Chapter 12
Intelligent Tutoring System as an Instructional Technology in Learning Basic Nutrition Concepts: An Exploratory Sequential Mixed Methods Study

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ABSTRACT

Children often make unhealthy food choices because they lack nutrition knowledge. This chapter consequently assessed the potential employment of a nutrition intelligent tutoring system (NutritionITS) for teaching and learning basic nutrition concepts in primary education. Following the K-12 Health Curriculum Guide by the Department of Education, NutritionITS incorporated the first quarter content in the grade 1 level. Using an exploratory sequential mixed methods design, it was evaluated by teachers and parents. The qualitative phase served as the participatory design process that extracted the features needed by teachers. On the other hand, the quantitative phase served as the prototype evaluation using the technology acceptance model constructs. The results presented in this chapter may assist educational leaders, teachers, parents, and students in achieving a better learning outcome in nutrition education. In addition to its contribution to the literature of educational research, this is the first study to develop an intelligent tutoring system in the field of nutrition science.

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INTRODUCTION

The acquisition of noncommunicable diseases is closely tied to dietary habits (Asakura et al., 2017; Garcia, 2019; Schmidt et al., 2011). Food education programs are therefore implemented worldwide to establish healthy eating patterns. Many of these programs (e.g., de Villiers et al., 2016) operate under the impression that most chronic diseases in adulthood emanate from the dietary practices developed during childhood. Worldwide, Egg et al. (2020) reported that the pervasiveness of obesity and overweight among children has increased from 4% to 18% between 1975 and 2016. On the other hand, the Philippines faced a different nutrition problem. Instead of being overweight and obese, undernutrition has always been a severe challenge. Mbuya et al. (2021) stated that it is one of the ten countries in the world with the highest number of stunted children and ranked fifth among countries in the East Asia and Pacific region with the highest prevalence of stunting. One of the commonly reported causes of these global nutrition problems is that young children make unhealthy food choices because they lack nutrition knowledge (Mirmiran et al., 2007; Zaborskis et al., 2012). Although nutrition knowledge alone may be insufficient, especially for countries that face hunger and undernutrition, it is still a critical competitive differentiator among schoolchildren (Triches & Giugliani, 2005). In reducing obesity and related chronic disease risk in children and youth, the school emerged as a critical setting (Flynn et al., 2006). Thus, school-based interventions are also being implemented to improve children's nutrition knowledge as well as their physical activity (Asakura et al., 2021; Gortmaker et al., 1999; Jansen et al., 2008; Manios et al., 2002; Nyberg et al., 2015).

MAIN FOCUS OF THE CHAPTER

Despite global implementations of dietary education programs and school-based interventions, various studies reported that improvement is still warranted. According to Kigaru et al. (2015), the portrayal of the media altered the concept of food from a means of nourishment to a source of pleasure and a marker of lifestyle. When food advertisements televised and shared on various media platforms are of highly processed foods with high caloric content yet little macronutrient content, children must be able to discern healthy foods from less healthy ones. Jansen et al. (2008) also added that more efficient interventions are urgently needed if we are to consider the consequences for immediate health as well as in later life due to tracking of nutrition-related problems into adulthood. Mbuya et al. (2021) recommended the implementation of a direct nutrition intervention that is readily available to each household. This chapter thereby investigated the potential employment of a Nutrition Intelligent Tutoring System (*NutritionITS*) for teaching and learning basic nutrition concepts in primary education. This instructional technology was the extended version of Virtual Dietitian (Garcia et al., 2021b). Specifically, it explored the technology acceptance of such an instructional technology among primary school teachers and parents using the theoretical lens of the technology acceptance model (TAM). In addition to its contribution to the literature of educational research, this is the first study to develop an Intelligent Tutoring System (ITS) in the field of nutrition science (Bringula, 2020).

