

Making Health Education Palatable: A Usability Study of a Digital Game about Nutrition

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Abstract: Nutrition is a component of elementary health education that can influence children's health and well-being. Unfortunately, when educating children about nutrition, many schools face challenges that limit the quality of health instruction. To help address these challenges, a video game called *Monster Mealtime* was designed to supplement fourth grade health instruction. The game was intended to teach fourth graders about nutrients' role in maintaining the human body. After the game was developed, it was evaluated through three rounds of usability testing. Twelve adults ($n = 12$) with elementary teaching experience played the game to assess its ability to support students' learning of the game and its core concepts while providing a satisfying play experience. After each round, revisions for the game were made to enhance its design. Data were collected through a questionnaire, a usability protocol, and a post-survey. By the end of round three, the game was perceived as satisfying. However, problems persisted with the game's learnability. While learnability issues related to the game's visual design were corrected, misconceptions about the game's mechanics remained prevalent throughout the evaluation period. To enhance the quality of future educational video games, strategies for communicating game instructions clearly must be explored further.

Statement of the Problem

In the United States, obesity still threatens children's health. Recent data suggests that the overall occurrence rate for childhood obesity in America has reduced over time (Anderson et al., 2019). However, a reduced rate is not synonymous with decreased prominence. This indicates that many children are still affected by childhood obesity. Additionally, childhood obesity is associated with other negative health impacts for children. Children who are obese can develop additional health conditions like diabetes (Hannon et al., 2005, as cited in Arnett & Maynard, 2017), and they are more likely to be rejected by peers (Puhl et al., 2010, as cited in Arnett & Maynard, 2017). Thus, childhood obesity negatively affects multiple aspects of children's well-being.

Health education can combat childhood obesity and other health concerns. In elementary schools, long-term nutrition instruction can promote weight loss in students (Price et al., 2017). Unfortunately, elementary teachers are confronted with many challenges while attempting to provide nutrition education. Teachers identify instructional time constraints, inadequate funding, limited access to nutrition education resources, and higher needs for instruction in other content areas as challenges for teaching nutrition (Hall et al., 2016). Additionally, current health education resources are heavily dependent

on instructional strategies that are less impactful on children's eating habits (Peralta et al., 2016). Equipped with less effective instructional strategies and restricted by other classroom needs, elementary schools are struggling to provide the health education that students require. Based on this information, the following problem has been identified: schools are expected to promote student health through health education, but competing priorities along with limited time and resources, often impede their ability to do so effectively.

To help address this problem, a new game-based instructional resource was designed for elementary classrooms. Previous research has shown that game-based instruction can elicit positive learning outcomes in the domain of health education. For example, Sung et al. (2015) developed a health-based computer game that successfully enriched students' academic motivation, problem-solving capacities, and knowledge of post-surgical care. However, nutrition games are rarely studied in detail to determine their academic quality (Baranowski et al., 2019). In this regard, current nutrition games may be ineffective for supporting nutrition instruction within formal education settings. Thus, the purpose of this project was to design and evaluate game-based instruction so that it is easy to use and effective in supporting teachers as they overcome challenges related to elementary health education. In terms of evaluation, a usability study was conducted to evaluate the game's ability to be satisfying and learnable for Hawaii's fourth grade students.

Literature Review

A literature review was conducted to explore the viability of using game-based instruction to ameliorate elementary health education challenges. First, research regarding children's nutrition knowledge and eating habits was reviewed. Then, research about the use of game-based learning for elementary instruction was examined. Special attention was given to research that highlighted game-based instruction in nutrition concepts. Finally, studies that discussed students' engagement with game-based learning were considered.

The Influence of Nutrition Knowledge on Children's Eating Habits

Children's eating habits are influenced by their knowledge of nutrients, food, and their body. Asakura et al. (2017) notes that elementary students who demonstrated a deeper level of nutrition knowledge were more inclined to consume vegetables. In that study, nutrition knowledge was assessed based on students' familiarity with the biological role of nutrients within the body, nutrients within food, and ways that nutrients influence personal health. Since these components of nutrition knowledge can positively affect children's dietary choices, incorporating these concepts into nutrition instruction for elementary students is desirable. Emphasizing the purpose of nutrients in the human body through instruction could positively influence students' eating habits, thereby enhancing the overall quality of health education within elementary classrooms.

Game-based Learning in Formal Education Settings

The integration of digital games in classroom instruction has produced positive learning outcomes for students in various content areas. Digital games promoted student learning when utilized as a supplemental instructional tool for elementary music lessons (Lesser,

2020). Another study reported advancements in elementary students' math assessment scores when game-based instruction was implemented (Hwa, 2018). Finally, game-based learning encouraged elementary students to develop positive attitudes and behaviors toward math, linguistic studies, and science concepts (del Moral Pérez et al., 2018). Through these studies, the potential of using digital games for elementary education are clearly demonstrated. Games motivate students to engage in their learning while guiding their progress toward established learning objectives. Ultimately, effective nutrition instruction must accomplish the same outcomes. Lessons must inspire students to adopt healthy eating habits while developing their understanding of nutrition concepts. Therefore, a video game that facilitates game-based learning in nutrition education seems to be a promising option for expanding available health education resources in the elementary school community.

Game-based Learning in Nutrition Education

Previous studies attempted to create digital games that encourage children to eat healthy foods. These games incorporated tasks like food classification, memory matching, and meal preparation by food groups (Baranowski et al., 2019). Yet, these tasks offer few opportunities for students to examine nutrients within foods, thereby preventing them from developing a comprehensive understanding of the relationship between nutrients and food. Furthermore, existing nutrition games demonstrate limited effects on students' nutrition education. A study examining a game called *Virtual Sprouts* found that the game was unsuccessful in impacting students' eating habits (Bell et al., 2018). Another study evaluated a game called *Fitter Critters* (Schneider et al., 2012). That study suggested that students enjoyed the game and exhibited improvements in nutrition knowledge and perceptions of healthy food; however, students preferred in-game tasks that were not related to nutrition concepts. This implies that the game's educational tasks were less appealing to students, possibly compromising the educational impact of the game. Thus, to make an educational impact, new nutrition games should incorporate enjoyable tasks that highlight relationships between nutrients, food, and the body.

