Evaluation of a Curriculum-Based Nutrition Education Intervention Protocol in Elementary Schools: Feasibility Study

Jacqueline Marie Brown, Nicholas Rita, Beatriz Franco-Arellano, Ann LeSage, Joanne Arcand

Submitted to: JMIR Serious Games
on: November 25, 2024

Table of Contents

Evaluation of a Curriculum-Based Nutrition Education Intervention Protocol in Elementary Schools: Feasibility Study

Jacqueline Marie Brown[1] MHSc; Nicholas Rita[2] MEd; Beatriz Franco-Arellano[1] PhD; Ann LeSage[2] PhD; Joanne Arcand[1] PhD, RD

[1]Faculty of Health Sciences Ontario Tech University Oshawa CA
[2]Mitch and Leslie Frazer Faculty of Education Ontario Tech University Oshawa CA

Corresponding Author:
Joanne Arcand PhD, RD
Faculty of Health Sciences
Ontario Tech University
2000 Simcoe Street North
Oshawa
CA

Abstract

Background: Improving children's food literacy through school-based interventions can support developing healthy eating habits. Serious games, which are games designed for a purpose other than entertainment, have been demonstrated to improve children's food literacy and dietary intake. Further evidence is needed to understand how serious games can be researched within in schools to support nutrition education.

Objective: The objective of this study was to determine the feasibility of study processes, resources and management and conduct a preliminary assessment of scientific outcomes for implementing the serious game, curriculum-based nutrition education intervention, Foodbot Factory, in classrooms as part of research protocol.

Methods: A non-randomized study determined the feasibility of intervention implementation. Grade 4 and 4/5 classrooms were assigned to have nutrition education lessons for five days with either the Foodbot Factory or a control intervention. Outcomes were assessed in four feasibility domains of study processes (e.g., recruitment and attrition rates), resources (e.g., time taken to deliver the intervention) and management (e.g., challenges with intervention delivery), and a preliminary assessment of scientific outcomes pertaining to the acceptability and impacts of the interventions. These outcomes were captured in semi-structured field notes completed by study staff and questionnaires completed by participants. Data were analyzed descriptively and using a paired t-test.

Results: Four classrooms participated in the feasibility study, with varying recruitment rates for schools (15%), classrooms (100%), parents (53%) and children (91%). The time required to implement the protocol was sufficient and management of the study was overall successful. Some challenges were experienced with classroom management and electronic data collection. After the intervention, children reported a positive affective experience (63%) and learning something new about healthy eating (76%).

Conclusions: These findings indicate that the study protocol is feasible to implement to evaluate Foodbot Factory in a representative sample with select modifications.

(JMIR Preprints 25/11/2024:69242)
DOI: https://doi.org/10.2196/preprints.69242

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?

✓ **Please make my preprint PDF available to anyone at any time (recommended).**
Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.
Only make the preprint title and abstract visible.
No, I do not wish to publish my submitted manuscript as a preprint.

2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?

✔ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**

Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain v

Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in <a href="http

Original Manuscript

Original Paper

Evaluation of a Curriculum-Based Nutrition Education Intervention Protocol in Elementary Schools: Feasibility Study

Jacqueline Marie Brown MHSc[1], Nicholas Rita MEd[2], Beatriz Franco-Arellano PhD[1], Ann LeSage PhD[2], & JoAnne Arcand PhD, RD[1]

[1]Faculty of Health Sciences, Ontario Tech University, Oshawa, Ontario, L1G 0C5, Canada
[2] Faculty of Education, Ontario Tech University, Oshawa, Ontario, L1G 0C5, Canada

Address for Correspondence:
JoAnne Arcand PhD, RD
Associate Professor, Faculty of Health Sciences, Ontario Tech University
2000 Simcoe Street North, Oshawa, Ontario L1G 0C5
Tel: +1 (647) 296-8426
E-mail: joanne.arcand@ontariotechu.ca

Abstract

Background: Improving children's food literacy through school-based interventions can support developing healthy eating habits. Serious games, which are games designed for a purpose other than entertainment, have been demonstrated to improve children's food literacy and dietary intake. Further evidence is needed to understand how serious games can be researched within in schools to support nutrition education.
Objective: The objective of this study was to determine the feasibility of study processes, resources and management and conduct a preliminary assessment of scientific outcomes for implementing the serious game, curriculum-based nutrition education intervention, Foodbot Factory, in classrooms as part of research protocol.
Methods: A non-randomized study determined the feasibility of intervention implementation. Grade 4 and 4/5 classrooms were assigned to have nutrition education lessons for five days with either the Foodbot Factory or a control intervention. Outcomes were assessed in four feasibility domains of study processes (e.g., recruitment and attrition rates), resources (e.g., time taken to deliver the intervention) and management (e.g., challenges with intervention delivery), and a preliminary assessment of scientific outcomes pertaining to the acceptability and impacts of the interventions. These outcomes were captured in semi-structured field notes completed by study staff and questionnaires completed by participants. Data were analyzed descriptively and using a paired t-test.
Results: Four classrooms participated in the feasibility study, with varying recruitment rates for schools (15%), classrooms (100%), parents (53%) and children (91%). The time required to implement the protocol was sufficient and management of the study was overall successful. Some challenges were experienced with classroom management and electronic data collection. After the intervention, children reported a positive affective experience (63%) and learning something new about healthy eating (76%).
Conclusions: These findings indicate that the study protocol is feasible to implement to evaluate Foodbot Factory in a representative sample with select modifications.

Keywords: Nutrition Education, Serious Games, Children, Food Literacy, School Nutrition Intervention, Feasibility.

Introduction

One way to support children in acquiring and sustaining healthy eating patterns is by developing their food literacy. Food literacy describes the set of interrelated knowledge, skills and attributes (e.g., nutrition knowledge, food skills) that are required for healthy eating and navigating a complex food environment [1]. Research has demonstrated that children and adolescents with higher levels of nutrition knowledge, a core component of food literacy, are more likely to have a higher quality dietary pattern [2, 3]. Improving food literacy is especially relevant in Canada where the average child exceeds recommend intakes for saturated fat, sodium and free sugars, and consumes 21-25% of their daily caloric intake from foods that are not recommended by dietary guidelines [4, 5]. This dietary pattern can increase the future risk of non-communicable diseases such as cardiovascular disease and type 2 diabetes [6].

School curriculum, policies and programming are an important way to support the development of child food literacy, nutrition knowledge and healthy eating behaviours. All jurisdictions in Canada have food and nutrition as a core component of elementary health curricula [7]. Published literature shows that well-designed curriculum-based interventions can effectively improve nutrition knowledge and behaviours [8]. A meta-analysis of school- and curriculum-based nutrition education interventions found that experiential learning approaches, such as school gardens

and cooking classes had the greatest impact on child nutrition knowledge and dietary intake [9]. While these experiential teaching approaches enhance the student learning experience, they are resource- and time-intensive. Teachers report that a lack of time, training and resources dedicated for nutrition are key barriers for providing nutrition education in their classrooms, thus, alternative experiential learning approaches are needed [10-12].

Technology-based nutrition interventions can address some of these teacher-reported barriers, due to high access and ease of use in the classroom [13]. Serious games, which are games designed for a primary reason other than entertainment, have emerged as a leading technology-based educational platform as they utilize an experiential learning approach [14]. Research on nutrition-focused serious games has found that they can improve vegetable and fruit intake and nutrition knowledge among children [15-17]. Unfortunately, these nutrition-focused games are often not available to the public [18], do not consistently align with relevant nutrition curriculum, and are under-investigated in classrooms as a resource to support curriculum implementation. Research and resources are required to support teachers in providing nutrition education and create opportunities for children to develop their nutrition knowledge and food literacy in the classroom.

