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ORIGINAL ARTICLE

Effectiveness of Healthy Foodie Nutrition Game Application as Reinforcement Intervention to Previous Standard Nutrition Education of School-Aged Children: A Randomized Controlled Trial*

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Abstract

Objective. Games promoting nutrition education are helpful tools to improve nutrition knowledge. Healthy Foodie is an interactive web-based nutrition game for Filipino children. This study aimed to determine the effectiveness of Healthy Foodie on the nutrition knowledge of children aged 7 to 10 years old.

Methodology. This study had 2 phases. In Phase 1, we developed and validated the Healthy Foodie nutrition game application and Nutrition Knowledge Questionnaire involving 46 participants. The Nutrition Knowledge Questionnaire was divided into 2 15-item questionnaires: Part 1 pertained to Food Group Knowledge and Part 2 on Food Frequency Knowledge. Phase 2 was the implementation of the game and questionnaire. This was a randomized controlled trial conducted in two elementary schools in Manila, involving 360 participants divided equally into control and experimental groups.

Results. For Phase 1, internal consistency of the questionnaire using the Kuder-Richardson Formula 20 was 0.75 for part 1 and 0.70 for Part 2. In Phase 2, comparing the adjusted posttest mean Food Group Knowledge scores, there was statistically higher score (F=111.84, p=0.0001) in the experimental group (11.57±0.20) compared to the control (8.51±0.20). In the adjusted posttest mean Food Frequency Knowledge scores, there was a statistically higher score (F=56.12, p=0.0001) in the experimental group (10.70±0.15) compared to the control (9.07±0.15).

Conclusion. A nutrition game-based intervention such as Healthy Foodie is effective as a reinforcement intervention to previous standard nutrition education of school-aged children.

Key words: nutrition, health education, video games, nutrition questionnaire

INTRODUCTION

Good health and proper nutrition are essential for a child to fully achieve his full potential for growth and development. The double burden of malnutrition includes undernutrition and overnutrition. In a survey conducted by the Food and Nutrition Research Institute, there was a decreasing trend in the number of undernourished individuals, but there was an alarming rise in the trend for obesity among children.[1] The problem with pediatric obesity is that patients are prone to early development of cardiometabolic complications and subsequently, premature death in adulthood.[2] The various cardiometabolic complications associated with overweight and obesity in children are hypertension, vascular dysfunction, early coronary atherosclerosis, left atrial and ventricular dysfunction, insulin resistance, type 2 diabetes mellitus, dyslipidemia, obstructive sleep apnea, nonalcoholic fatty liver disease, cirrhosis, arthritis and atopy. It also has a psychosocial impact due to its effect on body image, self-esteem and socialization.[2,3] One way to prevent these untoward complications is to halt its progression with lifestyle modification at the earliest time possible.

The 3 basic food groups are the go, grow and glow foods. Go food pertains to carbohydrate-rich food. Grow food consists of protein-rich food. Glow food are those that are high in vitamins and minerals such as vegetables and fruits. Each food group is essential, with its own role in providing nutrients to make the body healthy. Interventions to promote education on healthy food abound. The American Academy of Pediatrics supports the 5-2-1-0 program, which is an excellent starting point for any nutritional counselling. This consists of 5 or more servings of fruits and vegetables a day, 2 hours or less of recreational screen time per day, one hour or more of daily physical activity and zero consumption of sugar

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sweetened drinks.[4] In the Philippines, the Department of Education released DO 13 s. 2017, detailing policies and guidelines on healthy food and drink choices in school canteens nationwide.[5] It categorized food into traffic light food groups of green, yellow and red. The green group includes food and drinks that must be served at all times by school cafeterias. Yellow consists of food and drink items that can be served restricted to the guidelines. The red group lists those that should not be served.[5] This has been implemented in public but not in private schools. Standard nutrition education has also been integrated into the school curriculum. As early as grade 1, healthful and less helpful foods are discussed in class. In grade 2, children are taught about the basic food groups, the Filipino food plate and the food pyramid.[6]

On the other end, malnourished children are at risk of not maximizing their learning abilities and opportunities. While bridging the socioeconomic gap is a Herculean task, innovative methods directed toward the improvement of nutrition status may be implemented. To prevent future complications of malnutrition, proper nutrition education should be emphasized as early as elementary school.

