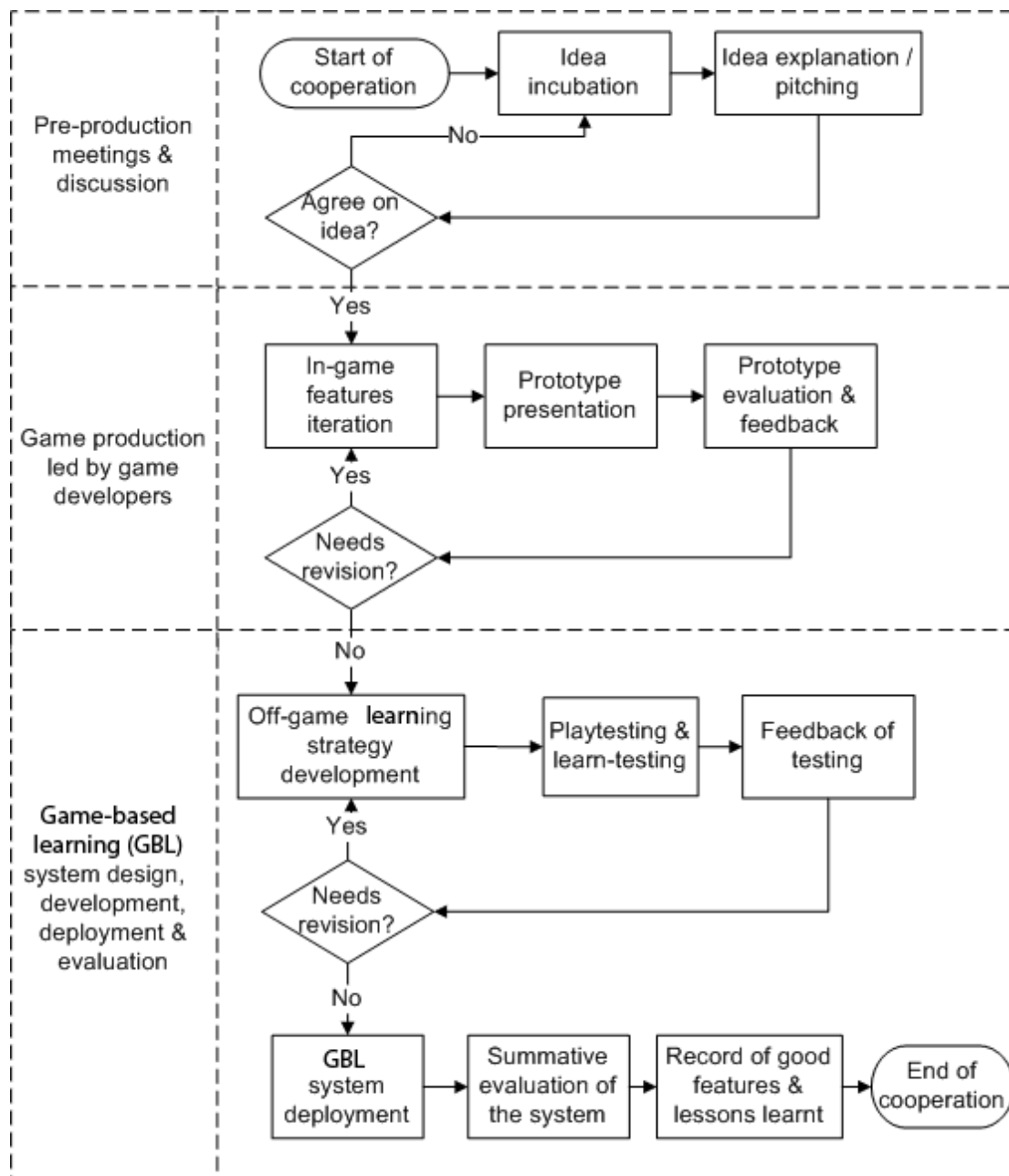
Figure 1 The Game Creation and Research Model (Tan, 2010)

Gamification for Childhood Obesity Prevention

The approach of gamification proposed by Tan was adopted to design and develop Fight Obesity 2.0 [12]. He proposed a five-step gamification approach which integrated six structural elements of games depicted by Prensky. According to Prensky, an effective game-based learning should encompass six elements of games: goals, rules, interaction, feedback, problems and narrative or fantasy [13]. The first step of gamifying childhood obesity prevention was setting and defining the purpose of gamification. The purpose of gamification was to turn non-game playing childhood obesity prevention content knowledge into game playing activities for preschool children. This purpose was aligned to the preference of game technology

which could be made available to the targeted player. A game goal was set for either the male or the female avatar in the Fight Obesity 2.0 that was to possess healthy food preferences and healthy lifestyle.

This game goal was broken down into three components, specifically observable behaviours of the game avatar, the conditions of goal attainment, and the degree of goal attainment. The game avatar represents individual game players, including their characteristics, where such representation comprises pedagogical information concerning both the knowledge acquired by players and their behavioural profile. The components of game goal were aligned to the intended outcomes of the childhood obesity prevention, as proposed by Tan, Nurul Fazmidar and Wang [14]. After the alignment, the game goal was used to determine the game challenge. In this gamification practice, preschool children were led to empathize with the challenges encountered by the male or female character they played. Meanwhile, game rules, game mechanics and physics of the game world were set based on the conditions of goal attainment. The game rules were made explicit, simple and succinct to accelerate the comprehension process and needs among the targeted preschool players, while the game mechanics were made as detailed as possible for game programmers to code and establish the physics of the game world.

The degree of game goal attainment was further developed by pedagogy experts and instructional designers, in order to set the model and modes of in-game interaction, and then to prepare formative and summative feedback in Fight Obesity 2.0. The six structural elements of Fight Obesity were not designed and developed in a linear production process. The gamification process was actually a series of iteration, where game designer, pedagogy experts, content experts, programmers and game artists went through several iterative negotiations, discussion and compromise situations, before reaching a mutual optimized design of the game.