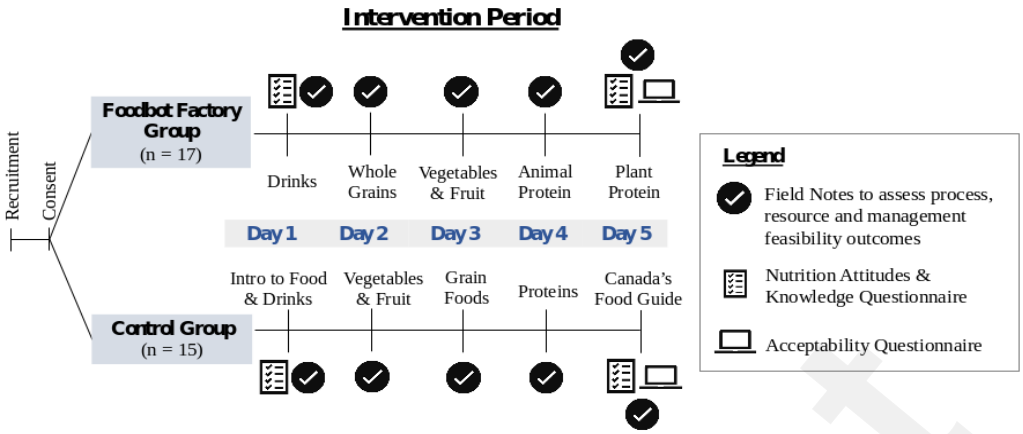
The Foodbot Factory intervention was developed to support elementary teachers with curriculum-based nutrition education and to improve children's nutrition knowledge [19]. The intervention includes a serious game for students played on a mobile app, with lesson plans for teachers. The content is designed for children ages 8-12 years (Grades 4 and 5) and aligns with the 2019 Ontario Health and Physical Education curriculum and Canada's Food Guide (CFG) [20, 21]. Our previous proof-of-concept research demonstrated that Foodbot Factory significantly improved children's nutrition knowledge compared to a control food-themed game [22]. However, this study was conducted in a controlled setting, not in the intended classroom environment. Prior to embarking on a larger randomized trial to evaluate the impact of Foodbot Factory in classrooms, a setting that comes with unique implementation challenges, a feasibility assessment of an intended research protocol is warranted. Therefore, the objective of this research was to determine the feasibility of a research protocol to evaluate the Foodbot Factory intervention and a control intervention with children in the classroom setting. Study processes, resources, management and scientific outcomes were the feasibility elements assessed. Such data will inform future research protocols to evaluate the efficacy of Foodbot Factory as part of a randomized trial.

Methods

Study Design

This was a non-randomized study to assess the feasibility of implementing a trial protocol for a nutrition education intervention (Foodbot Factory) and a control intervention among Grade 4 4/5 and 5 elementary school classrooms, over a 5-day period. Classrooms were assigned in a 1:1 ratio to one of two groups: 1) the Foodbot Factory group receiving nutrition education using the Foodbot Factory serious game and lesson plans, or 2) the control group receiving nutrition education using non-technology based learning activities. The primary objective was to assess the feasibility of implementing the study protocol using feasibility outcomes that are evaluated across four domains: study processes, resources, management, and a preliminary assessment of scientific outcomes [23]. Study processes, resource and management outcomes were documented throughout the study period. The preliminary assessment of scientific outcomes was assessed by having children complete questionnaires on their nutrition knowledge (Day 1 and Day 5) and intervention acceptability (Day 5; **Figure 1**).

Figure 1. Feasibility study overview.



This study protocol was co-created with several school board partners. This approach increased the feasibility of the study protocol from the school board's perspective, particularly in relation to the length of time required for the study and the use of a study teacher to provide the intervention (described below). This study was approved by the Ontario Tech University Research Ethics Board (#16930) and by the participating school board.

Participants

Grade 4, 4/5 and 5 classrooms in a Greater Toronto Area school board were eligible to participate if they had not yet covered the healthy eating component of the curriculum. Four classrooms from two elementary schools participated in the study. The research team randomly selected schools and contacted them via email to gauge interest in participation. Principals who expressed interest subsequently invited classroom teachers to participate in the study. In each school we recruited two classrooms, assigning one to the Foodbot Factory group and the other to the control group. Prior to the study, classroom teachers emailed parents the online consent form. Student assent was obtained on Day 1 of the study (Monday) from those with parental consent. For students who were absent on Day 1, assent was collected on Day 5 for the purposes of collecting data on intervention acceptability only. All students in a classroom participated in the intervention, but only those with parental consent participated in data collection and analysis.-

Interventions

Both interventions were five consecutive days in duration and classrooms received nutrition education for 35-40 minutes per day [24]. The interventions were provided by a hired certified teacher, who was part of the research team ("study teacher"). Due to the nature of their role, the study teacher was not blinded to the intervention group. The research team originally estimated that data collection would take a maximum of 20 minutes, and that lesson plan delivery would take 40 minutes. Classroom teachers were not involved in teaching the lessons, but they were present in the classroom during the study and supported classroom management.

Foodbot Factory Intervention

Classrooms in the Foodbot Factory group received nutrition education using the Foodbot Factory serious game and corresponding curriculum-based lesson plans [19, 25]. The Foodbot Factory intervention consists of five nutrition education lessons, with additional instructions for teachers on the importance of using food-neutral language, suggestions to incorporate cultural foods into each lesson and modifications for different learning needs. Each lesson follows the three-phase lesson structure, which is an effective format for structuring a lesson [26]. The first phase of the

lesson, *Minds On*, introduces children to the lesson topic and establishes expectations (5-10 minutes). In the second phase, *Exploration*, children play through one module of the Foodbot Factory serious game on a tablet provided by the research team (10-15 minutes). For the final phase, *Consolidation*, discussion and teacher-led activities allow children to connect their new knowledge from the serious game to their previous knowledge and lived experiences (10 minutes).

Control Intervention

Classrooms in the control group received nutrition education that covers the same topics as the Foodbot Factory intervention but used non-technology based learning materials (e.g., activity sheets). The control intervention also consists of five nutrition education lessons, following the same three-phase lesson structure (**Table 1**). However, in place of the Foodbot Factory serious game, the lesson plans incorporated pre-existing resources that were sourced from a popular online repository of educational materials [27]. These resources were carefully reviewed and selected by the research team to closely match the Foodbot Factory intervention learning goals and ensure their alignment with curriculum and quality. Unlike clinical practice, where there are often existing guidelines for usual care that may serve as a control group in research, there is great variation in the strategies teachers implement for nutrition education. However, a consistent control intervention is required for comparative research purposes. The approach for the control intervention in this study was informed by qualitative interviews and focus groups conducted with Canadian elementary school teachers who frequently reported using pre-existing resources found online for nutrition [12].