The rapid advancement in technology has modified standard teaching media. Teaching techniques have escalated from the usual blackboard to modern e-learning and slide show modules. Using games as an approach to improve nutrition education have been used worldwide. Depending on the game objective, games are innovative tools to impart important knowledge and concepts.[7-9] Moreover, the advantage of instructional technology is that it can motivate and engage learners in their own learning pace.[10] Video games for health provide innovative, potentially highly effective methods for enriching knowledge by delivering persuasive messages, changing attitudes and behavior, as well as improving health outcomes.[7] Serious games are video games that aim to entertain and promote change in behavior.[11]

Creating a culturally-adapted electronic application on basic nutrition for Filipino children is an innovative concept that will provide them with a window of opportunity to learn basic nutrition food groups and healthy food choices.

This study aims to develop and validate the Nutrition Knowledge Questionnaire and the Healthy Foodie nutrition game application. Furthermore, this study aims to determine the effectiveness of Healthy Foodie nutrition game application using posttest mean nutritional knowledge scores between the control group and the experimental group. Through this investigation, a validated and effective educational tool can be offered to schools to reinforce existing nutrition education among elementary school children.

METHODOLOGY

This study was approved by the University of Santo Tomas Hospital Institutional Review Board. This study's ethical principles were guided by the Ethical Research Involving Children document developed by UNICEF. Parental consent and child verbal assent were secured prior to joining any part of the study.

This study had 2 phases. Phase 1 involved instrument development and validation of the Nutrition Knowledge Questionnaire and the Healthy Foodie nutrition game application. Phase 2 encompassed testing for effectiveness of the Healthy Foodie nutrition game application. The study design was a randomized controlled trial. Figure 1 summarizes the flow of this study.

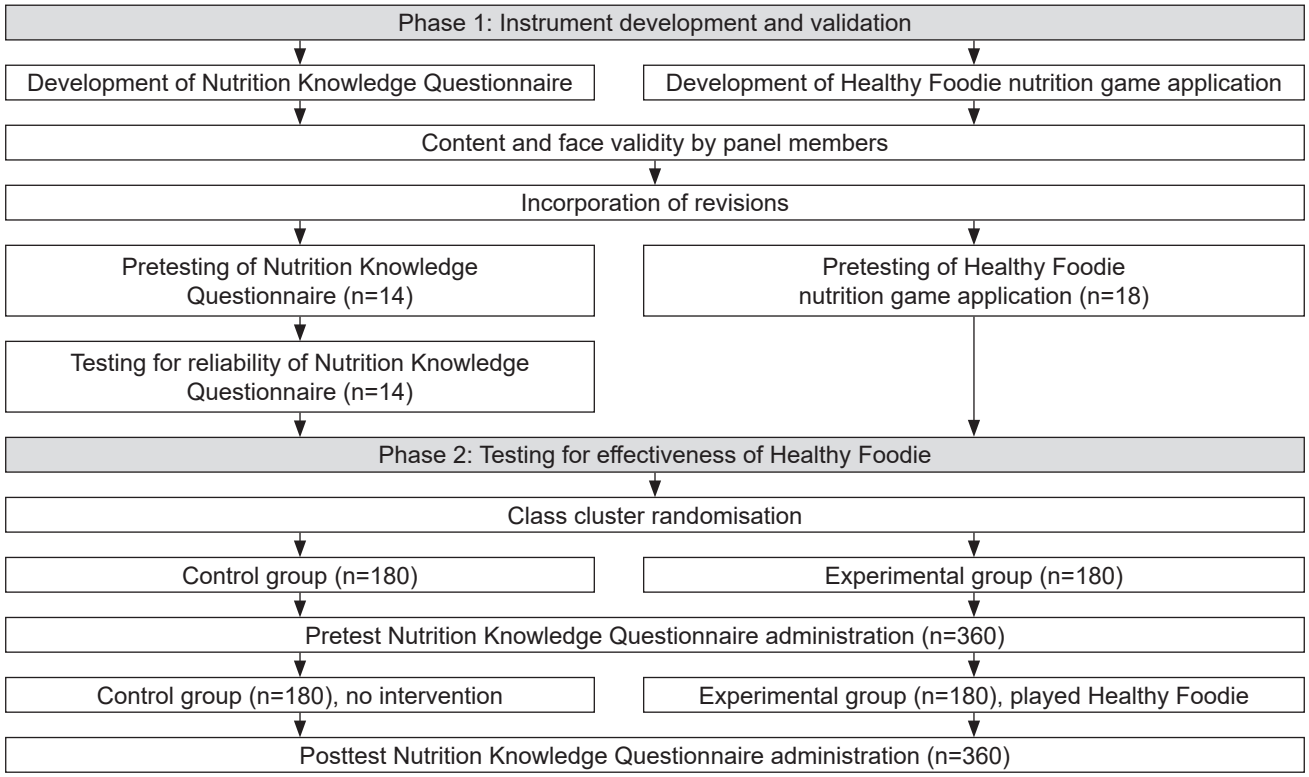

Figure 1. Study flow diagram.