Preparing Content Knowledge
In terms of content knowledge, seven prompting questions and answers were prepared based on recommendation of World Health Organization, as shown in appendix table. The questions were grouped under three types of knowledge for the game: (1) Knowledge of children obesity. (2) Knowledge of ways and means of treating children obesity. (3) Knowledge of the universals and abstractions in treating children obesity. In order to ensure the achievement of game objectives would yield the attainment of intended learning outcomes in Fight Obesity 2.0, a constructive alignment proposed by Tan, Nurul Fazmidar and Wang was adopted [14], as shown in Figure 2.
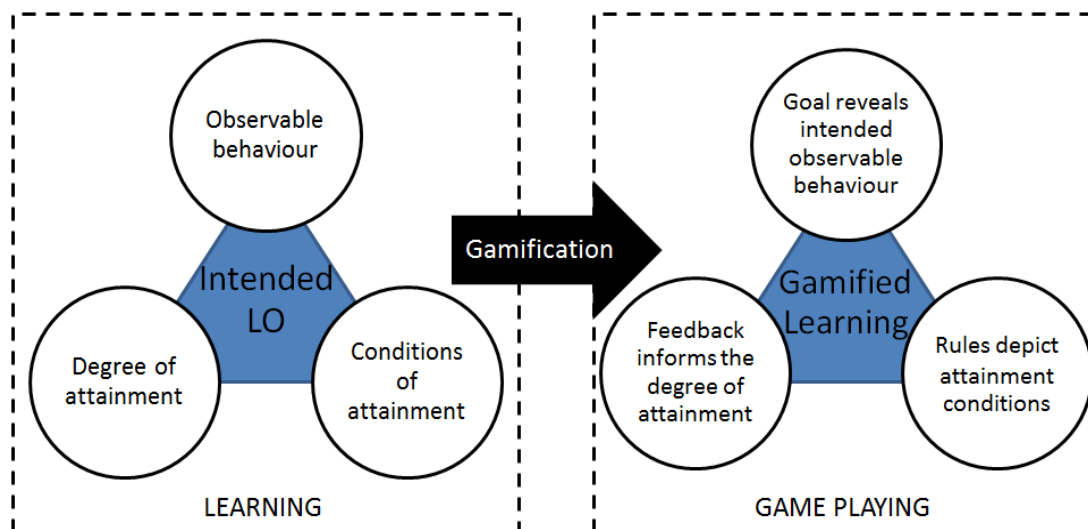
Figure 2 Constructive Alignment Model Used in the Game Design Process

Fight Obesity 2.0 Mobile Game

The design of Fight Obesity 2.0 started by setting its gameplay. It combined three types of challenges—knowledge, time pressure, and physical coordination to engage players, as depicted in Table 1. As a serious game intended to intervene lifestyle of preschool children, knowledge challenge was the key challenge of this game. As for game interaction model and mode, Fight Obesity 2.0 is a single-player avatar-based game, in which player can only role-play and control one avatar—either a boy or a girl game character in the game world, acting upon stimulus perceived by the avatar when overcoming challenges featured in three game levels. The game goal of Fight Obesity 2.0, i.e. the goal set for the main character in the game world was to keep a healthy lifestyle by choosing healthy diet and doing exercise. In terms of game rules, players must complete three game levels, especially by answering all ten questions asked in Level 3 correctly.

Table 1 Combination of game challenges in Fight Obesity 2.0

Game level			Challenge type	Descriptor
1	2	3		
✓	✓	✓	knowledge	To test players' knowledge on factual information.
	✓		Time pressure	To test players' capability to achieve game goal before running out of time.
✓	✓		Physical coordination	To test players' hand-eye coordination when responding to stimulus shown to them.

In terms of development, the tabletop version of Fight Obesity game was revised to build the Fight Obesity 2.0 mobile game (see Figure 2.3). Unity3D was chosen as the authoring tool for this game. A game flow diagram was developed to finalize the sequence of all events in Fight Obesity 2.0. These events were player events (rhombuses), in-game events (rectangles), and narrative events (circles and ovals), as shown in Figure 3 Fight Obesity 2.0 consists of four characters: The Boy, the Girl, the Mommy and the Doctor. The Boy and the Girl are two main characters while the Mommy and the Doctor are supporting characters.

As the hero or the heroin in the game world, the design of the Boy and the Girl were the utmost important matter for Fight Obesity 2.0.

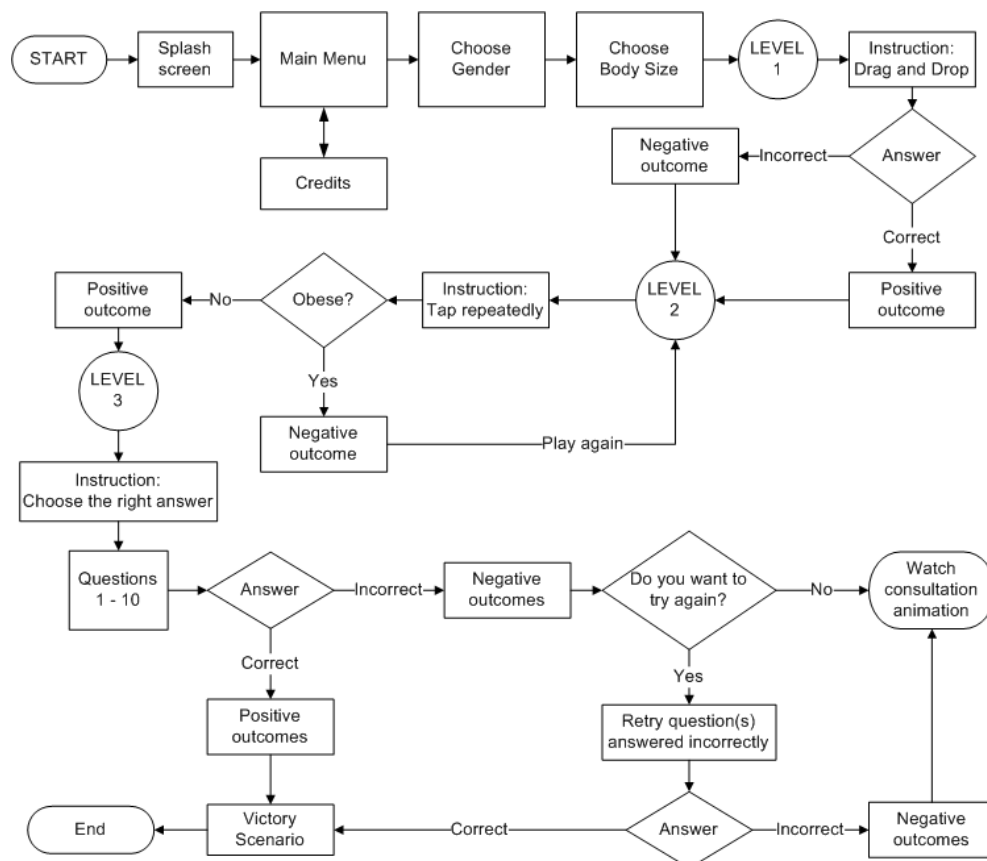Figure 3 The Splash Screen of Fight Obesity 2.0