BACKGROUND OF THE STUDY

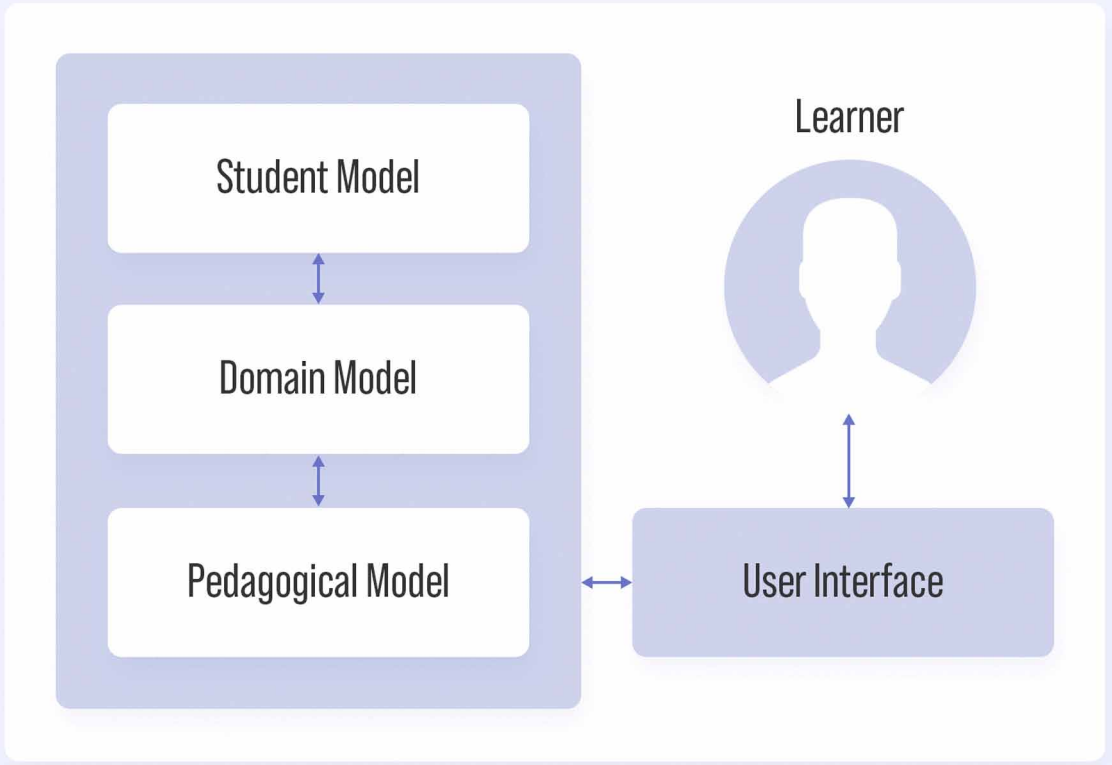
Remote Learning in Primary Education

Remote learning can be described as the process of teaching and learning that does not require teachers and students to be physically present at a school. Before the COVID-19 pandemic, this learning delivery was not extensively utilized. Garcia (2022) argued that the global health crisis of 2020 forcefully introduced the arrival of the online education era. Many institutions acknowledge that learning remotely is not easy for any child, but it is better than allowing learning losses to solidify (Fung et al., 2022; Lau et al., 2021; Zheng et al., 2022). In some countries, although many primary school students performed poorly in distance education and faced many challenges (Sánchez Amate et al., 2021), they still exhibited enthusiasm for participating in online classes (Cui et al., 2021). A systematic review found teachers recruited the assistance of instructional technologies to assist in online and blended teaching and learning for all levels of education (Topping et al., 2022). The most popular intervention was educational games, which have been used in early childhood education even before the pandemic (e.g., Garcia, 2020b). For teaching children online, teaching strategies that are fun and engaging are very significant since they could not pay attention to online learning for more than 20 minutes (Scarpellini et al., 2021). Thus, teaching nutrition knowledge remotely may require a similar instructional technology (e.g., *NutritionITS*) to ensure a successful knowledge transfer.

Intelligent Tutoring Systems

ITS is an educational application designed to provide instant and tailored instruction or feedback to learners often without human teacher intervention. It operates various heterogeneous forms of knowledge, ranging from pedagogical to domain knowledge (Nkambou et al., 2010). In its generic format (see Figure 1), Badaracco et al. (2013) described the ITS architecture as a composition of a student model (who is taught?), a domain model (what is taught?), and a pedagogical model (how is it taught?). In a systematic review of the literature, Dermeval et al. (2018) reported that there have been positive reviews on the effectiveness of ITS. When ITS is well-designed and aligned with the educational goals, it can complement other instructional models regardless of educational levels and academic subjects. Bringula (2020) asserted that it can be valuable supplementary material for teachers, especially for those who handle a large class. It can also be beneficial to students since it adapts to their academic needs and abilities. Consequently, many researchers have been developing their version of ITS. For instance, Graesser et al. (2018) created *ElectronixTutor* – an ITS that blends multiple empirically based components into one application to teach an electronic course. One of its features is that it automatically presents certain video lessons under pre-defined conditions. Unlike this ITS, *NutritionITS* was not a full-blown system but rather a small prototype only. Bringula (2020) found that only 1 out of 24 ITS studies in the country were conducted at the primary education level. Therefore, it is only practical to identify first the acceptance level among stakeholders of the primary schools before initiating the development of a costly and time-consuming application.