Subjects

This study included grade 2 and grade 3 elementary students from the Cecilio Apostol Elementary School and Saint Jude Catholic School ages 7 to 10 years old. Individuals were excluded if they were blind, deaf, mentally challenged or unable to understand the English language.

Phase 1: Instrument development and validation

A multistep process was followed in the development and evaluation of the Nutrition Knowledge Questionnaire and Healthy Foodie nutrition game application.

Nutrition Knowledge Questionnaire

Literature search for nutrition knowledge questionnaire using the PubMed database yielded no content-specific basic nutrition knowledge questionnaire that matched the needs of the study. A questionnaire was subsequently developed. This was composed of 15 Food Group Knowledge questions and 15 Food Frequency Knowledge questions. The food group classification was based on the recommendations from the Food and Nutrition Research Institute.[12] The food frequency classification of the traffic light food group was based on guidelines from the Department of Education. The panelists had specific training in questionnaire construction and knowledge background on nutrition. The nutrition knowledge questionnaire included food frequently taken by Filipinos. The age group of the audience was taken into account in the construction of the questionnaire. While the average number of test questions in 2016 in grades 2 and 3 were 12 and 13, respectively, standardized assessments tend to choose 15 as the usual number of questions.[13]

The pretest and posttest questionnaires were the same (Appendix A). Close-ended pre-selected multiple choice responses were chosen as the response format. For the scoring system, a point was awarded for each correct answer.[14]

The draft was presented to 3 panel members composed of one physician, one elementary school teacher and one parent, to assess content and face validity. The clarity of the instructions and questions provided was assessed with a score of 1 to 3, with 1 as easily understandable, 2 fairly understandable and 3 difficult to be understood. If 2 or more members perceived an item as fair or difficult to understand, it was replaced and reevaluated. On the other hand, the content of the questionnaire was judged as appropriate or inappropriate. If 2 or more of the panel members perceived an item as inappropriate, it was deleted. A convenience sample of 14 grade 2 and grade 3 students age 7 to 10 years participated in the pretesting of the Nutrition Knowledge Questionnaire. Parental consent and child assent were secured prior to the pretesting. The students judged the clarity of the instructions and questions using a score of 1 to 3, with 1 as easily understandable, 2 fairly understandable and 3 difficult to understand. If more than half of the children perceived an item as fair or difficult to understand, it was replaced and reevaluated. For internal consistency of the questionnaire, a convenience sample of another set of 14 students with the same selection criteria was gathered to answer the pretest and posttest. Using Stata 13.0, the Kuder-Richardson Formula 20 (KR 20) was computed. The KR 20 was used to measure the relationship of the items in the questionnaire as a group. Acceptable consistency was an alpha level ≥0.7.[15]

Healthy Foodie Nutrition Game Application

Literature search for nutrition games in PubMed was done. The game category was games for health to increase knowledge.[7] The game concept development was guided by the principle of social cognitive theory.[16,17] This was developed in cooperation with students from the Institute of Information and Computer Science of the University of Santo Tomas. Screenshots of the game are found in Appendix B. The authors and game developers conducted meetings every 2 weeks for game development updates and finalization.

The game was composed of 2 parts. Part 1 discussed the 3 basic food groups (go, grow and glow) and the Filipino food plate. Part 2 tackled the traffic light food groups (red, yellow and green) and the food pyramid. Prior to each mini-game, a short discussion on the significance and examples of each food group was given. For game instructions in the mini-game of the basic food groups and traffic light food groups, the player had to collect 5 food articles and/or drinks from the specified category within one minute. Once a food item was clicked, the correct answer was displayed. If the player gets 3 incorrect answers or time runs out, the player had to redo the challenge again. The player can only move on to the next food group if he had accomplished the game successfully. The Eberly Center of Testing Excellence recommended that the quiz master should provide thrice his time to accomplish the mini game, so that one minute was deemed sufficient to answer each mini-game.[18]