Table 1. Foodbot Factory and control intervention learning topics and activities

Daily Learning Topic/Study Group		**Phase 1: Minds On** Introductory activities and set expectations (~10 minutes)	**Phase 2: Action** Main lesson activity (~10-15 minutes)	**Phase 3: Consolidation** Summarize and review lesson (~10 minutes)
Day 1 Drinks (Foodbot Factory) & Introduction to Food and Drinks (Control)	Foodbot Factory	• Introductory slide show on food and drinks • Teacher-led class activity • Class discussion	• Play "Drinks" module in Foodbot Factory serious game	• Complete Phase 1 class activity, adding to it based on what was learned • Class discussion
	Control	• Introductory slide show • Complete activity sheet on food groups and drinks independently • Class discussion	• Complete activity sheet on different food groups and drinks independently	• Think-pair-share activity sheet • Take up answers from Phase 2 activity • Class discussion
Day 2/3[a] Whole Grain Foods (Foodbot Factory Day 2 & Control Group Day	Foodbot Factory	• Introductory slide show • Class discussion	• Play "Whole Grain Foods" module in Foodbot Factory serious game	• Small-group activity and take up answers • Class discussion
	Control	• Introductory slide show	• Complete activity sheets	• Take up answers from

3)		• Class discussion	on whole grain foods independently or in pairs	Phase 2 activity • Class discussion
Day 2/3 Vegetables & Fruit (Foodbot Factory Day 3 & Control Group Day 2)	Foodbot Factory	• Introductory slide show • Complete activity sheet on vegetables and fruit independently • Class discussion	• Play "Vegetables & Fruit" module in Foodbot Factory serious game	• Complete Phase 1 activity sheet, adding to it based on what was learned • Class discussion
	Control	• Introductory slide show • Class discussion	• Complete activity sheets on vegetables and fruit in pairs or small groups	• Take up answers from Phase 2 activity • Complete activity sheet in pairs or small groups
Day 4 Animal Protein (Foodbot Factory) & Protein Foods (Control)	Foodbot Factory	• Introductory slide show • Class discussion	• Play "Animal Protein" module in Foodbot Factory serious game	• Teacher-led class activity • Class discussion
	Control	• Introductory slide show • Class discussion	• Complete activity sheets on animal and plant protein foods independently or in pairs	• Take up answers from Phase 2 activity • Small group activity sheet • Class discussion
Day 5 Plant Protein (Foodbot Factory) & Canada's Food Guide (Control)	Foodbot Factory	• Introductory slide show • Class discussion	• Play "Plant Protein" module in Foodbot Factory serious game	• Teacher-led class activity • Class discussion
	Control	• Introductory slide show • Class discussion	• Complete activity sheet on Canada's Food Guide independently	• Take up answers from Phase 2 activity • Class discussion

[a] Study groups cover both the topics of Whole Grain Foods and Vegetables and Fruit on different days.

Outcomes

Study Processes

Feasibility of study processes refers to the main elements of a study that are necessary for its success, including recruitment and retention of participants [23]. We assessed five variables related

to study processes including school recruitment, parent recruitment, child recruitment, attrition rate and data collection completion rate. Recruitment rates were calculated as the number of recruited participants over the total number of eligible participants. The attrition rate was calculated as the number of children recruited to the study with data available from two data collection questionnaires, a baseline NAK questionnaire and post-intervention NAK, over the total number of child participants. The data collection completeness rate was calculated as the number of child participants with two fully complete NAK questionnaires over the total number of child participants.

Study Resources

Feasibility of study resources refers to the time and resources required to run the study [23]. Three variables related to study resources were assessed including time taken to deliver the intervention, time taken to collect data and impacts on study personnel who were the study teacher and outcome assessor (i.e., what was the qualitative experience for those conducting the study). Variables related to time were taken with a stopwatch and impacts on study personnel were assessed qualitatively. This study did not assess outcomes related to material resources as all necessary resources were brought into classroom by the study team (e.g., tablets to play the Foodbot Factory game, activity sheets, writing supplies).

Study Management

Feasibility of study management assesses possible issues with study implementation [23]. In this feasibility study we collected data on two variables related to study management, which included challenges with data collection and challenges with intervention delivery. These outcomes were assessed qualitatively.

Preliminary Assessment of Scientific Outcomes

A preliminary assessment of the scientific outcomes of the study, namely impacts of an intervention and its safety, provide an idea of how the intervention will impact participants. This data is intended to inform a future fully-powered study, not to determine the effectiveness of an intervention [23]. Three variables were assessed in this category including acceptability of the intervention, adverse events and impacts of the intervention on nutrition knowledge. An acceptability questionnaire assessed the perceived acceptability of the intervention by children. The acceptability questionnaire was based on the Theoretical Framework of Acceptability [28] and consisted of 11 items on a numerical 5-point Likert scale questions defined by level of agreement (1 = strongly disagree to 5 = strongly agree). Adverse events were documented in study field notes and a self-report question on the acceptability questionnaire asking participants about feelings of stress due to the intervention. Nutrition knowledge was measured using the validated Nutrition Knowledge and Attitudes (NAK) questionnaire [22, 29]. The NAK questionnaire consists of 20 questions to assess a child's overall nutrition knowledge, and four sub-scores of nutrition knowledge (five questions per sub-score) to assess knowledge of a specific food group (e.g., Drinks, Whole Grain foods, Vegetables & Fruit, Protein foods).

Outcome Assessment

Feasibility outcomes were collected throughout the study from: a) structured daily field notes completed by the research team (e.g., study process, resource and management outcomes); b) assessments of nutrition knowledge using the NAK questionnaire [29]; and c) an acceptability questionnaire. The two questionnaires were used to provide a preliminary assessment of the scientific impacts of the intervention.

Field notes were completed each day of the study by the study teacher and observer (Days 1 through 5). The NAK questionnaire was administered to children by an outcome assessor on Day 1, before the first nutrition education lesson, and again on Day 5, after the final lesson. The

acceptability questionnaire was also administered by the outcome assessor and completed on Day 5, after children completed the NAK questionnaire. The questionnaires were completed independently by children at their desks in the classroom with the outcome assessor circulating to monitor progress. The outcome assessor was present in each classroom throughout the intervention period as an observer, thus they were not blinded to the intervention group. In the first and second classrooms, students completed electronic forms using Qualtrics; however, there were several issues with electronic data collection (described in Results) and the remaining two classrooms completed paper-based forms.

Sample Size

Our research team previously conducted a pilot study of the Foodbot Factory serious game, which provided us with an understanding of the distribution and effects sizes for the outcome of nutrition knowledge [22]. Thus, our objective with this feasibility study was pragmatic in that we needed to understand the logistics of recruitment, data collection and intervention delivery in the classroom setting [30]. Our aim was to recruit four classrooms, which resulted in 102 children eligible to participate and allowed us to assess the feasibility of implementing the interventions in different neighborhoods, understand the pragmatic elements required to scale the intervention up in a fully powered study and would likely result in an appropriate sample size for feasibility research. For this type of feasibility study, 12 to 30 subjects per group is suggested [31, 32].