Factors Related to Student Engagement in Game-based Learning

Some research has uncovered game mechanics and features that foster student engagement within and through gameplay. Captivating narratives and aesthetics within the game can stimulate student interest in games (del Moral Pérez et al., 2018). Children especially like detailed imagery that uses similar shapes, colors, and other design characteristics (Javora et al., 2019). Regarding gameplay aspects, students favor tasks that incorporate interactive graphic elements and opportunities to solve challenges that are adequately difficult; they also appreciate timely feedback for game performance (Martinovic et al., 2016). Consideration for these factors is crucial for designing an educational game that appropriately encourages students to participate in the game-based learning experience. With effective integration of these visual and structural gameplay characteristics, students may be motivated to cognitively engage with the game's content.

Considering the research presented in this literature review, game-based learning exhibits great potential to support nutrition education. Implementation of game-based learning has improved cognitive and affective learning outcomes in various content areas. Yet,

existing games in nutrition instruction have been less successful. These games tend to overlook critical connections between nutrition concepts. This is an important limitation because cultivating students' awareness of those connections is essential if positive changes in dietary habits are desired. Therefore, to make an effective game-based instructional resource for elementary schools, the game must prioritize explorations that feature relationships between nutrients, food, and the body. The game's design should also motivate students to play the game while supporting their efforts toward achieving meaningful in-game goals. Incorporating these considerations into a game's design may make it possible to develop an age-appropriate game that engages students in learning about essential nutrition concepts; it could create a game that indirectly benefits the field of elementary nutrition education.

Methodology

The purpose of this project was to create an educational video game that effectively supplements nutrition instruction in elementary classrooms. To accomplish this, the project was divided into two phases. First, a video game was designed and developed based on research about game design and instructional design. Then, a usability study was conducted to evaluate aspects of the game. To describe each of these phases, this section of the paper will begin by describing the process that was used to design and develop the game. Then, the project's usability study will be described in detail including its purpose, instruments, and procedures.

Game Overview

The game-based instruction is presented through *Monster Mealtime*, an educational video game that was developed for this project. *Monster Mealtime* is intended to strengthen children's knowledge of carbohydrates, proteins, and fats. It also aims to empower students by teaching them essential skills that enable them to choose healthy foods and maintain their well-being. The primary objective of *Monster Mealtime* is to consume a combination of meals that allows the main character, Morsel, to travel a specified distance and collect several objects. Students can also pursue optional objectives like finding rare items or minimizing the number of fat crystals remaining at the end of the day. Each day, students feed Morsel three meals to collect nutrients. Carbohydrates provide Morsel energy, fats create additional energy in the form of fat crystals, and proteins unlock temporary upgrades that enhance Morsel's performance. The distance traveled by Morsel and the number of objects collected is determined by the consumed amounts of each nutrient. Thus, different meal combinations may be used to help Morsel perform well. Inadequate nutrient consumption also creates consequences. For example, Morsel travels a shorter distance if more sugar is consumed than unrefined carbohydrates. The game ends after students complete five in-game days. Excluding time required to explore optional challenges, a fourth grader should take approximately 30 minutes to finish the whole game.

Content Analysis

The game must improve students' attitudes toward healthy eating while promoting changes in their nutrient knowledge. Thus, *Monster Mealtime* targets the cognitive and affective domains of learning. Learning objectives for each domain were identified by

combining the National Health Education Standards (Centers for Disease Control and Prevention, 2019) with concepts from a college-level nutrition textbook (Grosvenor & Smolin, 2015). The researcher ensured that the concepts were age-appropriate for elementary students by selecting topics that can be assessed within this population (Asakura et al., 2017). Specifically, two standards from the National Health Education Standards were selected:

- Standard 1: Students will comprehend concepts related to health promotion and disease prevention to enhance health
- Standard 5: Students will demonstrate the ability to use decision-making skills to enhance health

By incorporating these concepts, 10 learning objectives were identified for *Monster Mealtime*. These learning objectives are addressed simultaneously as students play the game. Ideally, by playing this game, students should be able to prioritize healthy variants of nutrients for consumption, recognize the functions and impacts of nutrients in the human body, and identify foods that provide essential nutrients. See Table A1 in Appendix A for detailed learning objectives.

Instructional Strategy and Project Design

Prior to planning the design and development of *Monster Mealtime*, existing research was reviewed to identify instructional strategies and design elements that could guide the game's development. The following paragraphs briefly summarize key design considerations discussed in research. Then, the procedures used to design and develop *Monster Mealtime* are described.

Instructional Needs of Fourth Graders. The game was designed for fourth graders. Fourth graders are approximately 10 years old and may attend various elementary schools within Hawaii. Students' prior knowledge in nutrition concepts may be limited due to low exposure to nutrition instruction and health education (Hall et al., 2016). At this age, children are more likely to be nearsighted (Arnett & Maynard, 2017). Regarding cognitive development, Piaget (as cited in Arnett & Maynard, 2017) believed that these students are learning to use strategies to mentally organize their conceptualizations. Students within this age group also possess a stronger working memory than younger students (Arnett & Maynard, 2017). Children socialize within specific friend groups; they may enjoy playing rule-based activities together and reference peer performance when evaluating personal achievements (Arnett & Maynard, 2017). Thus, fourth graders have a range of needs that must be accommodated by the game's design. For example, visual clarity within the game was maintained by incorporating large images and text for students who are nearsighted. Additionally, information within the game was presented gradually and logically to assist students as they organize new ideas. Furthermore, rules that were established within the game offered an appropriate challenge for students, while discouraging competition between students; this was attempted to reduce dissatisfaction with the game experience.