For the Filipino food plate, the child had to choose one go food, one grow food and two glow foods (one fruit and one vegetable) and drag these food items to the proper place in the plate. Upon clicking next, the background of food placed in the proper category would be highlighted in green, while those highlighted in red were incorrect answers. The player had to get the correct combination to progress to the next part of the game. For the food pyramid, the child had to choose 3 green light food items, 2 yellow light and one red light. These should be dragged and dropped in the correct category inside the pyramid. Upon clicking next, the background of food placed in the proper category would be highlighted in green, while those highlighted in red were incorrect answers. The player would only be able to finish the game if a correct combination was made. If the student felt that the pace was going too fast, the back button takes the participant a step backward to review previous concepts. The game could be completed in 25 to 40 minutes. Content and face validity was assessed by 3 members composed of one physician, one elementary school teacher and one parent. The clarity of each sentence was assessed with a score of 1 to 3, with 1 as easily understandable, 2 as fairly understandable and 3 as difficult to understand. If 2 or more of the members perceived an item as fair or difficult to understand, it was replaced and reevaluated. Each illustration was graded 1 to 3, with 1 as easy to identify, 2 fairly identifiable and 3 difficult to identify. If two or more of the panel members perceived an illustration to be fair or hard to identify, it was replaced and reevaluated by the panel members. The content was assessed as appropriate

or inappropriate. If 2 or more of the members perceived an item as inappropriate, it was deleted. The Healthy Foodie nutrition game application was pretested to 18 students for content and face validity. The clarity of each sentence was judged with a score of 1 to 3, with 1 as easily understandable, 2 fairly understandable and 3 difficult to understand. If more than half of the children perceived an item as fair or difficult to understand, it was replaced and reevaluated. The illustrations were reviewed. Each illustration was graded 1 to 3, with 1 as easy to identify, 2 fairly identifiable and 3 difficult to identify. If more than half of the children perceived an illustration to be fair or difficult, it was replaced and reevaluated.

Phase 2: Testing for effectiveness of Healthy Foodie

Procedure and intervention

Parental consent and child assent were secured by the process discussed above. Students were grouped by class and subsequently randomized to either control or experimental groups by drawing lots conducted by the school coordinator. A pretest Nutrition Knowledge Questionnaire was administered to all students. This served as baseline knowledge scores of participants from both the control and experimental groups. Thereafter, the experimental group played Healthy Foodie in the school's computer laboratory. Each student was provided with his own computer terminal and personal headset while playing the game. The primary investigator and class teacher supervised the students during the administration of the program. The duration was 30 minutes. Both the control and the experimental groups took the posttest Nutrition Knowledge Questionnaire one week after completion of the pretest Nutrition Knowledge Questionnaire and/or Healthy Foodie Nutrition Game Application. All gathered data were kept safely in an envelope stored inside the office locker of the investigator. Dropouts defined as subjects who did not finish the pretest and posttest Nutrition Knowledge Questionnaires and/or Healthy Foodie Game Application were not included in the study.

Sample size computation using G*Power version 3.1.7 showed that a minimum sample size of 67 was necessary to achieve a power of at least 80% and a medium effect size of 0.35 at a significance level of 0.05 (two-tailed). A total of 360 grade 2 and grade 3 students were included in the study. The total population for both schools was 735, including second and third graders age 7 to 10 years old, two-thirds of whom were female.

Statistical analysis

The difference between ages of the students was compared using the independent T-test. Differences between gender, grade level and school category of students were compared using the Chi-square test. One-way multivariate analysis of variance (MANOVA) was used to compare the pretest scores between the control and the experimental groups. A significant result was a p value <0.05. One-way multivariate analysis of covariance (MANCOVA) was used to compare the mean posttest examination scores between the control and experimental groups. A significant result was a p value <0.05.

Debriefing through verbal feedback from children was noted by asking open-ended questions, such as "What can you say about the game?" and "What did you learn from the game?".

RESULTS

The participants were recruited on October 1, 2018 and December 7, 2018. A total of 735 students were invited to join the study, but only 360 returned completely filled-out parental and child assent forms. There were no dropouts. All the 360 participants finished the posttest.

Phase 1: Instrument Validation

Validation of Nutrition Knowledge Questionnaire

Content and face validity

The final questionnaire was assessed to have easily understandable instructions and questions with appropriate content by all members of the panel of experts. All 14 recruited students deemed the instructions clear and questions easily understandable.

The reliability of the questionnaire was computed and analyzed using the Kuder-Richardson Formula 20. Internal consistency was 0.75 for Part 1 (Food Group Knowledge Questionnaire) and 0.70 for Part 2 (Food Frequency Knowledge Questionnaire). Both Parts 1 and 2 of the Nutrition Knowledge Questionnaire met the minimum reliability coefficient, and it was then used for data collection in Phase 2.