Figure 1. Generic Intelligent Tutoring System Architecture



Technology Acceptance Model

Technology acceptance is described as the attitudinal perception and the behavioral intention to use a technological tool. Many information systems studies (Barzekar et al., 2019; Garcia, 2023; Ketikidis et al., 2012) used this as a predictor of technology adoption and usage. One of the most popular information systems theories that model how users decide to accept and use technology is the TAM. Originally developed by Davis (1989) on the grounds of the Theory of Reasoned Action, TAM posits that the perceived usefulness and ease of use of a particular technology determines the extent of user acceptance. Since its inception, TAM has been expanded considerably by various researchers in different disciplines (Mustafa et al., 2022; Mustafa & Garcia, 2021). For instance, a recent systematic review showed that TAM has been extensively used in healthcare, especially for telemedicine, electronic medical records solutions, and other health information systems (AlQudah et al., 2021). Nutrition research also employs TAM to explain the causal relationship between users and their decision in accepting new technologies (e.g., Han et al., 2020). With the overwhelming evidence of TAM as an effective information systems theory (e.g., Nadal et al., 2020; Rahimi et al., 2018), using it as a theoretical basis provides a solid foundation for determining the acceptance of *NutritionITS*.

METHODOLOGY

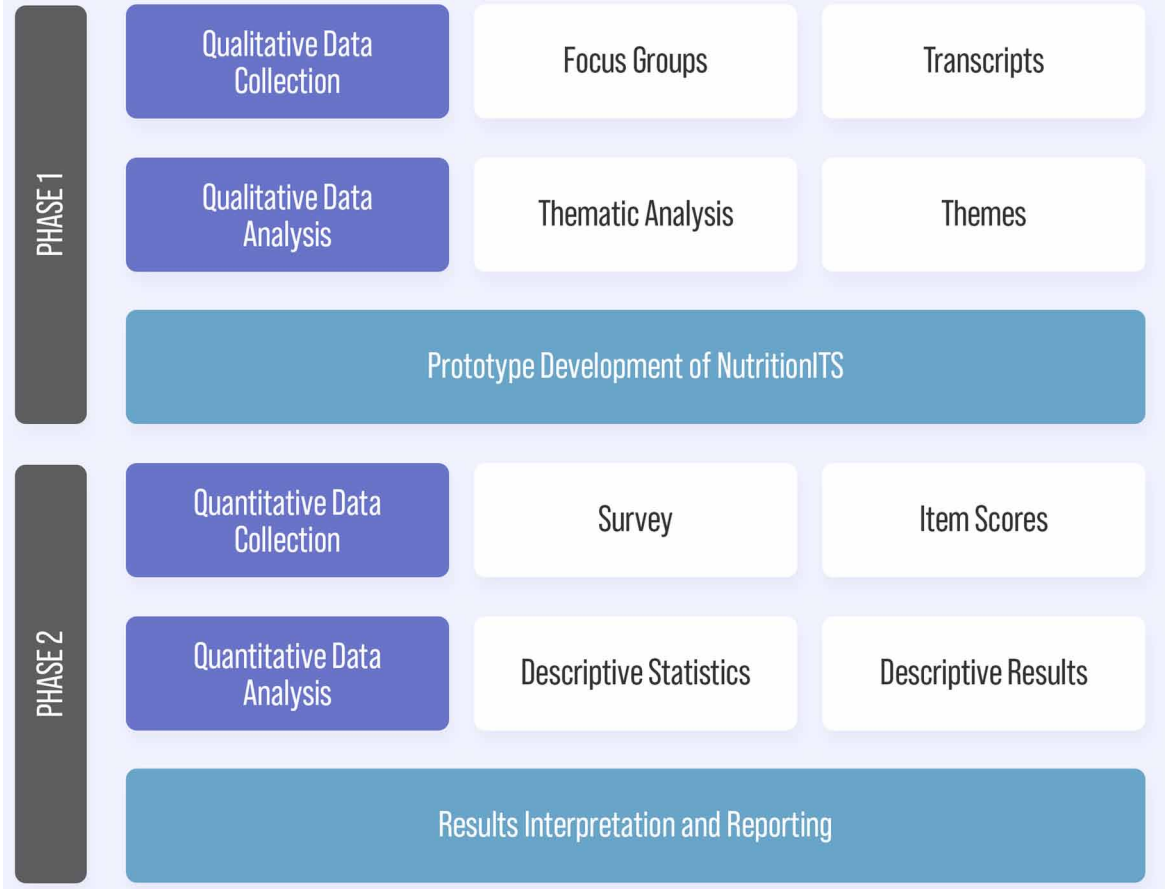
Research Design

This chapter employed an exploratory sequential mixed methods design to explore the applicability of an ITS for teaching and learning basic nutrition concepts in primary education. This research design involves the integration of quantitative and qualitative data analyses and their results within a single study (Creswell & Clark, 2017). Mixing two research methods is believed to be superior as it is likely to offer more valuable insights into the phenomena that cannot be fully understood by using only a single research method (e.g., Garcia et al., 2020). Moreover, Bringula (2020) found that all ITS-related papers in the country used quantitative methods and there is currently a research methodological gap due to the lack of mixed-method studies. These justifications led to the employment of mixed-methods research. In terms of the specific design, this chapter employed the exploratory sequential design because its primary purpose of exploring the applicability of ITS in primary education is more qualitatively oriented. In practice, this mixed method design begins with a quantitative phase, followed by a qualitative phase, and then combined both quantitative and qualitative in the final phase. The research design and the corresponding timeline for all phases are presented in Figure 2.