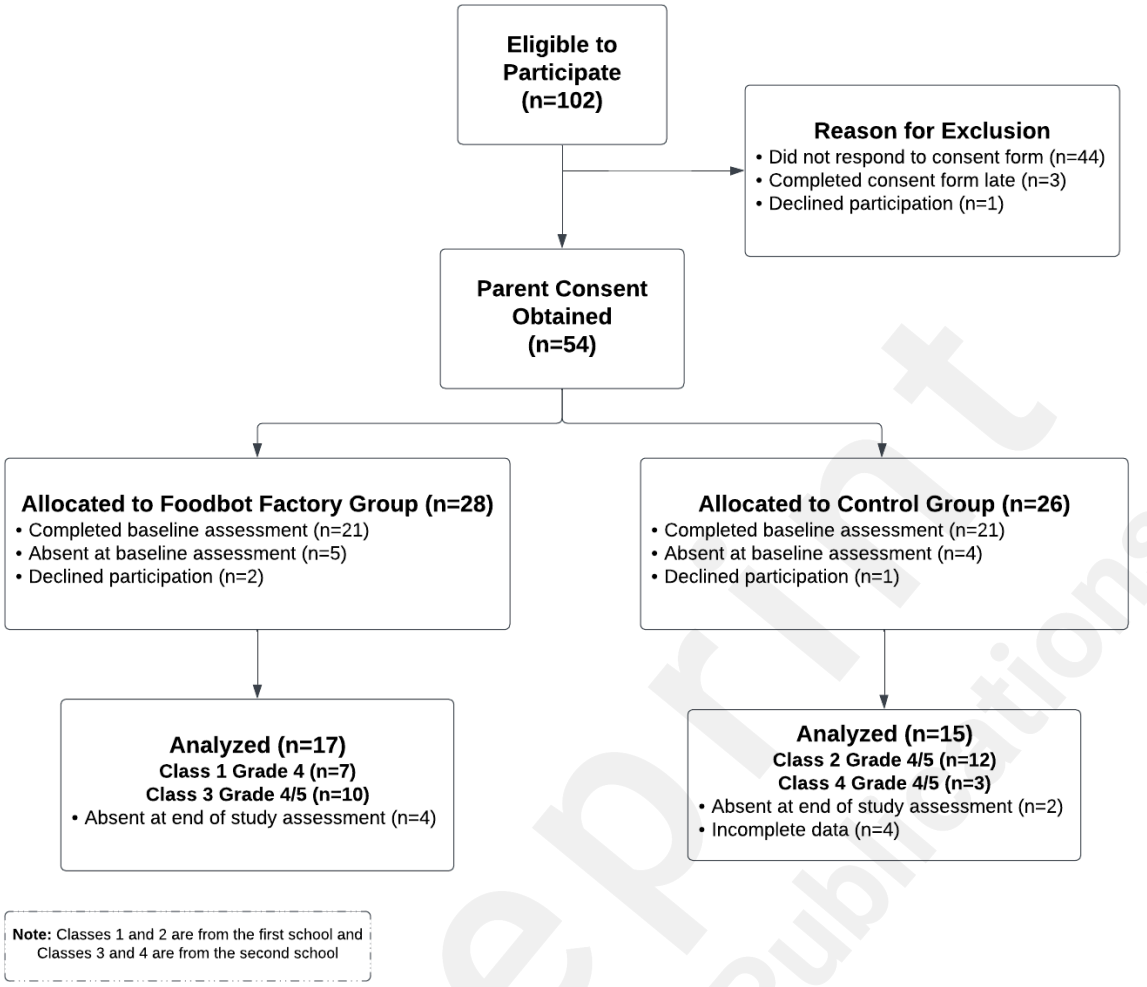
Data Analysis

We holistically determined if each study outcome was feasible for a research protocol by considering the context of each individual outcome, and if the outcome would reasonably facilitate a fully powered study. Outcomes related to study *processes* were analyzed using descriptive statistics, frequencies and percentages. *Resource* outcomes were assessed using descriptive statistics and impacts on study personnel were assessed narratively. Outcomes related to *management* were assessed narratively. The *scientific* outcome of acceptability was analyzed using descriptive statistics. On all Likert scale questions, a response of 1 or 2 was considered as disagreement, a response of 3 was considered neutral and a response of 4 or 5 was considered as agreement. Intervention safety was analyzed using both descriptive statistics and narratively. The *scientific* outcome of intervention impacts was assessed using descriptive statistics but was not considered in the final determination of protocol feasibility as the sample size would not have sufficient power. Within-group analysis was completed using a paired t-test, after confirming the data were normally distributed. Participants were excluded from the analysis of the overall knowledge score if there were any missing data. However, participants were included in nutrition knowledge sub-score analyses if they had complete data for a particular sub-score. All statistical analyses were completed using R Statistical Software version 4.2.0 [33].

Results

Four classrooms participated from two schools between February to May 2023 (**Figure 2**). Both schools were in urban areas in culturally and linguistically diverse neighborhoods. The first school was in a higher socioeconomic-status neighborhood while the second school was in a neighborhood with a higher proportion of newcomers to Canada and government subsidized housing. Participating classrooms included one Grade 4 and three Grade 4/5 split classes.

Figure 2. Flowchart of participant progress through the study.



Study Process Outcomes

School recruitment rate was low (n=3, 15%). Twenty principals were contacted by email and 70% (n=13) did not respond, 10% (n=2) declined participation, and 5% (n=1) replied with a question about the study but were lost to follow-up. To counter low email response rate, the research team used phone calls for recruitment and were able to recruit one school after three phone calls. Once a principal agreed to have their school participate, 100% of classroom teachers in those schools agreed to have their classroom participate. Four classrooms from two of the three recruited schools were scheduled for participation with a total of 102 children. Parent recruitment rate was low (n=54, 53%): 43% (n=44) did not respond to the consent form, 3% (n=3) consented after the study start date and 1% (n=1) declined participation. To improve parent recruitment, the research team requested that classroom teachers send a reminder email. Reminders were sent by teachers in two classrooms, resulting in a 77% parent recruitment rate compared to 40% in classrooms with no reminders. Anecdotally, one classroom with a lower parent recruitment had a high number of parents who did not speak English as a first language and the classroom teacher noted this was likely a barrier to participating in the study. Most children with parental consent (n=49, 90.7%) agreed to participate in the study, with 24 in the intervention group and 25 in the control group. The average age of participants was 9.6 ± 0.68. Participants self-reported their gender as boy (n=24, 49%), girl (n=18, 37%), or a self-defined identity (n=2, 4%), with the remaining participants preferring not to answer (n=4, 8%). In the intervention group, 17 children completed the study, however, only 10 had a complete set of data. In the control group, 15 children completed the study with 9 having a complete

set of data. Missing data may be partially attributed to study personnel being unable to verify completeness of the electronic data forms prior to submission. The attrition rate was 19%. The instrument collection completion rate (73%) and data collection completion rate (71%) were both moderate.

Study Resource Outcomes

The average time required for child assent was 6.5 minutes, lesson plan delivery was 34 minutes, acceptability questionnaire completion was 5.5 minutes and NAK questionnaire completion was 13 minutes; all consistent with original estimates. Study personnel, including the study teacher and outcome assessor, reported an overall positive experience as they enjoyed interacting with the students. In one classroom, classroom management was a significant challenge due to a handful of students who frequently interrupted the lessons and outcome assessments. This was a minor psychological stressor for the study teacher. There were challenges with retaining the hired study teachers on the project due to career changes and an unanticipated emergency, requiring the research team to reschedule two classrooms to a later date.