Validation of Healthy Foodie Nutrition Application

Content and face validity

The sentences in the game were assessed as easily understandable while the content was deemed appropriate by all the panel members. The following illustrations were revised to meet the criterion "easy to identify" by the panel members: bread, *pan de sal*, cereal, coconut, chicken breast, banana *cue* and *kamote* (sweet potato) *cue*. The game was administered to 18 students. The clarity of the instructions provided was judged as easily understandable. The illustrations were generally easy to understand. One student deemed the following as fairly understandable: beans, spaghetti, cabbage and apple. Two students believed that the chicken breast illustration was fairly understandable.

Phase 2: Testing for effectiveness of Healthy Foodie

Table 1 lists the demographic profile of the students. The mean age of the control and the experimental groups were 8.07±0.78 and 7.94±0.79 years, respectively, which were not statistically different (t=1.62, p=0.106). The control group was mostly composed of males (52.22%), in contrast to the predominantly female experimental group (56.11%). Comparative analysis showed that these proportions were not statistically different (χ^2=2.50, p=0.114). The control group was equally composed of Grade 2 and Grade 3 respondents, while majority of the experimental group were from Grade 2 (56.67%). These proportions, nonetheless, were not statistically different (χ^2=1.61, p=0.205). The control (78.33%) and experimental (68.33%) groups were composed of students from a private school, analyzed to be statistically higher based on comparative analysis (χ^2=4.60, p=0.03).

Table 1. Demographic profile of respondents according to group assignment

Characteristic	Control (n=180)	Experimental (n=180)	Total (n=360)	Statistic	*p*-value (two-tailed)
Mean age, years (SD[a])	8.07 (0.78)	7.94 (0.79)	8.01 (0.78)	1.62	0.106
Sex (%)				2.50	0.114
Male	94 (52.22)	79 (43.89)	173 (48.06)		
Female	86 (47.78)	101 (56.11)	187 (51.94)		
Grade level (%)				1.61	0.205
Grade 2	90 (50.00)	102 (56.67)	192 (53.33)		
Grade 3	90 (50.00)	78 (43.33)	168 (46.67)		
School category (%)				4.60	0.032
Private	141 (78.33)	123 (68.33)	264 (73.33)		
Public	39 (21.67)	57 (31.67)	96 (26.67)		

[a] SD, standard deviation

Table 2. Between-group comparison[a] of the mean pretest Food Group and Food Frequency Knowledge scores

Pretest Score	Control (n=180)	Experimental (n=180)	F-statistic	*p*-value (two-tailed)
Mean Food Group Knowledge score (SD[b])	9.55 (3.72)	9.08 (3.48)	1.55	0.214
Mean Food Frequency Knowledge score (SD[b])	9.67 (2.79)	9.16 (2.55)	3.28	0.071

[a] Multivariate test: Pillai's Test=0.01, F=2.10, p=0.124
[b] SD, standard deviation

Table 3. Within-group comparisons[a] of the mean pretest and posttest Food Group and Food Frequency Knowledge scores

Test Score	Pretest	Posttest	F-statistic[b]	*p*-value (two-tailed)	Partial η^2
Mean Food Group Knowledge score (SD)					
Control	9.55 (3.72)	8.66 (3.82)	18.19[d]	0.001	0.092
Experimental	9.08 (3.48)	11.42 (3.25)	92.50[d]	0.001	0.341
Mean Food Frequency Knowledge score (SD)					
Control	9.67 (2.79)	9.22 (2.75)	6.25[c]	0.013	0.034
Experimental	9.16 (2.55)	10.55 (2.28)	61.00[d]	0.001	0.254

[a] Multivariate test: Pillai's Test=0.30, F=75.14, p=0.0001
[b] Adjusted for the effects of significant confounders: pretest Food Group Knowledge score for posttest Food Group Knowledge score, and both pretest Food Group Knowledge and Food Frequency Knowledge scores for the posttest Food Group Knowledge score
[c] Significant at 0.05
[d] Significant at 0.01

Table 4. Between-Group comparisons[a] of the mean posttest Food Group and Food Frequency Knowledge scores

	Control Group (n = 180)		Experimental Group (n = 180)			*p*-value	
Test Score	Crude Mean (SD)	Adjusted Mean[b] (SE)	Crude Mean (SD)	Adjusted Mean[b] (SE)	F-Statistic	(two-tailed)	Partial η^2
Posttest Food Group Knowledge Score	8.66 (3.82)	8.51 (0.20)	11.42 (3.25)	11.57 (0.20)	111.84[c]	0.0001	0.239
Posttest Food Frequency Knowledge Score	9.22 (2.75)	9.07 (0.15)	10.55 (2.29)	10.70 (0.15)	56.12[c]	0.0001	0.136