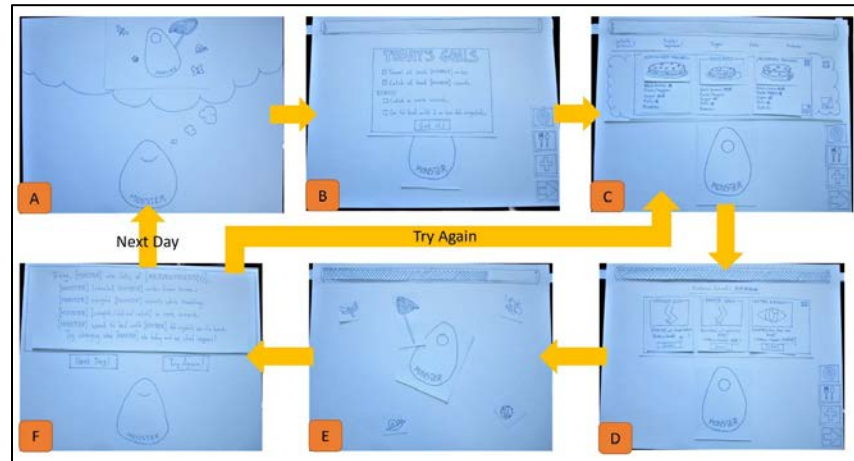
Design Approaches for Children's Games. Fisher (2015) shared specific game characteristics that create age-appropriate gameplay for children. For example, gameplay should accept various strategies for completing in-game tasks, visual features should

support students' navigation within the game, and initial tasks should promote satisfaction efficiently (Fisher, 2015). These suggestions were combined to form an instructional strategy designed to maximize students' engagement with the learning experience.

The Content Centric Framework for Game Design. Larsen's (2018) content centric framework is intended to guide instruction for college students studying game design. In this framework, the game designer considers four components of game design: establishing fundamental game mechanics, expanding upon these mechanics using game design thinking strategies, developing the game using organized procedures for continued progress, and enriching the game by improving player immersion (Larsen, 2018). These components became the foundational steps in the design and development processes used for this project. Each step is described in the following paragraphs.

Game Mechanics. Like any game, students need to achieve various game objectives to advance through the game. If the game is educational, students should simultaneously progress toward the learning objectives as they play the game. In *Monster Mealtime*, this allows them to apply nutrition concepts to make healthy eating choices in the real world. The game mechanics were intended to incorporate age-appropriate nutrition knowledge (Asakura et al., 2017) while improving upon instructional limitations that are present in existing nutrition games (Baranowski et al., 2019; Bell et al., 2018; Schneider et al., 2012). Additionally, game mechanics should integrate child-friendly challenges that have multiple solutions (Fisher, 2015; Martinovic et al., 2016). For this reason, the researcher outlined more specific game mechanics based on these design priorities. See Appendix A for detailed game objectives and learning objectives.

Paper Prototyping. Paper prototyping is a game design thinking strategy that allows a game designer to arrange ideas for game mechanic implementation (Larsen, 2018). Once the game mechanics for *Monster Mealtime* were finalized, paper prototyping was used to organize early ideas for the game. The game's scenes, menus, and gameplay structure were arranged through hand-drawn images on sheets of paper. Fisher's (2015) suggestions for visual navigation support influenced menu design. Feedback strategies were also explored since research has shown that in-game feedback significantly influences engagement with games (Martinovic et al., 2016). Ideas for other important aspects like visual design and background narratives (del Moral Pérez et al., 2018) were examined as well. For example, the researcher attempted to maintain consistent line thickness, shapes, and other visual design elements to make the graphics appealing to students (Javora et al., 2019). The game also integrates local Hawaii meals to demonstrate cultural awareness toward the target population (Asakura et al., 2017) and enrich the game's perceived relevance for Hawaii's elementary students. Figure 1 depicts initial game planning through paper prototypes. The final paper prototypes were referenced as a design guide when game development began. See Appendix B to see all paper prototypes created for this project.

Figure 1*Paper Prototypes for Gameplay Flow*

Game Construction. The game was developed using the Godot game engine. Godot is an open-source application that is used to program 2D and 3D video games. Godot can simultaneously publish games for Windows and macOS devices. This ability to publish to multiple platforms increases access to the game for participants of the study and students in future classrooms. Godot's programming language is also simple to use, so the development of this project was more efficient. Development was managed using modified Scrum strategies as described by Larsen (2018) where development goals are determined at the beginning of each programming session based on priority of completion. Each screen from the paper prototypes was created in Godot as a wireframe. Then, the researcher programmed user navigation between each screen. Once navigation between all screens was possible, the researcher programmed more specific game mechanics such as food selection and character movement in the activity stage. Minor adjustments to the game's design were made throughout development. See Appendix C to view screenshots of the Godot wireframes.

Enrichment of Game-based Experience. Graphics and audio were added and refined in the final stages of development. Both visual and aural characteristics are aspects of vertical design, an approach to game design that prioritizes player immersion during gameplay (Larsen, 2018). Animations were incorporated to create interactive visual elements to support student engagement (Martinovic et al., 2016) and graphics were refined further to embody qualities that children prefer (Javora et al., 2019). The researcher drew all graphics and animations for the game using graphic design programs (e.g., Paint 3D, Adobe Photoshop CS6). Audio files from open-source websites, FreeSound.org and OpenGameArt.org, were incorporated to create an immersive learning experience for learners. See Appendix D for screenshots of the finalized game prototype. Once the prototype was finalized, the game was exported through Godot for macOS and Windows devices. Each file was stored in a compressed folder and uploaded to a shared folder in the researcher's Google Drive.

Research Questions

To meet the intended learning objectives, the game must fully engage students in the learning tasks while providing an enjoyable experience. Thus, the following research questions guided this study:

1. How does the game's design influence the learnability of in-game tasks for fourth graders?
2. How satisfying is the digital game's learning experience for fourth graders?

Evaluation Instruments

Evaluating a game's design allows developers to maintain an engaging gameplay experience as development progresses (Larsen, 2018). Thus, conducting a usability study for *Monster Mealtime* was an essential evaluation step that could enrich the game's design and structure. In total, three evaluation instruments were used to collect qualitative and quantitative data for this project. Each instrument will be described here briefly.