Study Management Outcomes

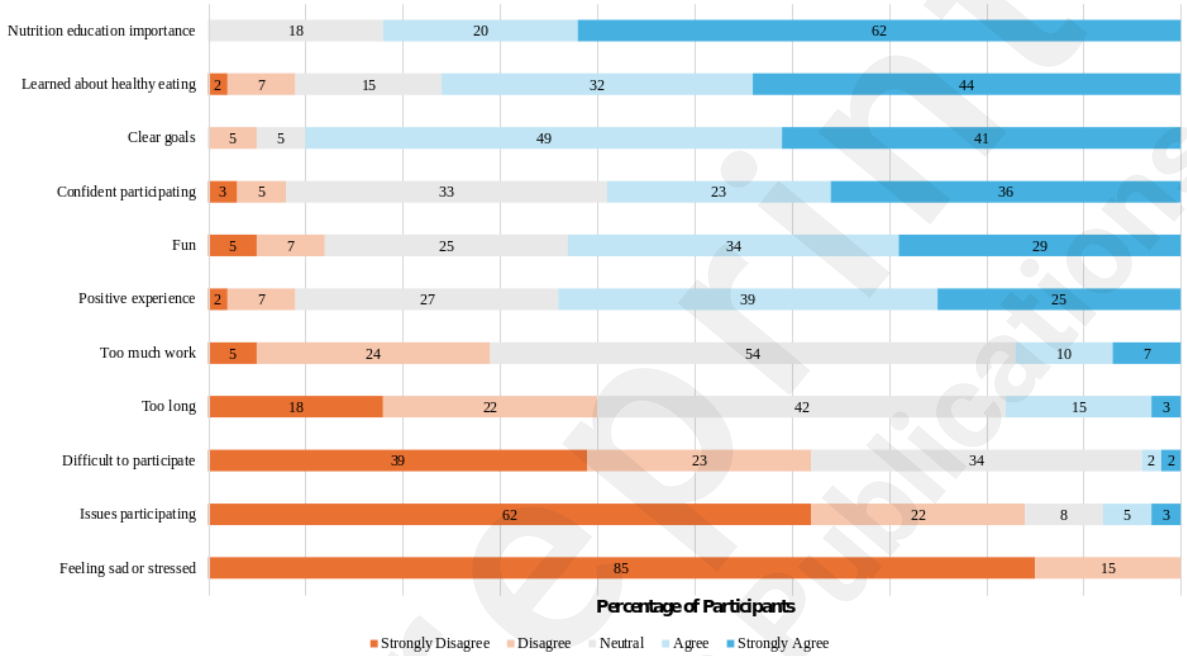
Data collection procedures and delivery of the intervention were executed as planned, although some challenges were experienced. Tablets were originally used for children to complete data collection forms, but this posed a few unanticipated challenges. For example, children intentionally or unintentionally “refreshed” or navigated away from the online NAK questionnaire, leading to the loss of completed responses. Additionally, once a NAK questionnaire was submitted, study personnel were unable to verify if all questions had been completed. This resulted in incomplete data for some children. Several children struggled to focus on completing the data collection forms due to distractions in the classroom. The most significant distraction occurred when other children who were not participating in the study were allowed by the classroom teacher to engage in other activities, namely the use of electronic devices. Furthermore, as children completed the questionnaire independently, those who finished early then moved on to a different activity. Children who needed more time to complete the questionnaire became increasingly distracted as children around them finished, which may have contributed to them rushing to finish and skipping questions.

Based on the implementation of the interventions in the first two classrooms, some changes were made to the intervention content that were implemented in the subsequent two classrooms. The changes clarified instructions, modified select discussion questions and added slideshows with the daily learning objectives instead of writing them on the board. In the study, classroom management was particularly challenging in one classroom due to some children repeatedly interrupting the study teacher. Study personnel found that having the classroom teacher and educational assistants support classroom management was helpful. In two classrooms, the intervention schedule was modified to occur over four days instead of five, due to a conflicting school-wide track and field event. On one of the four days, two intervention lessons were provided consecutively instead of having one lesson each day. While it was logistically feasible to provide two lessons back-to-back in one day, student engagement was lower during the second lesson. Another challenge occurred in the Foodbot Factory intervention group, where some children struggled with the augmented reality components in the Foodbot Factory serious game. The research team responded to this by improving instructions about how the augmented reality features work. In addition, some children struggled to transition away from using the tablet to play the Foodbot Factory serious game to the next learning activity as they found the game engaging and wanted to keep playing. -

Preliminary Assessment of Scientific Outcomes

Based on observations, children enjoyed participating in both the Foodbot Factory and control intervention lessons and were engaged in learning about nutrition through the activities. Overall, intervention acceptability among children was moderate to high, with most participants reporting that they had a positive experience (63.4%, n = 26), understood the goals of the nutrition education lessons (90.3%, n = 37) and that they learned something new (75.6%, n = 31; **Figure 3**). No children reported feeling sad or stressed about food and nutrition from the lessons on the acceptability questionnaire nor did study personnel observe any verbal or non-verbal signs of concern from children in the classroom.

Figure 3. Acceptability of the nutrition education interventions as rated by participants (n=41).



Scores on the NAK questionnaire were normally distributed as determined by the Shapiro-Wilk test. Both groups demonstrated improvements in their overall nutrition knowledge (Foodbot Factory group: 10.8 ± 2.1 to 12.5 ± 3.5; Control group: 11.8 ± 1.9 to 12.7 ± 1.8), although these improvements were not statistically significant**.** For sub-scores of nutrition knowledge, children in the intervention group demonstrated statistically significant improvements in knowledge of vegetables & fruit and protein foods. Children in the control group demonstrated statistically significant improvements in knowledge of grain foods (**Table 2**).

Table 2. Changes in overall and sub-scores of nutrition knowledge within the Foodbot Factory and control groups[b]

	Foodbot Factory Group				Control Group			
	n	Baseline	End-of-study	*P*-Value	n	Baseline	End-of-study	*P*-Value
Overall Nutrition Knowledge	10	10.8 ± 2.1	12.5 ± 3.5	.127	9	11.8 ± 1.9	12.7 ± 1.8	.094
Drinks	17	3.94 ± 0.66	3.76 ± 0.56	.332	15	3.93 ± 0.70	3.93 ± 0.59	1.00
Grain Foods	16	2.31 ± 1.2	2.75 ± 1.1	.168	15	2.87 ± 1.1	3.40 ± 1.1	.027
Vegetables & Fruit	15	2.27 ± 0.88	3.00 ± 0.93	.044	14	2.86 ± 0.86	3.07 ± 1.0	.609
Protein Foods	12	1.92 ± 0.90	2.75 ± 1.6	.025	10	2.60 ± 1.1	1.70 ± 0.95	.054

[b]Data presented as means and standard deviations with paired t-tests used to assess changes in knowledge from baseline

to the end-of-study within groups. Sample sizes vary as only participants with a complete set of responses were included in the analysis.

Discussion

Our research study determined the feasibility of implementing the Foodbot Factory nutrition education intervention as part of a research protocol in Grade 4 and 4/5 classrooms, identifying nine facilitators to support a larger study and four risks that will require mitigation. Elements of the study that were deemed feasible included: classroom recruitment, child recruitment, the attrition rate, time taken to deliver the intervention and collect data, the impacts of the study on personnel, management of delivering the intervention, lack of adverse events and acceptability of the intervention. However, strategies will be needed to improve school recruitment, parent recruitment, data collection completeness and the management of data collection procedures. In this feasibility study, we made minor modifications to the protocol on implementation to improve recruitment and intervention implementation (e.g., conducting recruitment phone calls, modifying intervention instructions for the classroom). With further modifications to mitigate the aforementioned risks, our findings largely support the feasibility of this research protocol to evaluate the Foodbot Factory nutrition education intervention as part of a fully powered randomized controlled trial.