[a] Multivariate test: Pillai's Test=0.30, F=75.14, p=0.0001
[b] Adjusted for the effects of significant confounders: pretest Food Group Knowledge score for posttest Food Group Knowledge score, and both pretest Food Group Knowledge and Food Frequency Knowledge scores for the posttest Food Group Knowledge score
[c] Significant at 0.01

Table 2 shows the comparison of the pretest Food Group and Food Frequency Knowledge scores. The mean Food Group Knowledge scores of the control (9.55±3.72) and the experimental groups (9.08±3.48) were not statistically different (F=1.55, p=0.214). A similar finding was noted with the comparison of the mean pretest Food Frequency scores (F=3.28, p=0.071) of the control (9.67±2.79) and the experimental groups (9.16±2.55).

Table 3 illustrates within-group comparisons between the pretest and posttest scores. For the Food Group Knowledge score of the control group, there was a significant (F=18.19, p=0.001) decline from the pretest (9.55±3.72) to the posttest score (8.66±3.82). This finding was also noted in the comparison of the Food Frequency Knowledge scores, with a statistically significant decrease (F=6.25, p=0.013) from pretest (9.67±2.79) to posttest (9.22±2.75). For the experimental group, the Food Group Knowledge scores statistically increased (F=92.50, p=0.001) from pretest (9.08±3.48) to posttest (11.42±3.25). Moreover, 34.10% of the change in Food Group Knowledge score was attributed to the intervention. There was a statistically significant improvement (F=61.00, p=0.001) in the Food Frequency Knowledge scores from pretest (9.16±2.55) to posttest (10.55±2.28). The computed partial η^2 was 0.254, indicating that 25.40% of the improvement in the score was attributed to the intervention.

The between-group comparison of the posttest Food Group and Food Frequency Knowledge scores is presented in Table 4. The adjusted posttest mean Food Group Knowledge scores was statistically higher (F=111.84, p=0.0001) in the experimental (11.57±0.20) compared to the control group (8.51±0.20), after controlling for significant confounders. The 23.90% difference in scores between the control and the experimental groups was attributed to the intervention. The significant confounder was Pretest Food Group Knowledge Score for Posttest Food Group Knowledge Score.

After adjusting for statistically significant confounders, the adjusted posttest Food Frequency Knowledge scores in the control (9.07±0.15) and in the experimental group (10.70±0.15). were statistically significant (F=56.12, p=0.0001) using MANCOVA. The 13.60% difference between the adjusted mean scores was due to the study intervention. Both Pretest Food Group Knowledge and Food Frequency Knowledge Scores were significant confounders for the Posttest Food Group Knowledge Score.

Feedback

The game received positive verbal feedback from the students. Responses included: "*Marami akong natutunan* (I learned a lot)," "*Madali lang* (Easy)," "*Masaya* (Fun)," "I want to play again," and "Fun and easy."

DISCUSSION

The study had developed and validated culturally–adapted, helpful and innovative educational nutrition tools for second and third grade students, namely the Nutrition Knowledge Questionnaire and the Healthy Foodie nutrition game application.

Nutrition Knowledge Questionnaire

Most validated nutrition questionnaires for children addressed food and nutrition literacy in various aspects, such as nutrition knowledge, dietary patterns, behavior, attitudes, food preparation, cooking skills and food labeling.[19-25] These validated questionnaires were long and contained topics not related to this study's nutrition topics. This study's Nutrition Knowledge Questionnaire addressed nutrition knowledge with special interest to common food taken by Filipino children. It was concise, simple and easily administered. Since the content of the questionnaire encompassed topics in the Healthy Foodie game, the change in nutrition knowledge scores after playing Healthy Foodie can be reliably reflected.

Healthy Foodie Nutrition Game Application

Healthy Foodie was developed for Filipino children, with the clear intention to include foods common to Filipinos. Examples were rice, *pan de sal*, *puto* (rice cake), *kamote* (sweet potato), mango, coconut, *banana cue*, *kamote cue* and fish ball. Food seen in fast food chains, such as burger, fries, pancake and donut were also chosen to be included. Inasmuch as the authors wanted to include more examples, the game screen would appear overcrowded. As such, only 9 examples per food group were chosen.