Questionnaire. The Play-Tester Questionnaire was used to collect demographic data that examined participants' knowledge of the target audience and their preconceptions about educational computer games. Participants were asked to enter information about their elementary education teaching experience and their use of educational technology using pre-determined response options. They also ranked the educational value of computer games using a 5-point scale and described their beliefs about educational games. The 9-item questionnaire was administered to each participant through Google Forms prior to his or her scheduled usability session. Approximately 10 minutes were required to complete the questionnaire. See Appendix E for a copy of the Play-Tester Questionnaire.

Usability Protocol. As participants played the game, a usability protocol was implemented remotely to document participants' engagement with the game. The protocol consisted of a facilitator script and interview questions based on Krug's (2010) procedures for usability studies. Typically, usability studies present tasks for participants to complete as they use a product (Krug, 2010); however, utilizing such tasks for game usability studies can improperly influence participants' actions while playing the game (Barendregt et al., 2003, as cited in Barendregt & Bekker, 2006). Thus, instead of assigning usability tasks to the participant, the researcher observed participants as they played the game independently for 20 minutes and documented their gameplay through notes. Each gameplay session was also recorded through Zoom, a web-conferencing application. At the beginning of the usability session, users answered three interview questions that allowed the researcher to gather additional information about their knowledge of the target audience and educational computer games. These questions were separate from the items included in the Play-Tester Questionnaire. At the end of the usability session, participants took part in a post-interview that contained seven questions. These questions asked participants to identify characteristics of the game they felt contributed to a learnable, satisfying game experience, as well as share suggestions for improving the game's learnability and satisfaction. The protocol took approximately 45 minutes to implement. See Appendix F for a copy of the protocol.

Post-Survey. The post-survey was administered through Google Forms after participants finished playing the game. About five minutes were required to complete this

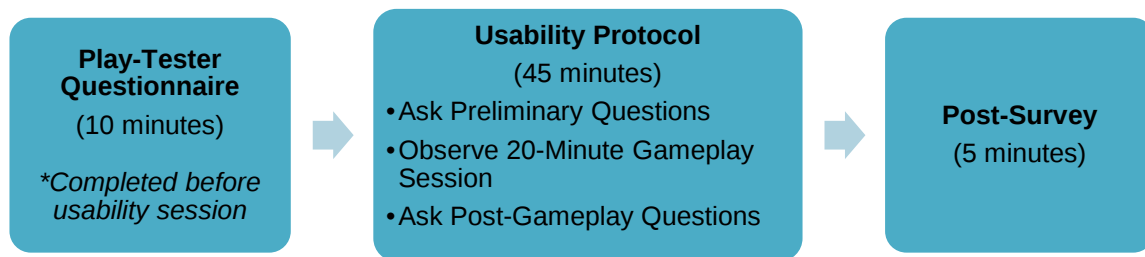
survey. Using a 5-point scale (1 = strongly disagree, 5 = strongly agree), participants rated the learnability of the game's interfaces and objectives for fourth graders based on their knowledge of the target audience and their experiences with the game. They also rated the game's ability to provide a satisfying learning experience for fourth grade students. All 12 items in the post-survey were adapted from Phan et al.'s (2016) Game User Experience Satisfaction Scale (GUESS). GUESS is a validated instrument containing 55 items that evaluate a chosen game's usability, entertainment value, sensory design choices, and other game elements. Survey items were derived from three subscales in the GUESS instrument: Usability/Playability, Enjoyment, and Personal Gratification. Items from the Usability/Playability subscale were used to assess the game's learnability while items from the Enjoyment and Personal Gratification subscales were intended to evaluate participant satisfaction. See Appendix G for a copy of the post-survey.

Participants

Monster Mealtime was created for fourth graders from Hawaii. However, because the game was only recently developed, elementary educators ($n = 12$) participated in this study. The researcher hoped that the teachers could identify critical areas of improvement within the game's design prior to actual implementation in a live classroom setting. Additionally, teachers have experience with providing instruction to children and leading health instruction. This enables them to provide critical feedback about the game's design in relation to the needs of elementary students. Thus, adults who are currently employed or were previously employed as elementary teachers in a Hawaii school were invited to participate in this study. Participants were not required to have teaching experience with fourth graders. However, participants were expected to know how to use a computer. Participants were recruited through email correspondence with the researcher. See Appendix H for a copy of the recruitment email and follow-up messages that were sent to potential participants.

Procedures

The researcher conducted three rounds of usability tests that occurred two weeks apart. Each round consisted of 3 – 5 one-to-one usability sessions. All sessions were conducted online through Zoom. Only one participant participated in each session, and each participant only participated in one usability session. Prior to implementation, the researcher completed training modules to prepare for the project's evaluation process. See Appendix I for the researcher's relevant certifications for conducting research. The first round of testing began after approval was obtained from the Institutional Review Board (IRB). Each usability session took approximately 50 minutes to complete. Participants were also required to answer the Play-Tester Questionnaire prior to their usability session; this likely took about 10 minutes to complete. Figure 2 summarizes the evaluation process that was followed for each usability session; it describes when each evaluation instrument was used, and the amount of time required to complete each instrument. The procedures for this study were carefully managed using checklists. See Appendix J for the usability checklists.

Figure 2*Procedure for Usability Sessions*

Preparation Procedures. After initial recruitment, an email containing a consent form was sent to each prospective participant. See Appendix K for a copy of the consent form. The consent form was sent through Google Forms for ease of completion and submission. Once consent was attained, the researcher emailed each participant to schedule a usability session. Participants selected three possible dates and times that were convenient for them based on the available session dates. If a participant was not available on the proposed dates, alternative dates and times were offered. The researcher followed-up with another email to confirm the participant's session date and time. About a week before the scheduled usability session, the researcher sent another email to the participant that provided instructions for installing *Monster Mealtime* and accessing Zoom. A URL link to the Play-Tester Questionnaire (Appendix E) was also included in this email. Afterwards, the researcher sent a follow-up email to reconfirm participants' appointments and remind them to complete the steps described in the previous email about one or two days before their scheduled usability session.