The primary strength of this study was our ability to better understand how to collaborate with schools, teachers, parents and children in our future research. Key takeaways learned from this study that will be valuable to other researchers, include the importance of consulting with school boards prior to conducting research, ensuring recruitment materials and methods are relevant for the target audience, engaging classroom teachers and testing data collection methods prior to their implementation. We discussed our methodology and objectives with staff from several school boards prior to seeking school board approval to conduct the research. From the outset, this approach resulted in a protocol that would be more feasible and acceptable to implement in classrooms and ensure value to our participants and the school board. For example, the initial version of our study protocol requested five hours of total class time, which was perceived as too much time taken away from other curriculum. Not only did we modify the protocol to reduce the total time by one hour, we also updated our recruitment materials to highlight alignment of the study with curriculum. This was a critical change as teachers have very limited time to cover content that is outside of the curriculum. Ultimately, the resulting protocol is not only acceptable to school boards, but the duration of the intervention now better aligns with the time teachers typically allocate to a lesson and clearly communicates the value of the study to possible participants. These features increase real-world acceptability of the intervention. Researchers should consult with their local school boards and teachers to establish a collaborative relationship from the beginning to develop interventions and research protocols that are suitable and valuable.

When recruiting individual schools, classroom teachers, and parents, recruitment materials should be succinct and highlight the value of study participation. In this study, phone calls were effective at recruiting schools as they enable direct consultation on the practical aspects of the study and allow the school to quickly evaluate if the study will work for them. Low recruitment of schools was still seen in this study and has been reported as a challenge in other school-based health studies due to low interest, poor timing, and other commitments [34, 35]. During this study, engagement of the classroom teacher was critical for parent recruitment, as we were not permitted to contact parents directly. We found low parent recruitment was driven by parents not returning consent forms, rather than them explicitly declining participation, which has been observed in other studies [34]. We also observed significant improvements in recruitment when the classroom teacher sent reminders to parents about the study, highlighting the important role of classroom teachers in engaging parents in study participation.

In this study we show the importance of testing data collection methods prior to

implementation in a classroom setting. First, an important takeaway from this study is electronic data collection presented several challenges. Although other studies have used electronic data collection methods, it may present more challenges if the technology has not been used before in that context [36]. In the present study, training was not provided to children on how to complete the electronic data collection form prior to data collection, which could minimize issues like children accidentally refreshing the page and skipping questions [36]. In this study, questions on the electronic data collections forms were not made mandatory for submission as study participation was voluntary. Second, children completed data collection independently, requiring them to utilize their literacy skills to read and respond to each question. This data collection approach reduced accessibility and led to children finishing at varying timepoints and the classroom environment becoming increasingly distracting for children who needed more time. Missing data in other school-based studies, particularly survey-based research, is a common phenomenon ranging from 11-50% at a given outcome assessment timepoint [37, 38]. In a future protocol, data collection could be modeled on the procedures classrooms use when administering standardized tests. This would align research data collection with procedures that are already familiar to children, provide clear instructions, increase accessibility, allow for verification of data collection completeness to encourage complete responses and directly guide the classroom as a group through the questions so all participants finish at the same time.

This study also examined the impacts of the developed nutrition education interventions on children's nutrition knowledge. Statistically insignificant improvements in overall nutrition knowledge were observed in both groups, and children in the Foodbot Factory group significantly improved their knowledge of vegetables & fruit and protein foods. The results within-groups at the individual level indicate improvements in nutrition knowledge but do not have the same effect size as a larger proof-of-concept study of the Foodbot Factory serious game, where significant improvements in children's overall nutrition knowledge were observed both within and between groups [22]. This indicates that the findings in this feasibility study for nutrition knowledge are inconclusive, due to the insufficiently powered sample size, and should be used primarily for descriptive purposes and informing future research [39].

This study had several strengths and limitations that can inform future research. This study included a small sample size, which is primarily driven by low parent recruitment. Recruitment may be a primary feasibility challenge moving forward to a fully powered study. Including more classrooms may have revealed additional feasibility issues; however, the classrooms were intentionally sampled from schools in neighborhoods with known differences in their sociodemographic profiles. In this study, we chose not to randomize classrooms as we were unsure of how successful our recruitment would be. Non-randomized feasibility studies are common for research in earlier phases of preparation for a trial and when there are significant unknowns [40]. To address the lack of randomization and balance school- and neighborhood-level characteristics, the research team assigned one classroom at each school to a different group; however, we acknowledge the potential of selection bias and an uneven balance of characteristics between groups that may have been introduced. In future research we will recruit two classrooms per school and utilize pair-matching randomization to both reduce bias and ensure groups are balanced on school and neighborhood level variables that can impact our outcomes of interests. Due to the study design, where classrooms rather than individuals were assigned to each treatment arm, we were unable to assess differences between groups as the data should be analyzed at the classroom cluster level, which this study was not powered to do. In future research, an adequately powered randomized controlled trial that randomizes classrooms as clusters would be more appropriate to assess the impact of the interventions in a pragmatic fashion. At this stage, our research team did not assess retention of knowledge or examine other variables that may be impacted by a nutrition education intervention, including dietary intake and behaviours. We also did not assess acceptability of the study protocol from the perspective of classroom teachers, which was not the focus of this study.

Retention of knowledge and dietary intake will be assessed in future research and qualitative interviews will also be conducted with classroom teachers to inform implementation needs and strategies for the Foodbot Factory intervention. A current limitation of the Foodbot Factory intervention is that it predominantly covers nutrition knowledge and does not address all elements of food literacy. The serious game is also only available for use on mobile devices. Our future work aims to make a web-accessible version of the Foodbot Factory serious game and expand the content to different age groups and food literacy concepts.

In conclusion, the majority of feasibility outcomes assessing study processes, resources, management and intervention acceptability suggest that the study protocol was feasible [41]. The data offer several insights to inform future studies and, when the protocol is implemented into a fully-powered trial, the successes identified can be leveraged, and the risks associated with school recruitment, parent recruitment and data collection can be averted with targeted mitigation strategies. The development and evaluation of the protocol in this study was an important step in understanding how to best evaluate technology-based nutrition education interventions in Canadian classrooms. The lessons learned in this study will also support the rising number of researchers embarking on school-based nutrition and health interventions in school and classroom settings both in Canada and abroad.

Acknowledgements

Funding for this research was provided by Ontario Tech University's Dean's Discretionary Fund Small Research Grants Program (JA), a Social Sciences and Humanities Research Council (SSHRC) Explore Grant (BFA), an Ontario Graduate Scholarship (JMB) and a Canadian Institutes of Health Research (CIHR) Canada Graduate Doctoral Scholarship (JMB). The authors would like to thank the principals, teachers, parents and children for being part of this research.

Conflicts of Interest

None declared.