Sensory immersion pertains to the audiovisual effects of the game that engages the player to be "hooked" to the game.[26,27] Healthy Foodie came with audio properties wherein all the sentences and food items were read out loud and background music was available. Sound volume was also adjustable. This key audio feature made players more immersed in the game.[26]

Behavioral concepts present in a game were the central themes that guided the development of this game. First, knowledge as foundation for change was included in the basic concepts prior to each game play.[11] Second, mastery learning is a key concept in this game. Mastery of the concept was demonstrated by achieving the minimum criterion of collecting 5 correct food items with less than 3 mistakes prior to advancement to the next concept.[11,17] Traditional classroom teaching is effective, but due to limited time and need for individualization, mastery of technique cannot be fully implemented.[17] In this regard, the children played Healthy Foodie at their own computer station and at their own pace to achieve mastery of concepts. Furthermore, the "back" button in the game anticipates the learning pace for players. The option to go back can also be used to master previous concepts presented. Third, video games are expected to be fun and entertaining without sacrificing the educational content. Fun is considered an intrinsic motivator to learn.[28] Similarly, Healthy Foodie was a balance of education and fun as evidenced by the feedback of the students.[11] The feedback provided relevant and critical links to the learning process not only for the children, but also to the authors and game developers.[17,29,30]

Second and third graders were chosen to reinforce previous nutrition topics discussed in grades one and two. Positive reinforcement resulted to increased behavior through presentation of a stimulus leading to operant conditioning. Operant behavior results from exposure to the environment. Healthy Foodie served as a positive reinforcer to the previous nutrition lectures in school.[31,32] The concepts were simple, appealing and easy to understand with the use of game play and colorful illustrations.

Effectiveness of Healthy Foodie

There was a statistically significant difference in the number of students from private and public schools. However, there was no statistically significant difference in the pretest scores of the participants. This showed that school category was not a factor in the difference in scores.

In the control arm, within group analysis showed that nutrition knowledge may decline through time. With reinforcement from Healthy Foodie in the experimental arm, the posttest scores of the students improved.

There was a statistically significant improvement in the posttest scores of the children who played Healthy Foodie. There was no immediate nutrition review prior to the pretest, but the tutorials in the game may have contributed to the significant improvement in the posttest scores of the experimental group.

Similar to Healthy Foodie, other nutrition games developed to promote nutrition education showed a positive association of nutrition games and nutrition knowledge improvement.

Pizza Please was a two-part program consisting of an interactive game board and a questionnaire focused on dietary behavior and nutrition knowledge. The topics included dairy consumption, fruit and vegetable consumption, food guide pyramid knowledge, nutrient-food association knowledge and nutrient-job association knowledge. On top of the intervention, nutrition educators provided curriculum-based modules in between assessments. Pizza Please showed that nutrition programs

improved dietary behavior and increased nutrition knowledge in children.[8] Compared to Healthy Foodie, this game incorporated tutorials conducted in a self-directed mastery learning process with minimal intervention from health educators.

Two nutrition education games, Alien Health and Super Shopper, were compared in another study. Alien Health was an interactive game focused on nutritional food profiles as well as the five macronutrients. Super Shopper was a web-based Flash application focused on the nutritional values of products. The study showed that children playing Alien Health outperformed children playing Super Shopper. Alien Health provided a short-term nutrition knowledge improvement as reflected in the immediate postgame play nutrition test scores, but not in long-term nutrition knowledge as reflected in the two-week follow-up test scores.[9] In our study, an immediate postgame nutrition test was not given. However, a one-week follow-up posttest revealed higher scores in the experimental group. The time of follow-up may have contributed in the difference in outcomes. While the pretest and posttest contained the same questions, a time interval of one to 3 weeks made it unlikely for the children to remember their initial responses to the pretest.[33] The posttest results of the Nutrition Knowledge Questionnaire reflected not only learnings from the game, but also knowledge retention after playing Healthy Foodie.

Nutrition games that increase knowledge are effective, but data on behavior correlation are contradicting. In a Japanese study, the relationship between nutrition knowledge and dietary intake of children was analyzed. A higher knowledge level was significantly associated with higher vegetable intake.[23] On the other hand, some studies showed that increased knowledge alone might not influence subsequent health behaviors.[7,16]

One limitation of this study is the measurement of improvement of nutrition knowledge. A follow-through that gauges real world nutrition choices may be done to assess the effect on nutrition behavior after playing Healthy Foodie. A repeat posttest with a longer follow-up may also be done to assess the long-term nutrition knowledge retention after playing Healthy Foodie. Future studies involving more students from different grade levels and different provinces can be considered. A Filipino translation of Healthy Foodie may also be developed to give children an option to choose a language that they are more accustomed to.