Conducting the Usability Session. On the day of the usability session, the researcher facilitated the session using the usability protocol (Appendix F). When the researcher completed her meeting preparations, she contacted the participant to begin the Zoom meeting. The researcher began recording the meeting through Zoom with the participant's consent. During the session, the researcher communicated with the participant using the facilitator script in the usability protocol. She also interviewed the participant and observed the participant as they played the game. After the participant played the game for 20 minutes, the researcher interviewed the participant about the game experience using the questions listed in the protocol. Observational notes and interview responses were documented using a set of Usability Data Collection Sheets. See Appendix L for a copy of these sheets. When the participant responded to the final question, the researcher stopped recording the meeting and concluded the usability session. She also sent the participant the post-survey (Appendix G) to complete as the final task in the usability session. Once the participant logged out of the meeting, the researcher ended the Zoom meeting to check if the recording was properly saved.

Data Analysis

To answer this project's research questions, participants' perceptions of the game's learnability and their satisfaction with the game were evaluated. First, ratings for each measure were derived from participants' post-survey responses. Two categories of

learnability were examined through these ratings: the learnability of structural components, like the game's controls and menu navigability, and the learnability of in-game objectives. Similarly, two categories of satisfaction were explored: satisfaction with gameplay and satisfaction with outcomes. The mean response of each post-survey item was determined. Then, each rating was calculated by taking the average score of three specific items from the survey. An average rating of 5.00 was the best possible score.

Once the ratings were obtained, the researcher analyzed the qualitative data collected through the usability protocol. First, the play-testing portion of each recorded session was reviewed. Participant comments were transcribed, and their in-game actions were noted. Then, the actions and comments were coded into three game design dimensions: the game's educational content, game mechanics, and visual design. Actions and comments were also classified as positive or negative. Positive codes represented data that indicated favorable perceptions while negative codes represented usability problems and other factors that were detrimental to the game's design. Next, the researcher determined the frequency of each comment or action between the participants in each round. Negative comments and actions were categorized as usability problems if two or more participants from the same round of testing demonstrated them. However, if a problem severely impacted the functionality of the game, it was categorized as a usability problem regardless of the number of participants who experienced it. The frequency was also used to determine the severity of each usability problem. A higher frequency represented a critical problem. Similar approaches were used for the participants' interview responses. All responses were transcribed from the interview portions of the session recordings. Responses were coded into game characteristics discussed during the interview. Then, the frequency of each response was documented.

Results

Participants in this study were 12 adults with elementary teaching experience. Three of these participants (25%) participated in the first round of testing, four participated in the second round (33%), and the remaining five participants took part in the third round (42%). Nine participants (75%) were currently employed as elementary teachers and three (25%) were no longer teaching. About 67% of the participants (8 participants) worked as teachers for no more than 10 years. The remaining 33% of the participants (4 participants) worked as elementary teachers for more than 10 years. Half of the participants (6 participants) were actively teaching early elementary students at the time of the study. However, about 67% of participants (8 participants) reported that they had taught upper elementary students in the past. Overall, the participants reported using technology to support instruction frequently, but they were less likely to use educational computer games in the classroom. Additionally, around 67% of the participants (8 participants) reported that they do not play video games frequently during their personal time. See Appendix M for a more detailed record of the participants' demographic information based on their responses to the Play-Tester Questionnaire.

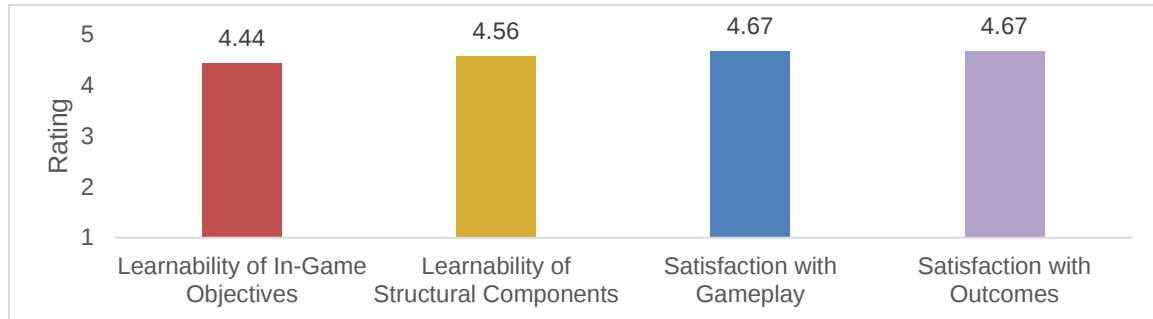
Usability Problems in Round 1

The learnability and satisfaction ratings derived from Round 1 were somewhat high. Figure 3 displays the ratings obtained from Round 1. All learnability and satisfaction

categories received at least a rating of 4.00. However, the learnability ratings scored slightly lower than the satisfaction ratings. The learnability of in-game objectives received the lowest rating of 4.44 ($SD = 0.88$). The satisfaction ratings received the highest rating for all categories. The satisfaction with gameplay received a 4.67 ($SD = 0.50$), and the satisfaction with outcomes also received a 4.67 ($SD = 0.50$).

Figure 3

Average Learnability and Satisfaction Ratings for Round 1 ($n = 3$)



Note: Likert-scale rating anchored by strongly disagree (1) and strongly agree (5)

Most of the usability problems identified in the first round of testing reflected misconceptions about *Monster Mealtime*'s game mechanics. The most severe misconception was the belief that the game's required goals could be achieved through the player's *performance* in the activity stage as opposed to feeding Morsel a balanced intake of nutrients. For example, all three participants thought they were required to catch the specified number of objects by the end of the activity stage to meet one of the required goals. Similarly, some participants thought they needed to find and collect the rare object during the activity stage to meet one of the bonus goals. Another major problem was created by the game's audio settings. During their interviews, participants expressed concern that the music was too loud. The sound volume also created testing disruptions because participants struggled to hear the researcher. Other minor problems were caused by the game's visual design. A few participants misinterpreted their fat crystal amount due to the symbols used to represent them. Some participants also did not notice the feedback that was displayed on the results screen. To review a detailed record of the usability problems identified in Round 1, please see Table N1 in Appendix N.