Abbreviations

CFG: Canada's Food Guide
NAK: Nutrition Attitudes and Knowledge

References

1. Thomas, H., et al., *Complexities in Conceptualizing and Measuring Food Literacy.* Journal of the Academy of Nutrition and Dietetics, 2019. **119**(4): p. 563-573.
2. Thakur, S. and P. Mathur, *Nutrition knowledge and its relation with dietary behaviour in children and adolescents: a systematic review.* Int J Adolesc Med Health, 2021.
3. Vaitkeviciute, R., L.E. Ball, and N. Harris, *The relationship between food literacy and dietary intake in adolescents: a systematic review.* Public health nutrition, 2015. **18**(4): p. 649-10.
4. Hack, S., M. Jessri, and M.R. L'Abbé, *Nutritional quality of the food choices of Canadian children.* BMC Nutrition, 2021. **7**(1).
5. Ng, A., M. Ahmed, and M. L'Abbe, *Nutrient Intakes of Canadian Children and Adolescents: Results from the Canadian Community Health Survey (CCHS) 2015 – Nutrition Public Use Microdata Files*. 2021.
6. Afshin, A., et al., *Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017.* The Lancet, 2019. **393**(10184): p. 1958-1972.
7. Canadian Pediatric Society. *School nutrition: Support for providing healthy food and*

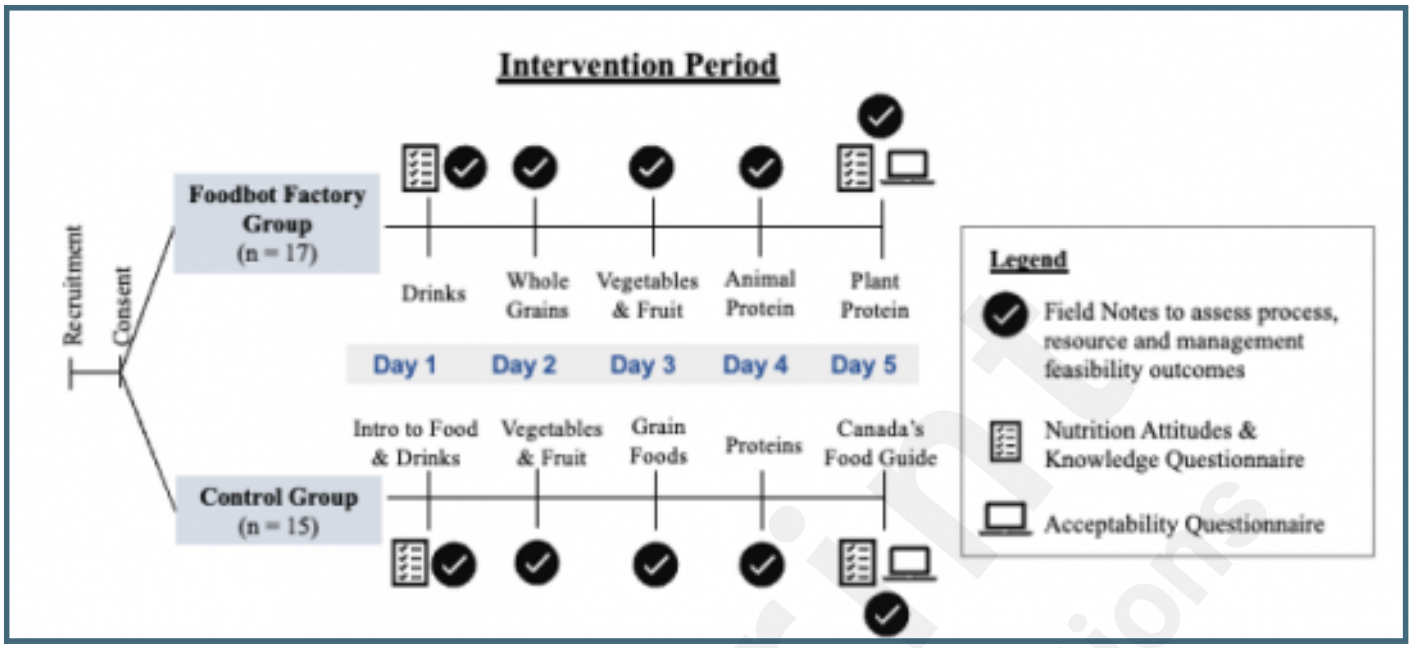
beverage choices in schools. 2020 [cited 2022 February 1]; Available from: https://cps.ca/documents/position/school-nutrition-support#:~:text=Schools%20provide%20important%20opportunities%20to,healthier%20dietary%20choices%20and%20behaviours.
8. Graziose, M.M., et al., *Cost-effectiveness of a Nutrition Education Curriculum Intervention in Elementary Schools.* Journal of Nutrition Education and Behavior, 2017. **49**(8): p. 684-691.e1.
9. Cotton, W., et al., *The effect of teacher-delivered nutrition education programs on elementary-aged students: An updated systematic review and meta-analysis.* Preventive Medicine Reports, 2020. **20**: p. 101178.
10. Jones, A.M. and S. Zidenberg-Cherr, *Exploring Nutrition Education Resources and Barriers, and Nutrition Knowledge in Teachers in California.* Journal of Nutrition Education and Behavior, 2015. **47**(2): p. 162-169.
11. Perera, T., et al., *Improving Nutrition Education in U.S. Elementary Schools: Challenges and Opportunities.* Journal of Education and Practice, 2015. **6**(30): p. 41-50.
12. Franco-Arellano, B., et al. *A qualitative study exploring elementary school teachers' experiences teaching nutrition in Canada.* in *International Society for Behavioral Nutrition and Physical Activity Annual Meeting*. 2023. Uppsala, Sweden: International Society for Behavioral Nutrition and Physical Activity.
13. Statistics Canada, *Education Indicators in Canada: An International Perspective, 2020*, Statistics Canada, Editor. 2020: Ottawa, Canada.
14. Laamarti, F., M. Eid, and A. El Saddik, *An Overview of Serious Games.* International Journal of Computer Games Technology, 2014. **2014**: p. 1-15.
15. Baranowski, T., et al., *Nutrition Education and Dietary Behavior Change Games: A Scoping Review.* Games for Health Journal, 2019. **8**(3): p. 153-176.
16. Thompson, D., et al., *Creating action plans in a serious video game increases and maintains child fruit-vegetable intake: a randomized controlled trial.* International Journal of Behavioral Nutrition and Physical Activity, 2015. **12**(1): p. 39.
17. Hermans, R.C.J., et al., *Feed the Alien! The Effects of a Nutrition Instruction Game on Children's Nutritional Knowledge and Food Intake.* Games Health J, 2018. **7**(3): p. 164-174.
18. Brown, J.M., et al., *The Content, Quality, and Behavior Change Techniques in Nutrition-Themed Mobile Apps for Children in Canada: App Review and Evaluation Study.* JMIR Mhealth Uhealth, 2022. **10**(2): p. e31537.
19. Brown, J.M., et al., *Optimizing Child Nutrition Education With the Foodbot Factory Mobile Health App: Formative Evaluation and Analysis.* JMIR Form Res, 2020. **4**(4): p. e15534.
20. Health Canada. *Canada's Food Guide*. 2019 [cited 2024 October 24, 2024]; Available from: https://food-guide.canada.ca/en/.
21. Ontario Ministry of Education, *Health and Physical Education Grades 1-8*, Ministry of Education, Editor. 2019, Government of Ontario: Toronto, Ontario, Canada.
22. Froome, H.M., et al., *The Effectiveness of the Foodbot Factory Mobile Serious Game on Increasing Nutrition Knowledge in Children.* Nutrients, 2020. **12**(11): p. 3413.
23. Thabane, L., et al., *A tutorial on pilot studies: the what, why and how.* BMC Medical Research Methodology, 2010. **10**(1): p. 1.
24. Brown, J.M., et al., *Co-Design and Refinement of Curriculum-Based Foodbot Factory Intervention to Support Elementary School Nutrition Education.* Nutrients, 2024. **16**(21): p. 3769.
25. Franco-Arellano, B., et al., *Updating the Foodbot Factory serious game with new interactive engaging features and enhanced educational content.* Applied Physiology,