CONCLUSION

The Healthy Foodie nutrition game application, together with Nutrition Knowledge Questionnaire, are validated and effective tools for reinforcement intervention to standard nutrition education of second and third grade children. This co-curricular strategy will positively impact nutrition knowledge of school age children.

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APPENDICES

Appendix A. Pretest and Posttest Nutrition Knowledge Questionnaire

Student ID: _____ Age: _____
Grade Level: _____ Gender: _____

PART 1. Food Group Knowledge Questionnaire

INSTRUCTION. Identify the food group where this food belongs. Check the appropriate box on the right that corresponds to your answer.

Food		Go	Grow	Glow
1). Banana				
2). Rice				
3). Carrot				
4). Milk				
5). Fish				
6). Egg				
7). Bread				
8). Eggplant				
9). Chicken				
10). Apple				
11). Pandesal				
12). Cheese				
13). Beef				
14). Noodles				
15). Tomato				

PART 2. Food Frequency Knowledge Questionnaire

INSTRUCTION. I know that some of these food items are your favorites, but how much can you eat these to stay healthy? Check the appropriate box on the right that corresponds to your answer.

Food		Eat More	Eat Some	Eat A little
1). Ice cream				
2). Mango				
3). Potato chips				
4). Rice				
5). Pancake				
6). Donut				
7). French fries				
8). Tomato				
9). Hamburger				
10). Hotdog				
11). Watermelon				
12). Banana cue				
13). Pizza				
14). Candy				
Drink		**Drink More**	**Drink Some**	**Drink A little**
15) Water				

Appendix B. Screenshots of Healthy Foodie

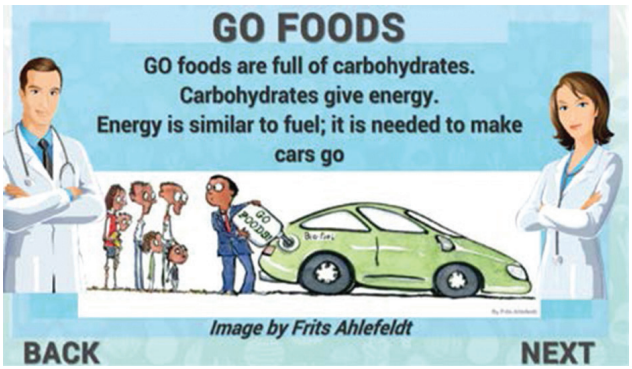

Figure 1. Information regarding Go Foods.

Figure 2. Examples of Glow Foods.

Figure 3. Gameplay of the Filipino Food Plate.

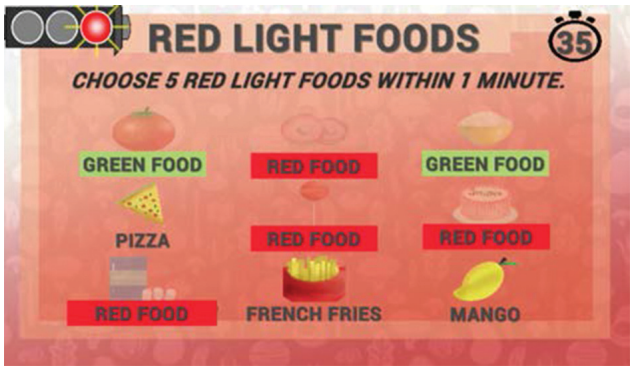

Figure 4. Gameplay of Red Light Foods. After clicking the food, the correct food group classification is displayed.

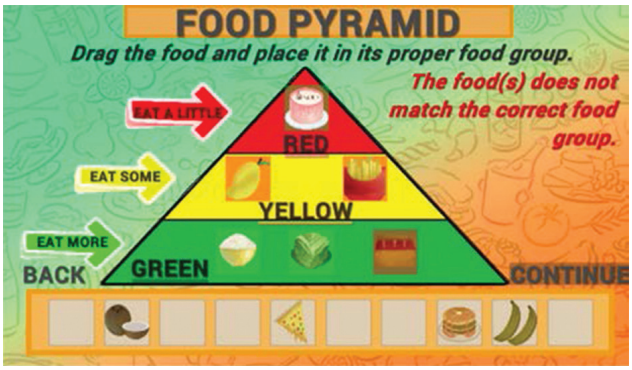

Figure 5. Gameplay of Food Pyramid. The boxes of food highlighted in green are correct while those in red are incorrect answers.