Sample and Procedures

Two samples were recruited in this chapter: teachers for the first phase (qualitative) and parents for the second phase (quantitative). A purposive sample of eight primary school teachers who were currently or have experience in teaching nutrition subjects participated in the qualitative phase. The sample size for the qualitative evaluation was based on data saturation. They were interviewed regarding their teaching strategies ("*How do you teach nutrition concepts to primary school students?*) as well as the problems they usually face in teaching the subject ("*What barriers or challenges do you normally encounter in teaching nutrition?").* The individual semi-structured interviews ended with a final question: "*What features do you look for in an instructional technology?*". The answers to these questions were expected to devise a tailored instructional technology in the form of an ITS. According to Bringula (2020), there is a compelling reason to incorporate culture in the development of ITS (e.g., how teachers in a specific country teach nutrition concepts). After developing the prototype of *NutritionITS*, a total of 55 parents of currently enrolled primary school students conducted a quantitative evaluation. The sample size for the quantitative evaluation was derived using Sloven's formula ($e = 0.10$). Unlike in the evaluation of a previous nutrition system (Garcia et al., 2021a; Garcia et al., 2022), the acceptance of the prototype version of *NutritionITS* among parents was evaluated using a pilot-tested and validated questionnaire based on TAM. Perceived usefulness, perceived ease of use, behavioral intention to use, and attitude toward using ITS were used as the questionnaire constructs.

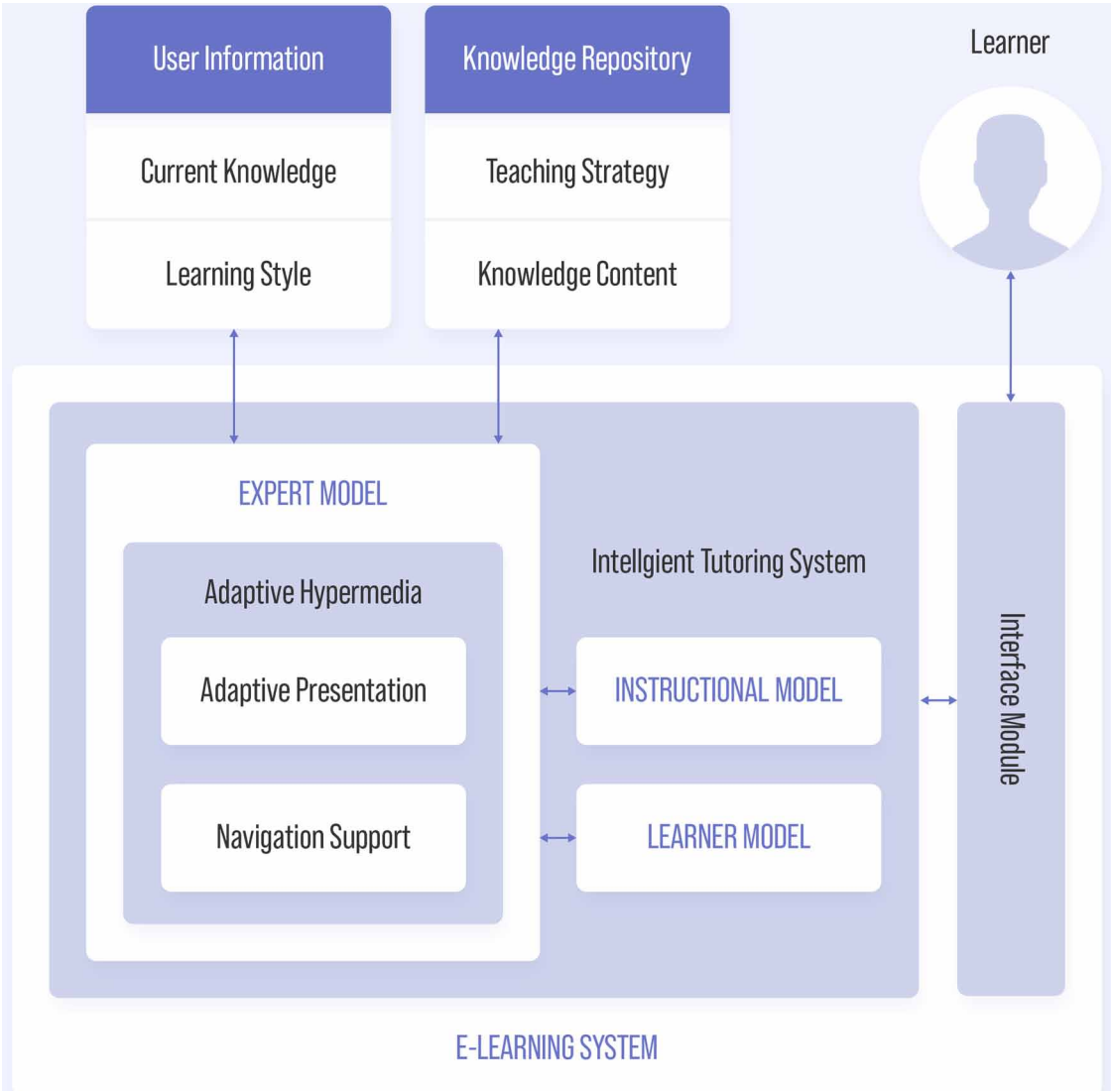
Figure 2. Exploratory Sequential Mixed Methods Research Design