Figure 4 The Overall Game Flow of Fight Obesity 2.0 Mobile Game

There are three levels in the Fight Obesity 2.0. Level 1 was designed to guide players to choose the gender and the body size of their avatar to represent their virtual self. After that, they could start playing three game levels sequentially. The design goal of this Level was to help tackling the problem of obesity in

Malaysia by educating children the virtue of healthy eating habits. In the ideation process, a constructive alignment was made between observable behaviour, condition and degree of attaining the intended outcome and game goal, rules and feedback, as shown in Table 2. Players need to choose healthy food to feed the avatar that is, by dragging a choice of food and dropping it into the avatar's mouth (Figure 5). In game development process, the initial idea was improved by having various food circling the avatar, optimizing the number of food can be presented to players in one time. If players chose healthy food, the health bar would increase and a big tick sign would pop up to reinforce players' positive action (Figure 6). However, if players chose unhealthy food, the health bar would decrease and a big cross sign would pop up to warn players' negative action (Figure 6).

Table 2 Alignment between intended outcomes of level 1and game goal, rules and feedback

| Observable behaviour Differentiate …	Condition …healthy food and non-healthy food…	Degree …by making less than 3 mistakes in less than 10 attempts.
Goal Choose the right food for the avatar.	Rule 1. Drag and drop healthy food to raise the health bar. 2. Choosing unhealthy food will lower the health bar. 3. Avatar can only eat maximum two units of unhealthy food.	Win Feedback Well done!! You eat healthy!! Lose Feedback You are obese / overweight!! You eat unhealthy!!
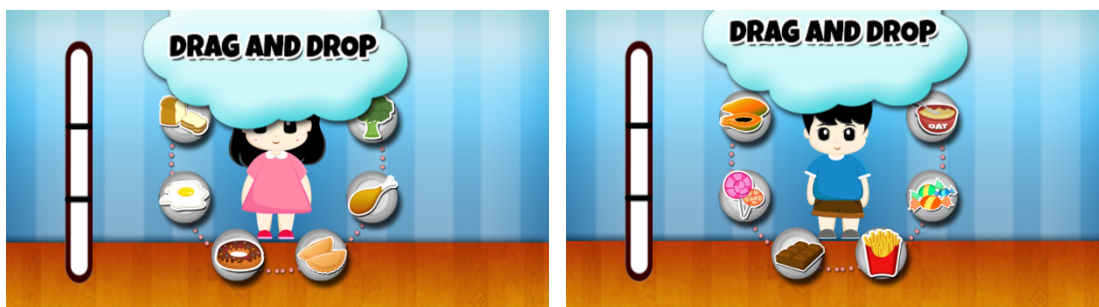
Figure 5 Drag and Drop Healthy Food to Feed the Boy or the Girl Game Character
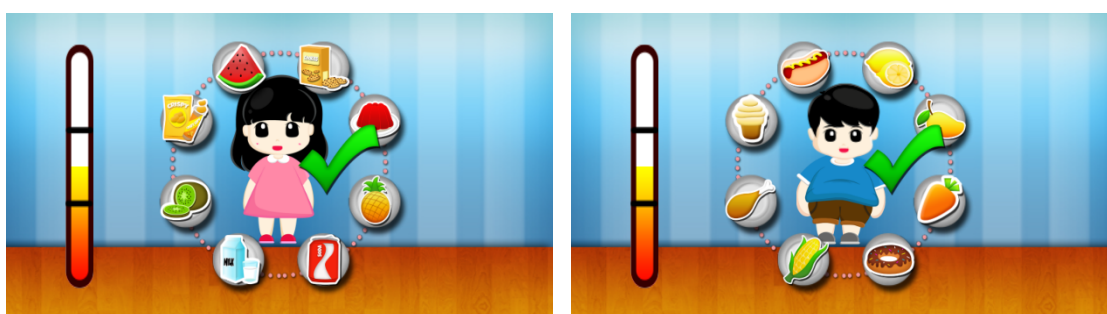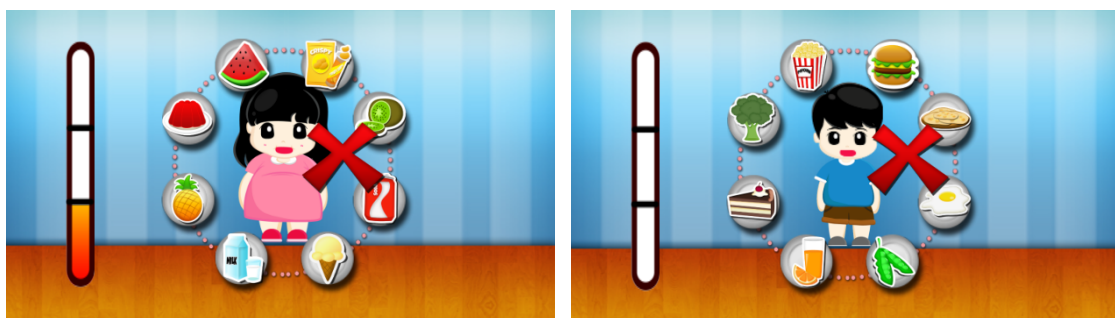
Figure 6 Positive and Negative Visual Feedbacks Reinforce Players' Behaviours

There were 42 options of food and drink created for Level 1, in which 23 of them were healthy while 19 were unhealthy, as shown in Figure 7. Players won Level 1 after the health bar turned full, and they would be directed to watch the winning animation. They would be praised for their achievement. However, when they made three mistakes, i.e. feeding the avatar with three units of any unhealthy food, they would be warned for losing Level 1 because their avatar was obese due to unhealthy diet. In terms of game mechanics, players must feed the avatar with six (without eating unhealthy food) to ten units (eating one or two unhealthy food) of food in order to win Level 1. In total, there are 33 possible winning conditions.

Level 2 was designed for children to learn the importance of exercise. The body size of players' avatar in Level would be carried forward to Level 2, signifying that exercise help shaping unhealthy body size caused by unhealthy diet. In the ideation process using constructive alignment, two exercise apparatus—hula hoop and skipping rope were chosen for Level 2 (see Table 3). The initial gameplay of Level 2 required players to choose an apparatus and tap the avatar for 60 seconds. However, in the implementation, instead of tapping avatar, players were instructed to tap the icon of hula hoop or skipping rope, and the duration was reduced to avoid players from getting bored (Figure 8). Players must keep the health bar green to fight against obesity. When the avatar did exercise, the health bar would turn into green colour; but when the avatar stopped doing exercise, the health bar would turn back to red colour. Once the health bar turned full at the end of 30 seconds, players won Level 2, and they would be directed to watch the winning animation. They would be praised for their achievement and advised for their failure.