Nutrition, and Metabolism, 2023. **49**(1): p. 52-63.
26. Van de Walle, J.A., J.M. Bay-Williams, and K.S. Karp, *Elementary and middle school mathematics : teaching developmentally*. Ninth edition (loose-leaf version) / John A. Van de Walle, late of Virginia Commonwealth University, Karen S. Karp, University of Louisville, Jennifer M. Bay-Williams, University of Louisville ; with contributions by Jonathan Wray, Howard County Public Schools. ed. 2016, Boston: Pearson.
27. Teachers Pay Teachers. *About Us*. 2022 [cited 2022 06-03-2022]; Available from: https://www.teacherspayteachers.com/About-Us.
28. Sekhon, M., M. Cartwright, and J.J. Francis, *Acceptability of healthcare interventions: an overview of reviews and development of a theoretical framework.* BMC Health Services Research, 2017. **17**(1): p. 88.
29. Franco-Arellano, B., et al., *Development and Pilot Testing of a Nutrition Attitudes and Knowledge Questionnaire to Measure Changes of Child Nutrition Knowledge related to the Canada's Food Guide.* Applied Physiology, Nutrition, and Metabolism, 2021.
30. Chan, C.L., et al., *Pilot and feasibility studies for pragmatic trials have unique considerations and areas of uncertainty.* Journal of Clinical Epidemiology, 2021. **138**: p. 102-114.
31. Julious, S.A., *Sample size of 12 per group rule of thumb for a pilot study.* Pharmaceutical Statistics, 2005. **4**(4): p. 287-291.
32. Johanson, G.A. and G.P. Brooks, *Initial Scale Development: Sample Size for Pilot Studies.* Educational and Psychological Measurement, 2009. **70**(3): p. 394-400.
33. R Core Team, *R: A language and environment for statistical computing.* 2022, R Foundation for Statistical Computing: Vienna, Austria.
34. Braga-Pontes, C., et al., *Nutrition education strategies to promote vegetable consumption in preschool children: the Veggies4myHeart project.* Public Health Nutrition, 2022. **25**(4): p. 1061-1070.
35. Epstein, D.S., et al., *Recruiting for research on sensitive topics in schools: an experience with Vaxcards, a collectable vaccine card game.* Trials, 2021. **22**(1).
36. Hodges, A., et al., *Evaluating the feasibility, fidelity, and preliminary effectiveness of a school-based intervention to improve the school participation and feelings of connectedness of elementary school students on the autism spectrum.* PLOS ONE, 2022. **17**(6): p. e0269098.
37. Mabungane, S., S. Ramroop, and H. Mwambi, *Analysis of Missing Data in Progressed Learners: The Use of Multiple Imputation Methods.* African Journal of Research in Mathematics, Science and Technology Education, 2023. **27**(2): p. 112-122.
38. Van De Weijer-Bergsma, E., et al., *The Effectiveness of a School-Based Mindfulness Training as a Program to Prevent Stress in Elementary School Children.* Mindfulness, 2012.
39. Tickle-Degnen, L., *Nuts and bolts of conducting feasibility studies.* Am J Occup Ther, 2013. **67**(2): p. 171-6.
40. Lancaster, G.A. and L. Thabane, *Guidelines for reporting non-randomised pilot and feasibility studies.* Pilot and Feasibility Studies, 2019. **5**(1).
41. Teresi, J.A., et al., *Guidelines for Designing and Evaluating Feasibility Pilot Studies.* Medical Care, 2022. **60**(1): p. 95-103.

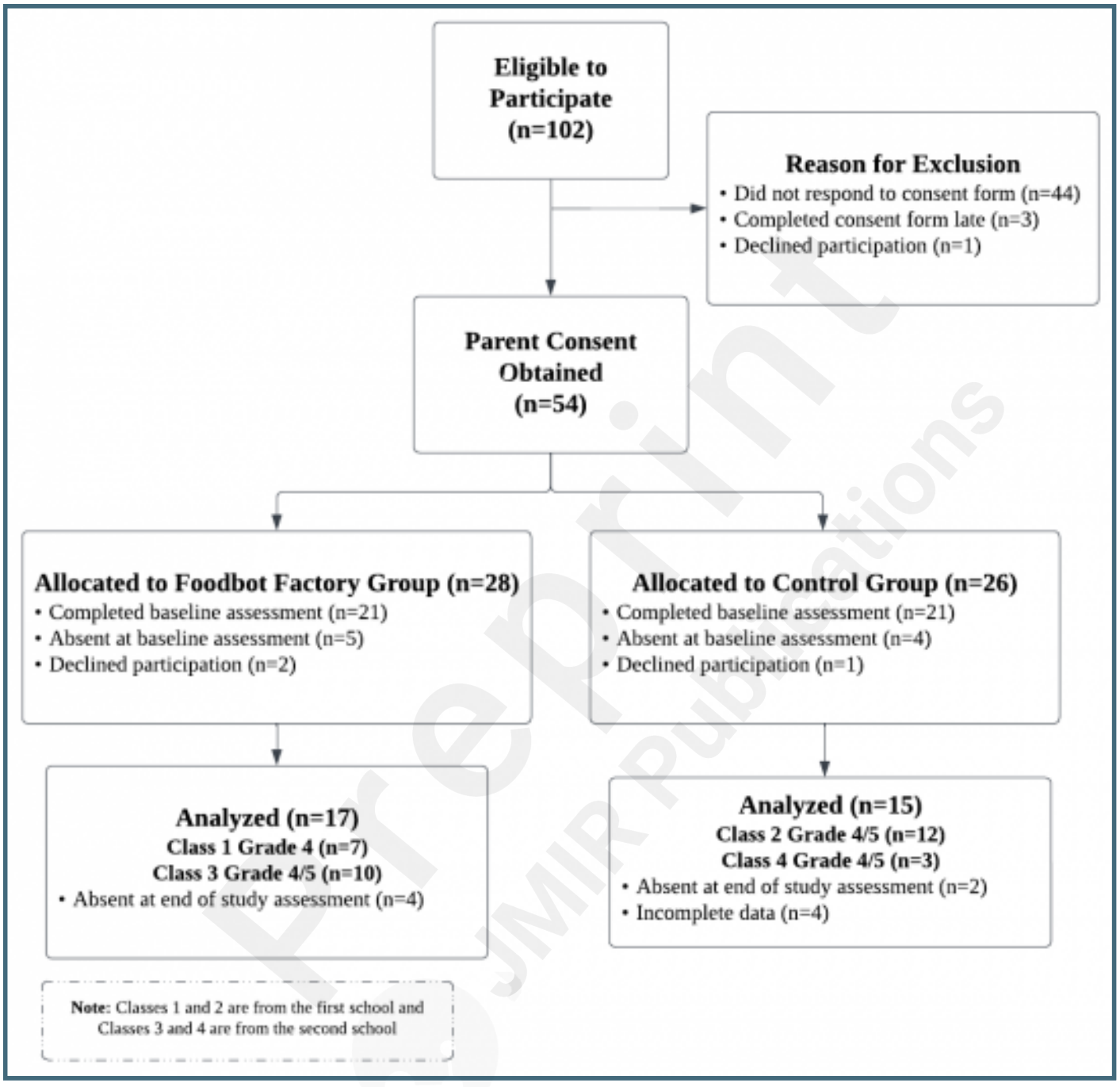
Supplementary Files

Figures

Feasibility study overview.



Flowchart of participant progress through the study.



Acceptability of the nutrition education interventions as rated by participants (n=41).