Nutrition Topics and Prototype Development

The nutrition topics and learning materials were based on the *K-12 Health Curriculum Guide* developed by the Department of Education (2016). Garcia (2020a) used the same source of content in developing another instructional technology for K-12 education. One of the health content areas in the health curriculum guide is nutrition, which aims to educate children on the importance of eating healthy and establishing good eating habits to enhance health and prevent diseases. Due to the extensiveness of the curriculum guide, this chapter focused only on the first quarter content in the grade 1 level. The topics include (1) healthful and less healthful foods, (2) the consequences of eating less healthy food, and (3) good eating habits. For the prototype development, the proposed architecture of Phobun and Vicheanpanya (2010) which integrated ITS into an online learning system was followed (see Figure 3). Since it was not the goal to develop a full-fledged ITS, but rather explore the acceptance of such an instructional technology, a simple adaptive online learning simulation of the three first-quarter topics was developed.

Figure 3. E-Learning with Intelligent Tutoring System



Quantitative and Qualitative Data Analyses

The transcript of interviews gathered during the qualitative phase was analyzed according to the thematic analysis principles outlined by Braun and Clarke (2006). After reviewing interview transcripts, a preliminary set of codes and related themes was inductively identified. With the assistance of external researchers, these codes were then refined and expanded using a deeper review of the data. In case of disagreement, the research members (including the corresponding author) resolved it through a discussion. Following the formula used by Yeung and Yau (2022), the agreement between coders was calculated by dividing the number of agreements by the total number of agreements plus the number of disagreements. The survey results gathered during the quantitative phase and the demographic information for both phases were analyzed using descriptive statistics. The survey questionnaire contained 15 items using a 5-point

Likert scale ranging from 1 to 5 representing the following values: (Strongly Agree: 5 points, Agree: 4 points, Not Sure: 3 points, Disagree: 2 points, Strongly Disagree: 1 point).

RESULTS

Background Characteristics of Study Participants

As shown in Table 1, of the eight teachers who participated during the qualitative phase, 75% of them were female and 62.5% of them were less than 30 years old and single. The primary purpose of the semi-structured interviews was to determine their current teaching strategies, the barriers they face in using these pedagogies, and what features they would like to see in instructional technology. This qualitative component of the study follows the concept of a participatory approach where people who are directly concerned with the research output are involved in the project (e.g., Revano & Garcia, 2021). In Phase 2, of the 55 parents who participated in the quantitative evaluation, 78.2% of them were female and 52.7% of them were less than 30 years old. Most of them were single ($n = 27$, 49.1%), employed ($n = 39$, 70.9%), and with at least a college degree ($n = 29$, 52.7%). The primary purpose of this quantitative evaluation was to measure the parental acceptance of ITS through the theoretical lens of TAM.

Table 1. Demographic Profile of the Respondents

Demographic Variables		Teachers ($n = 8$)		Parents ($n = 55$)	
		f	%	f	%
Gender	Male	2	25.0	12	21.8
	Female	6	75.0	43	78.2
Age	Less than 30 years	5	62.5	29	52.7
	More than 30 years	3	37.5	26	47.3
Marital Status	Single	5	62.5	27	49.1
	Married	2	25.0	25	45.5
	Widowed	1	12.5	3	5.5
Educational Qualification	Primary	0	0	9	16.4
	Secondary	0	0	17	30.9
	Degree and above	8	100.0	29	52.7
Employment Status	Working	8	100.0	16	29.1
	Not working	0	0	39	70.9

Teaching Strategies in Nutrition Education

Mapping the teaching strategies employed by primary school teachers in nutrition education may assist in formulating the most appropriate pedagogies to be integrated into *NutritionITS*. According to teachers, three of their most implemented strategies in the physical classroom are teacher-centered instruction, visual-based teaching, and inquiry-based learning.