Table 3 Alignment between intended outcomes and game elements of Level 2

| Observable behaviour	Condition	Degree
Understand the consequences of…	…doing exercise and stopping exercise upon the size of body…	…by relating exercise to healthy lifestyle and connecting obesity to stopping exercise.
Goal	Rule	Win Feedback
Tap ether skipping rope or hula hoop buttons to simulate exercise.	1. Tap skipping rope or hula hoop button rapidly for 30 seconds to keep avatar fit. 2. The body size of avatar may turn into obese when he or she stops doing exercise.	Well done!! You are healthy!! Lose Feedback You are obese / overweight!! You need more exercise!!
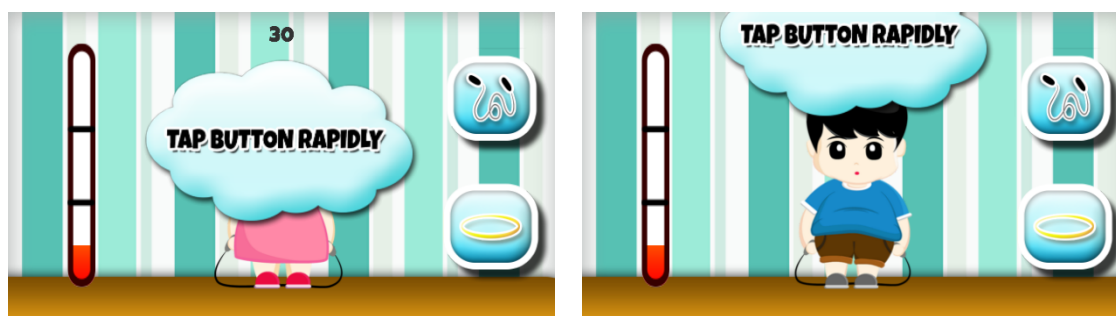
Figure 7 Finalized Gameplay for Level 2

In Level 3, the players are guided to learn characteristics of healthy lifestyle and good habits. As shown in Table 4, the constructive alignment requires players to answer ten questions correctly in order to win this game level. These questions were divided into three categories: the importance of doing exercise; the importance of right food choices; and the importance of right drink and drinking water. At the end of the level, a total score would be shown to the player. Question 1 and Question 9 stressed the importance of doing exercises and the consequences of not doing exercises. To reinforce the memory of players, these questions and the feedback of answering individual questions were presented through graphics and audio. Five questions were set to depict the importance of right food choices. These questions were asked by Mommy, in which players were prompted to choose healthy food in Question 2, 4, 6 and 10, and they were asked whether they like to eat fast food or not in Question 3. The feedback of answering individual questions was presented through graphics and audio in order to reinforce the memory of players. Three questions were set to depict the importance of choosing the correct drink and drinking plain water. The Mommy asked these questions and players had to choose plain water in Question 5 and 7, and they were asked whether they like to fruit juice or soda drink in Question 8. Correct answers given by players would prompt a same positive feedback in all three questions; while incorrect answers would trigger negative feedback.

Table 4 Alignment between intended outcomes and game goal, rules and feedback of Level 3

Observable behaviour Choose…	Condition …the right options which reflect healthy lifestyle…	Degree …in all ten questions, without making the same mistake twice.
Goal Tap on a correct option for healthy lifestyle.	Rule Answer all ten questions correctly. Players are given a second chance for every mistake made.	Win Feedback Very good! You will become healthy and strong! Lose Feedback You will become obese! You will become fat and lazy. You are not healthy! You should drink more water.

Virtual Consultation Animation

At the end of Level 3, players who made mistake when answering any question would be given chances to retry questions they answered incorrectly. If they chose not to retry those questions, they would be directed to watch a consultation animation on childhood obesity. A virtual doctor was featured in this animation, where he advises players about the consequences of obesity. Figure 8 shows the storyboard of the virtual consultation. Players could learn the consequences of obesity by understanding what would happen if they became obese. Once the animation is over, the players are prompted on whether they want to try Level 3 again. With the knowledge on how dangerous obesity can be, children would be convinced to choose healthy options for the scenarios featured in Level 3.
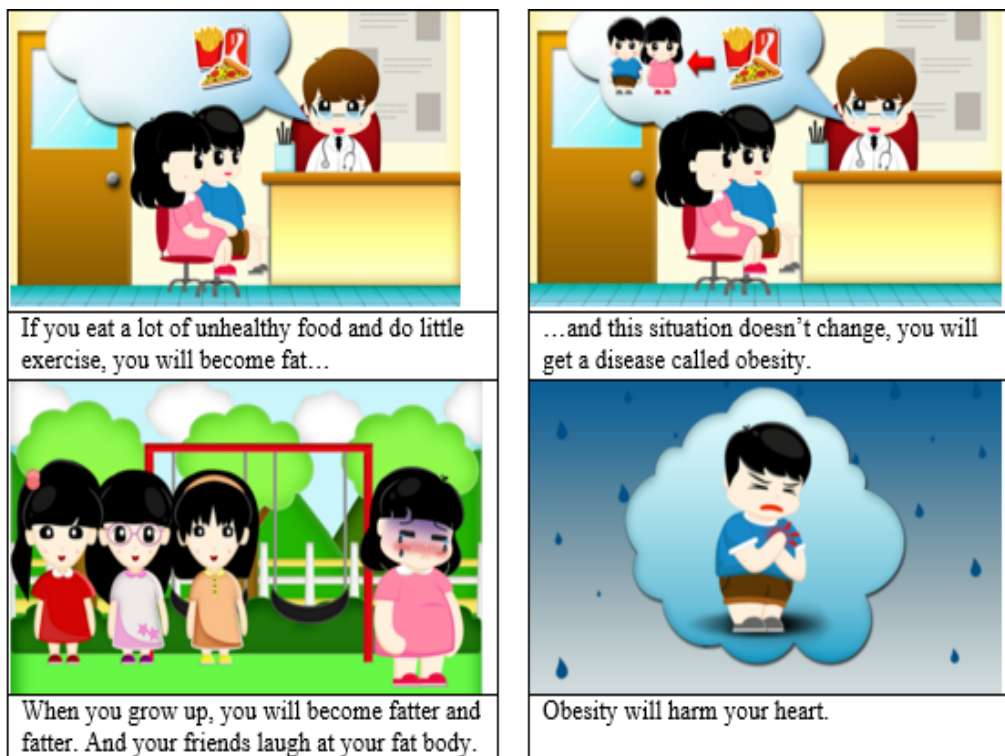
Figure 8 The Storyboard of Virtual Consultation in Fight Obesity 2.0