Since the learnability ratings were lower than the satisfaction ratings, revisions made after the first round of testing targeted learnability-based problems. Most of these revisions were intended to clarify information about the game's mechanics. More text was added to the tutorials to emphasize the idea that Morsel travels, collects objects, and searches for the rare object before the player begins the activity. Figure O1 in Appendix O shows this change. Additionally, a Settings button was added to the title screen of *Monster Mealtime* to allow players to adjust the game's volume. Please see Figure O2 in Appendix O to see how this revision appeared in the game. The default sound volume was also reduced. In addition, minor changes were made to the game's visual design as well. The symbol used to represent the amount of fat crystals was changed to "X" for

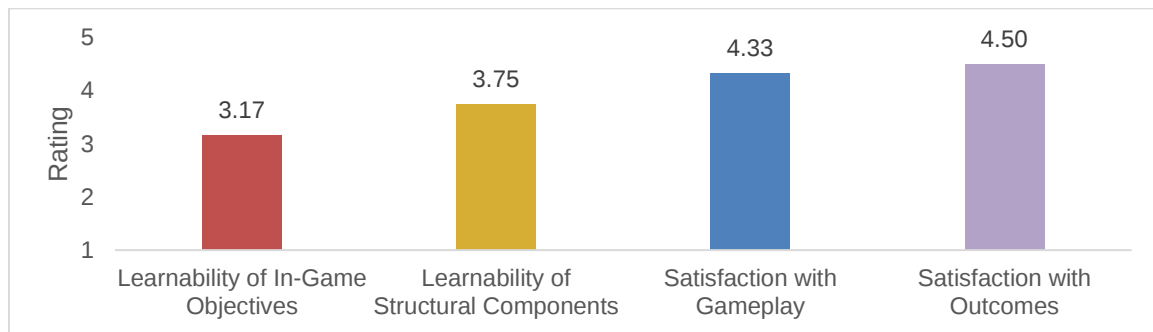
clarity. Figure O1 in Appendix O also shows this revision. Furthermore, the feedback section of the results was highlighted by a white rectangle to encourage players to read the feedback. Figure O3 in Appendix O illustrates this change. Finally, a critical error that caused the game to crash was corrected by ensuring that certain buttons were disabled when the meal selection screen is open.

Usability Problems in Round 2

Figure 4 depicts the learnability and satisfaction ratings that were earned after revisions were made to the game. For Round 2, all categories maintained a minimum rating of 3.00. The learnability ratings were lower than the satisfaction ratings. The lowest rating was 3.17 ($SD = 1.03$); the learnability of in-game objectives received this rating. In contrast, the highest score was 4.50 ($SD = 0.52$). This score was received for satisfaction with game outcomes.

Figure 4

Average Learnability and Satisfaction Ratings for Round 2 ($n = 4$)



Note: Likert-scale rating anchored by strongly disagree (1) and strongly agree (5)

Usability problems related to game mechanics were the most prevalent in Round 2. Three out of four participants (75%) were unsure how to meet the game's required goals while two participants (50%) misunderstood how to achieve the rare object collection goal. Additionally, some participants did not realize that movement penalties applied during the activity stage were due to an overconsumption of sugar. One participant perceived the decreased movement speed as the default movement speed while another participant thought they fed Morsel too many fats. Notably, several usability problems identified in Round 2 were related to the game's tutorials. Multiple participants felt that most students would not read the tutorial carefully. Participants believed that students who are not proficient readers would struggle to read the tutorial while others would simply not pay attention to the instructions. In addition, when instructions were gradually communicated through a few sentences at a time, participants tended to examine or interact with other areas of the screen before all instructions were displayed. The tutorial's visual design also created problems. For example, participants struggled to locate buttons during the tutorial sequence. Furthermore, participants seemed to experience difficulties with remembering instructions from the game. To see a more detailed record of the usability problems identified during Round 2, please see Table N2 in Appendix N. It should be noted, however, that technical difficulties were experienced during one of the four sessions.

Thus, some of the data from this session may not have been recorded due to audio problems and delayed screen projection.

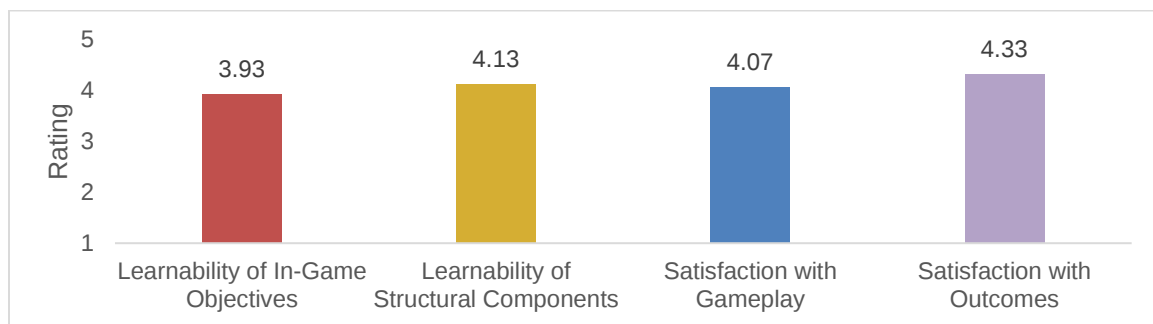
Because the learnability ratings failed to improve from Round 1 to Round 2, and several new problems were noted with the game's tutorials, revisions primarily focused on improving the game's tutorials. The preparation tutorial was split into two parts: a generalized tutorial that explains how to play the preparation stage and a navigation tutorial that familiarizes the player with the game's menus. This division was intended to help users focus on key information before attempting to complete the tasks within the preparation stage. It was decided that presenting the information in this format may also clarify how to achieve in-game goals. Visual supports were added to all tutorials to help students who might struggle with reading the tutorial text. The generalized tutorials included screenshots of the game with annotations emphasizing key information. Please see Figure O4 in Appendix O to see a sample generalized tutorial. Animated arrows were also added to both tutorials to indicate which buttons should be pressed, and button colors were brightened to further support navigability. Furthermore, the amount of text used for each tutorial was reduced. Figure O5 in Appendix O depicts an example of these tutorial revisions. Other revisions were made to provide reminders for essential information. Help buttons were added to the preparation stage and the activity stage. These allowed players to review the generalized tutorials for both stages. To remind the player of each menu button's function, hover text was also added. Additionally, the colors used in the nutrient counter were changed to create a visual reminder of the nutrients' functions. This can also be seen in Figure O5 in Appendix O.