Teacher-Centered Instruction. Some teachers still rely on the most conventional approach where most time is spent with them explaining concepts and assigning individual work.

"Most of the time my strategy is to be the information giver – a teacher-centered approach. My students are young, and it is usually a disaster if I use other strategies like grouping them for an activity. At least in my approach, I retain the full control of my classroom." – T2

"My daily routine in my class is to teach the topic usually for 10-20 minutes then I assigned them an individual activity that I prepared the night before. This is my assessment strategy to know if they really understand the lesson I just taught." – T6

Visual-Based Teaching. The use of visual materials (e.g., charts, diagrams, and other graphical elements) is also a popular technique to engage young students.

"I know not all my students are visual learners but them being kids is enough reason for me to use graphics, diagrams, and other visual materials for now. Based on my observation, they can relate better to what I am saying if they are seeing a representation of it." – T3

"My former professor always says that students can remember the lessons better when they are represented both visually and verbally and that is according to research. To this day, I treat this as advice and deliver my lessons with corresponding visuals." – T4

Inquiry-Based Learning. Making real-world connections and asking questions to foster authentic curiosity is another teaching strategy used by primary school teachers.

"When I think that the lesson that I am about to teach may be difficult for my students, I ask a series of questions that can lead to our discussion. My strategy is to trigger their curiosity, engage them in the class, and somehow allow them to be active learners." – T7

"In my experience, the best way to teach children is to relate the concepts and topics to real-life examples. When you tap the thought process of students by involving them through engaging questions, the discussion becomes more fruitful and enjoyable." – T8

Challenges in Teaching Nutrition Concepts

Facing a multitude of hurdles to manage and teach a class is part of a teacher's job description. Identifying these barriers may support identifying the teaching and learning practices that can enhance information delivery. According to teachers, some of their challenges were the lack of individualized instruction, student progress monitoring, and classroom management.

Lack of Individualized Instruction. The ability to cater to the individual needs of their students is a prevalent challenge among teachers at the primary education level.

"Our current teacher-student ratio is a barrier for a lot of us and it is hard to focus on the needs of individual students. I also have students who are slow learners, and it pains me to see that I cannot attend to their learning needs all the time." – T3

"Some of my students require more attention because they cannot seem to understand the lesson despite my different strategies. I just hope there is a way to cater all their needs whether it is for a nutrition subject or other lessons." – T4

Student Progress Monitoring. Teachers strive to better monitor their student's progress, but it does not seem feasible when they have excessive workloads.

"Monitoring the progress of my students is an important task for teachers like us but when you have many classes to handle, it becomes tedious to do everything. Instead of monitoring, I have to prepare the materials and activities for the next meeting." – T1

"I used to know everything about my students, their capabilities and learnings. When the pandemic began, it became difficult to do it online. Now that we returned with more workload than ever, I can't seem to find the time to monitor everything." – T8

Classroom Management. The ability to teach and their effectiveness as teachers are often affected by the difficulty of managing a classroom full of young students.

"It is understandable that my students, as they are still very young, often misbehave in the classroom. When they are not paying attention to the lesson, the whole class is affected. This issue makes teaching children more difficult." – T7

"When children have tantrums or emotional meltdowns, it's a losing battle to expect instant compliance from them. It is a class disruption where no one wins. However, as a teacher, it is my responsibility to prioritize these scenarios than proceed to my lessons." – T5

Features of Instructional Technologies

Given their current strategies and the challenges they face in teaching nutrition education in primary schools, the participating teachers were asked about what features they would like to see in instructional technology to help them become better in their jobs. By asking teachers directly about their expectations, as also one of the beneficiaries of *NutritionITS*, this strategy follows the participatory approach to ensure a context-specific application was developed. Co-designing the application with stakeholders increases the possibility that the final product meets their needs and is functional to its full extent. The features they recommend were as follows:

Provision of Feedback. Teachers acknowledge the importance of constantly giving feedback and its essential role in the teaching and learning process.

"As I mentioned, the teacher-student ratio makes it impossible to constantly monitor my students. If we have an application that can assist us in giving feedback on their projects, assignments, and assessments, that would be a big help." – T3

"If an application can do an individualized approach, I believe it should also be capable of giving timely and relevant feedback to the learners." – T4

Learning Analytics. A complete picture of student performance while using an online learning system with an integrated ITS was demanded by teachers.