Game Evaluation and Analysis

The Fight Obesity 2.0 were validated by multiple methods, including the game technology (GT), the content knowledge (CK), and the IARC Digital Game Content Rating. Table 4 shows the types of participants involved in the serious game validation. The LARC digital game content rating was done by google app store. This paper mainly focuses on the playtesting and content experts' evaluation part. In the playtesting evaluation part, we use the Mode choice models to analysis the raw data, because Mode choice models deals very closely with the human choice making behaviour. The software used in this research is Statistical Package for Social Sciences (SPSS).

Table 4 Validation methods of this four-phase research

Methods	Purpose	Types of participants	N	Scope of validation		
				GT	CK	PS
IARC Digital Game Content Rating	To achieve global standard rating and age classification.	Rating authorities in various regions	5		/	
Playtesting	To examine the usability of Fight Obesity 2.0.	Game designers	38	/		
Semi-structured interview	To examine the perceptions of pediatricians on Fight Obesity 2.0 and the game-based childhood obesity prevention framework.	Pediatricians	2		/	/
TOTAL			45			

Age Rating of Fight Obesity 2.0

Prior to the publication of Fight Obesity 2.0 in Google Play Store, the game went through an automated classification process under the governance of the International Age Rating Coalition (IARC). The coalition was established to streamline the acquisition of content ratings from authorities in different countries [15]. An IARC Rating Certificate was issued to Fight Obesity 2.0 on 15 May 2015, indicating the success of the game in passing a content validation, affording the game to be used with children aged three years old and above.

Overall of usability validation through playtesting

The purpose of playtesting the serious game was to validate the usability in five aspects, which were likeability, efficiency, helpfulness, control and learnability [16]. The underlying assumption of conduct of the playtesting session was that game designers know the most about game design, as compared to end users or stakeholders of the serious games. End users of the serious game were regarded as the subjects or participants in the quasi-experiment. They were preschool children who do not have the cognitive knowledge to comprehend the mechanics, dynamics and aesthetics of game design, therefore they were not fit to playtest the serious game in this research. Stakeholders of the serious game may be kindergarten teachers and parents. They were regarded as clients who have limited or no professional knowledge on game design, thus they were not fit to playtest the game. In this research, people who were qualified as game designers should have at least two years of formal study in game design and development courses at tertiary education.

The playtesting session was conducted with 38 out of 40 game designers who went through formal game design and development courses at higher education level. Most of the testers possessed a diploma in game technology, and had experience in game design and development. All participants were male, aged between 20 to 23 years old. No female game designer was available on the date when the playtesting session was specially set up in a computer lab in a higher education institution. Nevertheless, the game was designed by a female designer and it was important to have the male testers to assure the game as gender neutral

game. The instrument used in the playtesting session was a questionnaire adapted from the Software Usability Measurement Inventory (SUMI) developed by Kirakowski and Corbett [16]. The adaptation was made to ensure the context of the questions asked in early 1990s was adjusted to meet the validity requirements set for nowadays mobile apps and computing technology. Collected data were sorted using Microsoft Excel and then analysed using IBM SPSS, in which descriptive statistics were used to summarize the sample through frequency, mode, and cross tabulation tables. The perception of playtesters was measured on a three-point ordinal scale: agree, undecided, or disagree. The results of the playtesting were organized into five sections: likeability, efficiency, helpfulness, control and learnability, in which each construct consists of ten items.

There are 19 positive items and 31 negative items in the instrument, in which Fight Obesity 2.0 gained 16 modes on "Agree" in positive items and 24 modes on "Disagree" in negative items. In other words, the overall usability result was 80% (40 out of 50 items), as shown in Table 5. The game received more than 50% scores in efficiency (61%), helpfulness (52%) and learnability (64%). Its usability on likeability (49%) and control (48%) were slightly below 50% (Figure 9).

Table 5 Frequency of modes attained by Fight Obesity 2.0 in the playtesting

| | | Disagreed | Undecided | Agreed | Scored items | |
					Sub	Total
Likeability	5 positive Items	0	1	4	4	8
	5 negative items	4	0	1	4	10
Efficiency	6 positive Items	0	1	5	5	8
	4 negative items	3	1	0	3	10
Helpfulness	5 positive Items	0	1	4	4	7
	5 negative items	3	1	1	3	10
Control	3 positive Items	0	0	3	3	8
	7 negative items	5	0	2	5	10
Learnability	10 negative items	9	0	1	9	9
						10
Positive items (n = 19)		0	3	16		40
Negative items (n = 31)		24	2	5		50
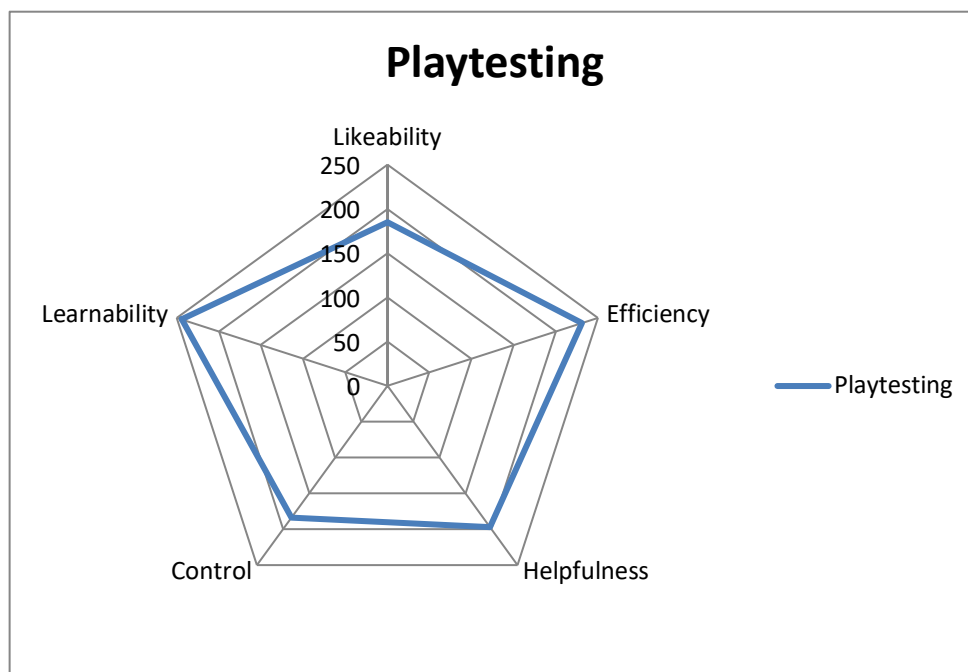
Figure 9 The Overall Usability Performance of Fight Obesity 2.0