Usability Problems in Round 3

Figure 5 represents the learnability and satisfaction ratings earned after the second set of revisions were applied. Almost all categories received a minimum rating of 4.00 for Round 3's iteration. The learnability of in-game objectives received the lowest score of 3.93 ($SD = 0.70$) while the highest score was earned for the game's satisfaction with outcomes. This category received a rating of 4.33 ($SD = 0.62$). The learnability of structural components outperformed the satisfaction with gameplay category by 0.06 points.

Figure 5

Average Learnability and Satisfaction Ratings for Round 3 ($n = 5$)



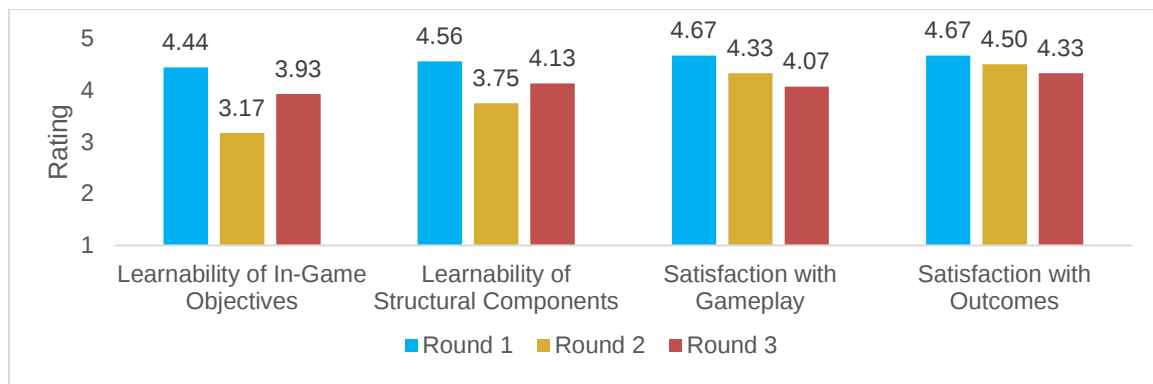
Note: Likert-scale rating anchored by strongly disagree (1) and strongly agree (5)

For Round 3, most of the usability problems were related to the game mechanics of *Monster Mealtime*. Four out of five participants (80%) believed that the required goals were achieved by performing well during the activity stage. Some participants also misunderstood how to achieve the rare object collection goal. Most participants also believed that the Stronger Legs upgrade would allow the main character to move faster during the activity; however, it is the consumed nutrients that affect Morsel's movement speed. Participants who received a movement penalty due to nutrient imbalances also could not determine the cause of the penalty. Other problems were related to the tutorials used in the game. Three out of five participants (60%) felt that the explanations provided for nutrient functions in the game were overwhelming. Additionally, three out of five participants (60%) stated that they had forgotten the nutrients' functions shortly after the tutorial was completed. Furthermore, minor usability problems were associated with the visual design of the tutorial. For example, participants examined the screenshot before reading the instructions shown below the screenshot. Some of the participants attempted to click on the screenshot as if it were the main screen of the game. Additionally, some participants thought that the text in the screenshot was difficult to read. Lastly, multiple participants expressed a desire for more rewards within the game after playing the game. For a detailed record of the usability problems found during Round 3, please see Table N3 of Appendix N.

Since no other usability sessions were scheduled, the researcher selected minor revisions to carry out immediately in response to the problems identified in Round 3. Based on the data, further refinements for communicating the game's mechanics were necessary. The generalized tutorial screens were reformatted. These revisions can be seen in Figure O6 of Appendix O. A header titled "How to Play" was added to the screen, and the instructions were shifted upward to encourage players to read the instructions before viewing the supporting image. Additionally, the food selection screen was revised to include a reminder regarding the function of each nutrient. Furthermore, to help players differentiate their activity from Morsel's activity, the player's collected items for each round was added to the results screen. Finally, since *Monster Mealtime*'s satisfaction with gameplay rating decreased, efforts toward adding more rewards and celebratory effects began. The rare object was set to appear next to Morsel at the end of the day if the player selected a balanced combination of nutritious meals. Please see Figure O7 and Figure O8 in Appendix O to see these revisions within the game.

Trends in Data Over Time

Over time, *Monster Mealtime*'s learnability and satisfaction ratings decreased. Ratings for all rounds of usability testing can be found in Figure 6. The game's satisfaction with outcomes consistently received the highest rating across all rounds of usability testing. Yet, the learnability of in-game objectives received the lowest rating for all three rounds. Additionally, the learnability and satisfaction ratings changed at different rates between usability rounds. Both satisfaction ratings slowly decreased from Round 1 to Round 3. In contrast, the learnability ratings experienced a more pronounced decrease between Round 1 and Round 2, then increased in Round 3. However, this increase did not allow the ratings to surpass the scores received in Round 1.

Figure 6*Average Learnability and Satisfaction Ratings by Round (n = 12)*

Note: Likert-scale rating anchored by strongly disagree (1) and strongly agree (5)

The most severe usability problems that persisted throughout all rounds of usability testing were related to the learnability of in-game objectives. Misconceptions about game mechanics remained prominent throughout the evaluation process. In each round, at least three participants expressed comments indicating misunderstandings or uncertainty about achieving required goals. There were also participants who believed that they were required to collect the rare object during the activity stage of the game in every round of usability testing. Other misunderstandings noted across multiple rounds included being unaware of the cause for nutrient-based movement penalties and experiencing confusion about using fat crystals during the activity stage.