"To monitor the progress of my students, I would like to have an analytics feature displayed in a visual format in a dashboard so I can use the data in my interventions." – T1

"I would like to track my students' journey to determine where they are excelling and not, especially if they are using a computer learning system outside the school." – T7

Personalized Student Experience. Teachers believe that the pace of learning as well as the instructional approach should be optimized for the needs of each student.

"Online learning systems are already common but I have yet to experience an application that can personalize the learning experience of students. I believe it should be readily available in these systems since computers can do it better than human teachers." – T4

"The system should offer customization of content delivery format. I like to see something that adapts to the needs of students like a slow learner being supplemented with more materials while a fast learner being given advanced activities." – T7

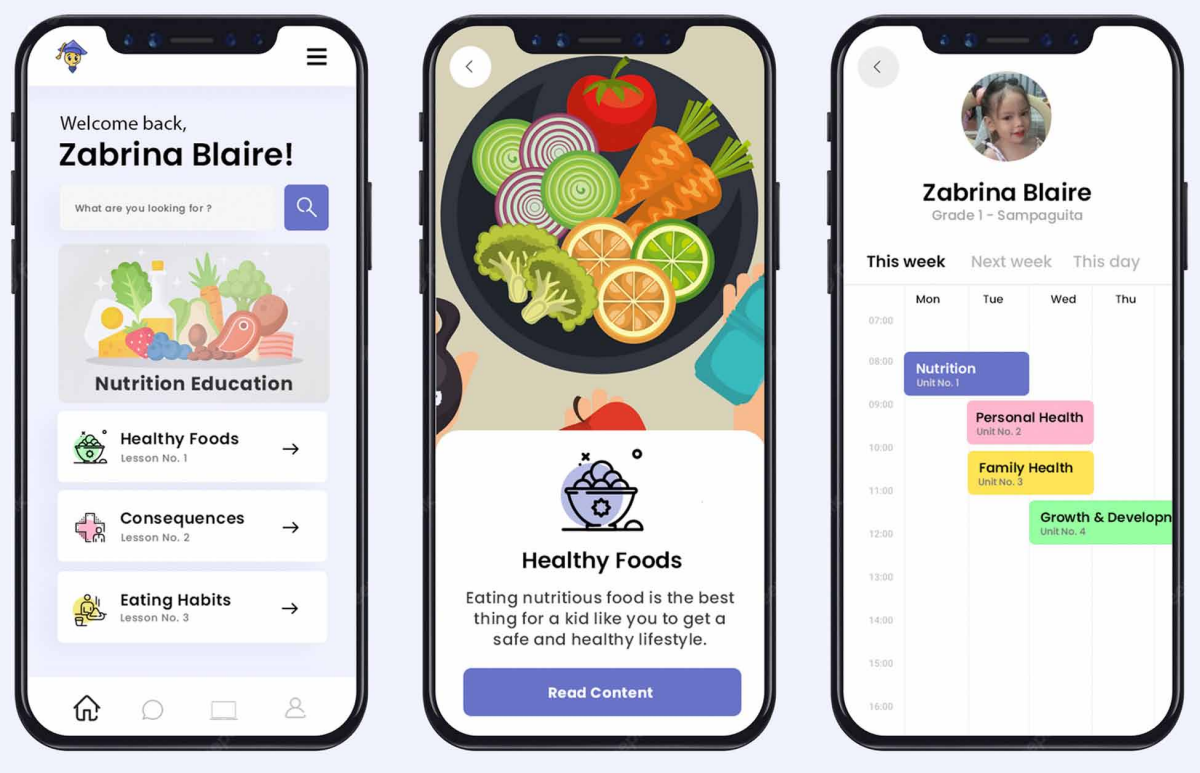
Evaluation of NutritionITS

After consolidating the qualitative feedback, the appropriate recommendations were applied in the next iteration of the systems development. Figure 4 shows screenshot examples of the new version. Parents then quantitatively evaluated *NutrionITS* using the TAM constructs. While most parents found the system useful, they were not sure in terms of its ease of use. Despite this uncertainty, they still have a positive attitude toward using the system. More importantly, they intend for their kids to use the application in their education.

Table 2. Evaluation of NutritionITS Using the TAM Constructs

Items	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
Perceived Usefulness	0%	0%	23%	26%	51%
Perceived Ease of Use	0%	1%	43%	33%	23%
Attitude Toward Use	0%	0%	6%	9%	85%
Behavioral Intention to Use	0%	0%	18%	39%	43%

Figure 4. Application Dashboard, Course Homepage, and Topic Schedule of NutritionITS