Likeability evaluation of Fight Obesity 2.0

Likeability or affect towards Fight Obesity 2.0 measured the testers' general emotional reaction to the game [16]. Eight of the ten items related to likeability showed positive outcomes. Testers agreed with four positive items and disagreed with four negative items (see Table 6). Most of them did not feel headache (Mode = Disagree), frustrating (Mode = Disagree) or tense (Mode = Disagree) when playing the game. Nearly half of the testers enjoyed their sessions with Fight Obesity 2.0 (Mode = Agree) and regarded playing the game as a satisfying experience (Mode = Agree). However, the testers were unsure whether Fight Obesity 2.0 was inconsistent or not (Mode = Disagree & Undecided). The majority of the testers would not like to use the game every day, probably because the game was too short (ranging from 2:50 to 5:00 per play session), and it was not meant for their age level. Therefore, the design of Fight Obesity 2.0 should focus on enhancing its replay-ability and stickiness in order to make targeted players keep coming back to it.

Table 6 Testers' perception on likeability of Fight Obesity 2.0
(D: disagree; U: undecided; A: agree; N: sample size)

Item		Perception			Mode	N
		D	U	A		
Positive	I would recommend Fight Obesity 2.0 to my peers	9	17	12	U	38
	I enjoy my sessions with Fight Obesity 2.0.	9	12	17	A	38
	Playing with Fight Obesity 2.0 is satisfying.	12	11	15	A	38
	Playing with Fight Obesity 2.0 is mentally stimulating.	9	9	20	A	38
	Fight Obesity 2.0 has a very attractive presentation.	7	7	24	A	38
Negative	I would not like to use Fight Obesity 2.0 every day.	7	7	24	A	38
	I think Fight Obesity 2.0 is inconsistent.	15	15	8	D & U	38

I think Fight Obesity 2.0 has made me have a headache on occasion.	25	9	4	D	38
Playing Fight Obesity 2.0 is frustrating.	23	11	4	D	38
There have been times in playing Fight Obesity 2.0 when I have felt quite tense.	27	8	3	D	38

Efficiency evaluation of Fight Obesity 2.0

When Fight Obesity 2.0 was play tested, the efficiency construct measured the degree to which testers felt that the game assisted them in understanding childhood obesity and was related to concept of transparency [16]. Three aspects of Fight Obesity 2.0 were tested, i.e. speed, ease of use, and visual organization. As a whole, six out of ten items yielded positive outcomes in the efficiency construct (see Table 7). Testers agreed with five positive items and disagreed with one negative item. Most of the testers agreed that the speed of Fight Obesity 2.0 was fast enough (Mode = Agree), affording task to be performed in a straightforward manner (Mode = Agree). The organisation of the menus seems quite logical (Mode = Agree), in which options at each stage can be seen at a glance easily at each game level (Mode = Agree). Also, the way the information was presented in a clear and understandable manner. Most of the testers disagreed that the game responded too slowly to inputs (Mode = Disagree). However, since testers were using emulator rather than tablet or smart phone to play test Fight Obesity 2.0, delay responses were possible, causing certain testers to agree with this item. Most of the testers disagreed that it was difficult to get data in and out of the game or not (Mode = Disagree), but no data files can be get in or out of the game actually, and this may be why some testers agreed or undecided on this item. Testers were not sure whether it was easy to restart the game or not if it stopped (Mode = Undecided). None of the 38 screencast videos captured in the playtesting sessions crashed or required testers to restart, so it made sense for them to be undecided on this item.

Table 7 Testers' perception on efficiency of Fight Obesity 2.0

Item		Perception			Mode	N
		D	U	A		
Positive	The speed of Fight Obesity 2.0 is fast enough.	13	5	20	A	38
	Tasks can be performed in a straightforward manner using Fight Obesity 2.0.	3	9	26	A	38
	The organisation of the menus or information lists seems quite logical.	3	2	33	A	38
	The way that system information is presented is clear and understandable.	2	1	35	A	38
	It is easy to see at a glance what the options are at each stage.	1	4	33	A	38
	Fight Obesity 2.0 allows the player to be economic of keystrokes.	6	19	13	U	38
Negative	If Fight Obesity 2.0 stops, it is not easy to restart it.	12	18	8	U	38
	Fight Obesity 2.0 responds too slowly to inputs.	17	9	12	D	38
	There are too many steps required to get something to work.	25	7	6	D	38
	Getting data files in and out of the game is not easy.	17	7	14	D	38

Helpfulness evaluation of Fight Obesity 2.0

In the playtesting, helpfulness was measured based on the degree to which Fight Obesity 2.0 was self-explanatory, as well as more specific things like the adequacy of help facilities and documentation [16]. In terms of helpfulness, half of the items under this construct generated positive outcomes in the playtesting (see Table 8). Testers agreed with four positive items and disagreed with one negative item. Testers generally agreed that instructions and prompts in the game were helpful (Mode = Agree). To them, Fight Obesity 2.0 documentation was very informative (Mode = Agree), and testers can understand and act on the information (Mode = Agree). It was obvious that the needs of players had been fully taken into consideration (Mode = Agree), and they disagreed that there was too much to read before they can play the game (Mode = Disagree). Half of the testers disagreed that the help information given by the game, particularly at the beginning of every game level was not useful (Mode = Disagree). Although most of the testers (15 out of 38) disagreed that there was never enough information on the screen when it was needed, more than half testers were either disagreed or undecided on this proposition. Most of them were unsure whether error prevention messages were adequate or not (Mode = Undecided). Therefore, more formative feedback would be needed to assure players on this matter. Nonetheless, testers were uncertain whether or not the game has helped them overcome any problems they had in playing it (Mode = Undecided).

Table 8 Testers' perception on helpfulness of Fight Obesity 2.0

Item		Perception			Mode	N
		D	U	A		
Positive	The instructions and prompts are helpful.	2	9	27	A	38
	Fight Obesity 2.0 documentation is very informative.	3	13	22	A	38
	I can understand and act on the information provided by Fight Obesity 2.0.	1	3	34	A	38
	Fight Obesity 2.0 has helped me overcome any problems I have had in playing it.	9	16	13	U	38
	It is obvious that user needs have been fully taken into consideration.	5	11	22	A	38
Negative	I find that the help information given by Fight Obesity 2.0 is not very useful.	19	15	4	D	38
	There is never enough information on the screen when it's needed.	15	11	12	D	38
	There is too much to read before you can play Fight Obesity 2.0.	29	3	6	D	38
	Error prevention messages are not adequate.	13	21	4	U	38
	Either the amount or quality of the help information varies across the system.	3	17	18	A	38

Control Evaluation of Fight Obesity 2.0

In the playtesting, the control construct was based on the extent testers felt in control of Fight Obesity 2.0, as opposed to being controlled by the game when playing a specific game level. As shown in Table 9, most of the testers felt in command when playing the game (Mode = Agree), where it was relatively easy to move

from one part of a task to another (Mode = Agree) and make the game do exactly what they want (Mode = Agree). Testers disagreed that the game stopped unexpectedly sometimes (Mode = Disagree), had not always done what they were expecting (Mode = Disagree), or disrupted the way they normally like to play game (Mode = Disagree). They also disagreed that sometimes they did not know what to do next (Mode = Disagree) or wonder if they were using the right command (Mode = Disagree). However, testers agreed that they felt safer if they used only a few familiar commands or operations (Mode = Agree), and preferred to stick to the facilities they knew best (Mode = Agree). Actually, it was on purpose since Fight Obesity 2.0 was designed specifically for preschool children, the only command needed to master was tapping on the screen. There were maximum two tap-able buttons on any screen of the game.

Table 9 Testers' perception on control of Fight Obesity 2.0

Item		Perception			Mode	N
		D	U	A		
Positive	I feel in command of Fight Obesity 2.0 when I am using it.	6	12	20	A	38
	It is easy to make Fight Obesity 2.0 do exactly what you want.	12	8	18	A	38
	It is relatively easy to move from one part of a task to another.	5	4	29	A	38
Negative	Fight Obesity 2.0 has at some time stopped unexpectedly.	24	11	3	D	38
	Fight Obesity 2.0 hasn't always done what I was expecting.	21	13	4	D	38
	Fight Obesity 2.0 seems to disrupt the way I normally like to play game.	16	13	9	D	38
	I sometimes don't know what to do next with Fight Obesity 2.0.	25	4	9	D	38
	I sometimes wonder if I'm using the right command.	21	7	10	D	38
	I feel safer if I use only a few familiar commands or operations.	6	11	21	A	38
	I prefer to stick to the facilities that I know best.	4	8	26	A	38

Learnability Evaluation of Fight Obesity 2.0

When Fight Obesity 2.0 was tested, the learnability construct was measured based on the speed and facility with which testers felt that they had been able to master the game, or to learn how to use new features when necessary. As shown in Table 10, most of the testers disagreed with nine negative items under the learnability construct. The only negative item they agreed was that Fight Obesity 2.0 was awkward when they wanted to do something not standard (Mode = Agree). The game was actually designed to stop preschool players from doing something that is non-standard. In general, as long as players follow instruction, the testers would not find Fight Obesity 2.0 awkward (Mode = Disagree). In general, learning to operate Fight Obesity 2.0 initially was not full of problem (Mode = Disagree), especially when learning how to use new functions (Mode = Disagree). Testers did not take too long to learn all commands (Mode = Disagree), and they did not think that it was easy to forget how to do things with the game (Mode = Disagree). The game did not occasionally behave in a way which cannot be understood (Mode = Disagree).

Consistent with findings on screencast videos, none of the testers went back to look at guides (Mode = Disagree) or look for assistance most times when playing Fight Obesity 2.0 (Mode = Disagree). Most of them disagreed that they would never learn to use all that was offered in the game (Mode = Disagree).

Table 10 Testers' perception on learnability of Fight Obesity 2.0

Item	Perception			Mode	N
	D	U	A		
Learning to operate Fight Obesity 2.0 initially is full of problems.	23	13	2	D	38
Learning how to use new functions is difficult.	21	6	11	D	38
It takes too long to learn the Fight Obesity 2.0 commands.	33	5	0	D	38
It is easy to forget how to do things with Fight Obesity 2.0.	25	9	4	D	38
Fight Obesity 2.0 is awkward when I want to do something which is not standard.	13	11	14	A	38
Fight Obesity 2.0 occasionally behaves in a way which can't be understood.	29	6	3	D	38
Fight Obesity 2.0 is really very awkward.	17	11	10	D	38
I keep having to go back to look at the guides.	32	2	4	D	38
I will never learn to use all that is offered in Fight Obesity 2.0.	17	14	7	D	38
I have to look for assistance most times when I play Fight Obesity 2.0.	34	3	1	D	38

Content Evaluation by Interviewing Pediatricians

The Semi-structured interview was conducted with two volunteering pediatricians who were interested in the game-based childhood obesity prevention to verify the accuracy of content knowledge on childhood obesity prevention contained in Fight Obesity 2.0. The findings of the interview sessions were expected to validate the use of Fight Obesity 2.0 mobile game in healthcare practices. The first interviewee, Dr LZY (pseudonym) is a female pediatrician working at the Child Healthcare Specialist Clinic in Ningbo Women and Children's Hospital, Zhejiang province China. The hospital is a tertiary specialized hospital for women and children, which offers medical treatment, health care, teaching, scientific research, disease prevention, first aid and rehabilitation (Ningbo Women and Children's Hospital, 2016). The online interview session with Dr LZY was held on 5 January 2017, in which she answered six interview questions and then she was asked to justify her answers one-by-one. The second interviewee, Dr LKF (pseudonym) was a male pediatrician working at the Specialist Pediatric Clinic in Hospital Tuanku Ja'afar Seremban (HTJS), Negeri Sembilan, Malayisa. To date, the HTJS is the largest public hospital funded by the Malaysia Ministry of Health in the state of Negeri Sembilan. An online interview session with Dr LKF was carried out on 11 January 2017, after being rescheduled for several times. Dr LKF was very keen in exploiting the potential and practicality of Fight Obesity 2.0 mobile game. He actually let his four-year-old son play the game on his mobile phone a day before the interview session.