DISCUSSION

In this chapter, the potential employment of a Nutrition Intelligent Tutoring System called *NutritionITS* at the primary education level was investigated. It followed an exploratory sequential mixed methods design that underwent qualitative and quantitative phases with teachers and parents, respectively. In teaching nutrition, primary school teachers prefer teacher-centered instruction, visual-based teaching, and inquiry-based learning. These strategies were specifically chosen because of their student demographics. For instance, despite the popularity of active learning pedagogies, they still employ teacher-centered instruction since some students may not be ready yet for self-administered learning at this early age. Teachers also encounter some challenges in teaching nutrition concepts, including the lack of individualized instruction, constant monitoring of student progress, and managing the classroom. Fortunately, these challenges can be mitigated by employing an ITS as an adjunct tool in the teaching and learning process. For instance, individualizing the lessons, assessments, and feedback are some of the fundamental goals of ITS. According to a meta-analysis (Ma et al., 2014), the use of ITS was associated with greater achievement in comparison with non-ITS computer-based instruction. This positive result suggests that teachers and students will benefit from this computer program.

Since parents have a high degree of influence over the instructional technologies used by their children (e.g., Garcia, Nadelson, et al., 2023), it is significant to investigate their technology acceptance. In terms of the TAM constructs, parents found the employment of a nutrition ITS as an instructional technology in their children's education useful. During the pandemic, it was repeatedly reported that parents have

had no choice but to become more involved in the education journey of their children (Alharthi, 2022; Garcia & Revano, 2022). The intensification of this responsibility may have overwhelmed them and the idea of having an ITS in the online learning system as an extra feature could be seen as a useful pedagogy. From a pedagogical perspective, educational leaders and policymakers may develop similar instructional systems that could help both teachers and parents in teaching nutrition concepts to children.

Meanwhile, they were not sure that using *NutritionITS* would be free of effort, which contradicts other TAM-related studies (e.g., Bicen & Aydogan, 2019). One possible reason is that an ITS is less common than other instructional technologies, such as digital games (e.g., Revano et al., 2018) and productivity software (Garcia, 2023) among others. Nonetheless, they still have a positive attitude toward using ITS, which is supported by the educational research literature on instructional technologies (Adiat et al., 2013; Tahir & Arif, 2015). Since these constructs predict the behavioral intention to use technology, it is unsurprising that the parents intend to use *NutritionITS* for teaching their kids. Given these results, school institutions should devote effort and time to demonstrating the advantages of an ITS and other instructional technologies to persuade parents that using these technologies as teaching and learning tools is going to help them and their kids. For instance, the computer-assisted instruction version of VD was found to be effective in teaching physical fitness and exercise during and after the COVID-19 pandemic (Garcia, Yousef, et al., 2023). Overall, the positive effects of using *NutritionITS* and ITS in general pose important pedagogical implications in early childhood education.

Despite the positive results, this chapter has potential limitations and the most obvious one was that of a small sample size. This limitation prevents a clear generalized statement about the parental acceptance of this instructional technology. In terms of the sample, primary school students were not involved in the evaluation of *NutritionITS*. One reason is the avoidance of a novelty effect, which is common among children. For instance, Mavletova (2015) analyzed gamification impact in two waves and found that the results were significantly different. Whereas the first wave yielded positive results, they were negative during the second wave. Another limitation of the study was the extensiveness of the features and technical infrastructure of the system. Because it was not a full-fledged system, it is possible that their evaluation could have been different should the *NutritionITS* have had comprehensive features. The same possibility is present if the nutrition topics were complete. In this prototype version, only the first quarter in the Grade 1 level was covered. Other researchers may also employ other instructional technologies applicable to children like video games (e.g., Arayata et al., 2022; Cortez et al., 2022; Parel et al., 2022). These study limitations offer avenues for future research.

CONCLUSION

The chapter brings attention to the possible deployment of an ITS in teaching basic nutrition concepts at the primary school level. By using an exploratory sequential mixed methods design, the features expected by parents in instructional technologies as well as the acceptance of parents in using them for their children were identified. With the scarcity of ITS research, this chapter contributes to the literature on educational research by being the first study investigating ITS in the field of nutrition science. With the challenges imposed by emergency remote education, *NutritionITS* could serve as a supplementary tool in assisting teachers, parents, and students in nutrition knowledge acquisition. The prevalence of global nutrition problems among children due to the lack of nutrition knowledge makes this chapter more valuable.

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KEY TERMS AND DEFINITIONS

Instructional Technology: It is the use of technology to design, develop, deliver, and evaluate educational materials and activities.

Intelligent Tutoring System: An educational software designed to provide instant and tailored instruction or feedback to learners often without human teacher intervention.

Participatory Design: A methodology that involves the active participation of the intended users of a product, service, or system in the design process.

Primary Education: It is the first stage of formal education that typically starts at around age 5 or 6 and lasts for 5-7 years, depending on the country.

Remote Learning: The process of teaching and learning that does not require teachers and students to be physically present at a school or other place of formal education.

Technology Acceptance Model: An information system theory that models how users come to decide to accept and use a particular technological tool.