Both of them played the game, watched the game trailer, and browsed through the Fight Obesity 2.0 website before the interview session. They were also informed that Fight Obesity 2.0 was intentionally created for preschool children to learn the following three things: 1: To differentiate healthy food and

unhealthy food, 2: To understand the relationship between healthy lifestyle and obesity, and 3: To the danger of overweight and childhood obesity. After matching the intended outcomes and the features shown in three game levels, they agreed that the content knowledge on childhood obesity prevention incorporated in the Fight Obesity 2.0 mobile was accurate. They further justified that, "diet and exercise are the main things for prevention of obesity." They believed the prevention strategy would be practical if the parent lead the child. Dr LKF added, "In clinic, we found the obese child very difficult to reduce weight". In fact, parents play an important role which affect their children's body size. When Dr LKF was asked when and where a game like Fight Obesity 2.0 can be used to prevent childhood obesity, he suggested that it "can be used before ordering food". In his opinion, both parents and children may use a game like Fight Obesity 2.0 to prevent childhood obesity. In practice, the game should emphasise on the bad things or the danger of obesity on both adulthood and childhood. At the end of the interview session, Dr LKF highlighted once again, "Parents need to be involved!"

Conclusions and Discussions

This paper contributes to the better understanding of the design, development and validation of a serious game for childhood obesity prevention. It presented an innovative obesity prevention approach for preschool children through the creation and validation of a game-based childhood obesity prevention framework. This mobile game was created using a combination multiple gamification approach, integrating the player-centric emotional design and the lean game production method. The approach would make current gamification practices more systematic and dynamic, particularly when aligning intended prevention outcomes with structural elements of games. The outcomes—the Fight Obesity 2.0 and its paratextual materials have been proven effective through the deployment of the three-scope validation strategy. By using this strategy, the quality of serious games for prevention can be assured through the validation of their content knowledge, game technology, and prevention strategy.

However, Fight Obesity 2.0 is an educational mobile app dedicated to teach preschool children the importance of maintaining a healthy diet and lifestyle. And it is created using researched information on obesity, and it is explored by allowing preschool children to interact with the app in a fashion similar to a mobile game. This novelty of Fight Obesity 2.0 has been enriched by game-based treatment framework drawn from an empirical study. The semi-structured interview sessions with pedestrians verified the accuracy of content knowledge on childhood obesity prevention contained in Fight Obesity 2.0. In the future study, a game-based obesity prevention could only be feasible and effective after teachers, caretakers or doctors get hold of information associated to the contexts where specific child lives and grows up. In particular, the success of game-based obesity prevention would require parents to get involved.

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Appendix

Content Knowledge of Children Obesity Prepared for Fight Obesity 2.0 (WHO, 2020)

Prompting Questions	Answers adapted from World Health Organization
Q1. What is childhood overweight and obesity?	Overweight and obesity are defined as "abnormal or excessive fat accumulation that presents a risk to health".
Q2. What the cause of childhood overweight and obesity?	The fundamental cause of childhood overweight and obesity is an energy imbalance between calories consumed and calories expended.
	Global increases in childhood overweight and obesity are attributable to a number of factors including: ● A global shift in diet towards increased intake of energy-dense foods that are high in fat and sugars but low in vitamins, minerals and other healthy micronutrients; ● A trend towards decreased physical activity levels due to the increasingly sedentary nature of many forms of recreation time, changing modes of transportation, and increasing urbanization.
Q3. What are the consequences of obesity?	Childhood obesity is associated with a higher chance of premature death and disability in adulthood. Children who face overweight or obesity problem are more likely to stay obese into adulthood and to develop non-communicable diseases (NCDs) like diabetes and cardiovascular diseases at a younger age. For most NCDs resulting from obesity, the risks depend partly on the age of onset and on the duration of obesity. Obese children and adolescents suffer from both short-term and long-term health consequences. The most significant health consequences of childhood overweight and obesity, that often do not become apparent until adulthood, include: ● cardiovascular diseases (mainly heart disease and stroke); ● diabetes; ● musculoskeletal disorders, especially osteoarthritis; and ● certain types of cancer (endometrial, breast and colon).

Content Knowledge of Ways and Means of Treating Childhood Obesity (WHO, 2020)

Prompting Questions	Answers adapted from World Health Organization

Q4. What can be done to fight the childhood obesity epidemic?	The goal in fighting the childhood obesity epidemic is to achieve an energy balance which can be maintained throughout the individual's life-span. General recommendations: 1. Increase consumption of fruit and vegetables, as well as legumes, whole grains and nuts; 2. Limit energy intake from total fats and shift fat consumption away from saturated fats to unsaturated fats; 3. Limit the intake of sugars; and 4. Be physically active - accumulate at least 60 minutes of regular, moderate- to vigorous-intensity activity each day that is developmentally appropriate.
Q5. How to develop healthy diet?	For diet, recommendations for populations and individuals should include the following: 1. Achieve energy balance and a healthy weight 2. Limit energy intake from total fats and shift fat consumption away from saturated fats to unsaturated fats and towards the elimination of trans-fatty acids 3. Increase consumption of fruits and vegetables, and legumes, whole grains and nuts 4. Limit the intake of free sugars 5. Limit salt consumption from all sources and ensure that salt is iodized.
Q6. What is the recommended level of physical activity for children aged 5 - 17 years?	For children and young people, physical activity includes play, games, sports, transportation, chores, recreation, physical education, or planned exercise, in the context of family, school, and community activities. In order to improve cardiorespiratory and muscular fitness, bone health, and cardiovascular and metabolic health biomarkers: 1. Children and youth aged 5–17 should accumulate at least 60 minutes of moderate- to vigorous-intensity physical activity daily. 2. Amounts of physical activity greater than 60 minutes provide additional health benefits. 3. Most of the daily physical activity should be aerobic. Vigorous-intensity activities should be incorporated, including those that strengthen muscle and bone*, at least 3 times per week. *For this age group, bone-loading activities can be performed as part of playing games, running, turning or jumping.

Content Knowledge of the Universals and Abstractions in Treating Childhood Obesity (WHO, 2020)

Prompting Questions	Answers adapted from World Health Organization
Q7. What are the principles for treating children overweight and obesity?	Overweight and obesity are largely preventable. It is recognized that prevention is the most feasible option for curbing the childhood obesity epidemic since current treatment practices are largely aimed at bringing the problem under control rather than effecting a cure. The goal in fighting the childhood obesity epidemic is to achieve an energy balance which can be maintained throughout the individual's life-span.

Graphics of Food and Drinks Created for Fight Obesity 2.0