Discussion

The purpose of this project was to create a game-based instructional resource that supports teachers in providing quality health instruction to fourth grade students. To accomplish this, the game must be satisfying and learnable for students. Based on the data collected during three rounds of usability testing, fourth graders will generally be satisfied with the learning experience provided by *Monster Mealtime*. Despite gradual decreases in the evaluation ratings, both satisfaction categories maintained a rating of at least 4.00 out of 5.00 throughout the usability study. Additionally, during their interviews, participants identified a variety of game characteristics that may contribute to fourth graders' satisfaction. One participant said, "The fact that each level added a slightly different challenge I think was initially exciting and...I think that would drive [the students] forward to see what happens next." This suggests that the variety of goals and activities used in each in-game day may support students' satisfaction. Another participant believed that students would enjoy the activity stage, stating that students would, "...get really competitive where they want to get as many insects as possible." Other commonly identified factors included the integration of in-game goals and the use of familiar foods. Some of the characteristics perceived as beneficial aligned with findings from previous research regarding game characteristics that facilitate student engagement. When examining the relationship between student engagement with games and game characteristics, Martinovic et al. (2016) discovered that students prefer games

that integrate tasks involving interactive visuals and hand-eye coordination. This type of gameplay can be found in the activity stage where the player must move the main character to catch moving objects. Goals that are set to an appropriate difficulty level also facilitated student engagement (Martinovic et al., 2016); therefore, the incorporation of the main character's daily goals may support students' satisfaction.

Unfortunately, the data indicated that the game's design was less successful in supporting the learnability of in-game tasks. The rating for the learnability of in-game objectives remained below 4.00 by the end of the usability study. Furthermore, misconceptions about *Monster Mealtime*'s game mechanics were evident in the participants' responses to the game. Based on the data, it seems the game's tutorials may be a contributing factor to the game's poor learnability ratings. Since the tutorials' instructions were predominantly delivered through on-screen text, several participants were concerned that students would not benefit from the tutorials as expected. The instructions may not align with students' reading proficiency or capture their attention, reducing the game's overall learnability. Some participants expressed that video-based modeling should be added to provide better access to the instructions. However, Fisher (2015) noted that audiovisual tutorials do not require student interaction, so they may not maintain students' attention. Additionally, a tutorial should not rely on spoken instructions because they require a sufficient volume level to be delivered and students may mute a game's audio (Fisher, 2015). Thus, further research regarding effective strategies for communicating game instructions to children is needed. Since text-based instructions may be ineffective, alternative methods for providing instructions to children must be explored to improve the learnability of *Monster Mealtime* and other educational video games for elementary students. For example, since highly visual tutorials are thought to be effective for supporting the learnability of children's games (Fisher, 2015), perhaps the use of graphic-dependent tutorials in *Monster Mealtime* should be examined next.

Interestingly, participants seemed to have different beliefs about the level of prior knowledge required to play the game. Most participants believed that students should possess a strong understanding of nutrition concepts to engage appropriately with the game. This was an unexpected reaction since the game was designed to allow for student-led explorations of nutrients. One participant explained, "...I think it's very important to talk to them about the nutrients, like what's really important, before playing the game so then that way, they have some kind of knowledge and maybe not feel overwhelmed." This seems to imply that a lack of prior knowledge would decrease the learnability of the game for fourth graders, and by extension, reduce students' satisfaction with the game. However, other participants felt that students could still learn from the game despite a lack of proficiency with nutrition concepts. For example, another participant said, "I think that the kids need to struggle a little bit for this game for them to realize like, 'Oh, I did use too much fat. Okay, now that means I kind of need to...balance each [nutrient].'" In this sense, this participant appeared to believe that students would learn how to play the game through the experience itself, so the game could still be learnable even if students are not fully proficient in foundational nutrition knowledge. Thus, these variations in beliefs about required levels of prior knowledge may have impacted the perceived learnability and satisfaction of *Monster Mealtime*. Conducting further research

may be beneficial to determine elementary teachers' expectations and preferences for utilizing educational video games for teaching. If these expectations are better understood, learnability scaffolds within educational video games can be designed to meet the needs of teachers' classrooms more aptly. This may also impact how teachers choose to integrate these games in their instruction.

The remaining learnability and satisfaction problems in *Monster Mealtime* can be addressed through future updates. These updates would require more time to finish, so they were reserved for larger revision sessions that could be made once the study was completed. To reduce the game's reliance on text-based information, more visuals must be created and added to the game to improve its learnability. For example, the tutorial should be restructured so that it is more interactive and visual. Additionally, to help clarify misconceptions about how goals are achieved, an animation should be created to show Morsel's actions that occur prior to the beginning of the activity stage. To improve satisfaction, game mechanics could be changed to incorporate new reward opportunities and more engaging gameplay. For example, the activity stages could be redesigned as "platformer" stages where students could move forward in an area to collect the specified objects. Other sensory-based reward cues such as celebratory music or special animations could be added to reward players for meeting all goals for a given day. Furthermore, to provide more rewards, the achievement of the rare object collection goal could be linked to unlocking unique skills for the player to purchase in subsequent rounds of play.

Conclusion

Monster Mealtime was designed and developed to provide supplemental instruction in nutrition concepts for elementary students. By creating this resource, the researcher intended to support schools in improving the quality of health education and students' well-being. At this time, however, the game requires further development and refinement before it can fully achieve this goal. While the game's design may provide a satisfying learning experience for fourth grade students, it may need further improvements to adequately assist them in learning how to play the game. Other means for communicating the game's instructions must be applied and tested prior to exploring students' interactions with the game. This realization could not have occurred without implementing a usability study and instructional design procedures. Thus, even though the learning that occurs in game-based learning appears dissimilar with traditional classroom instruction, instructional design practices are still relevant and essential in ensuring that the intended learning outcomes are achieved. Otherwise, game-based instruction merely becomes educational candy; it could be delightful and attractive, but it will not nourish the mind.

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Appendix A
Game Objectives and Learning Objectives

Table A1*Learning Objectives*

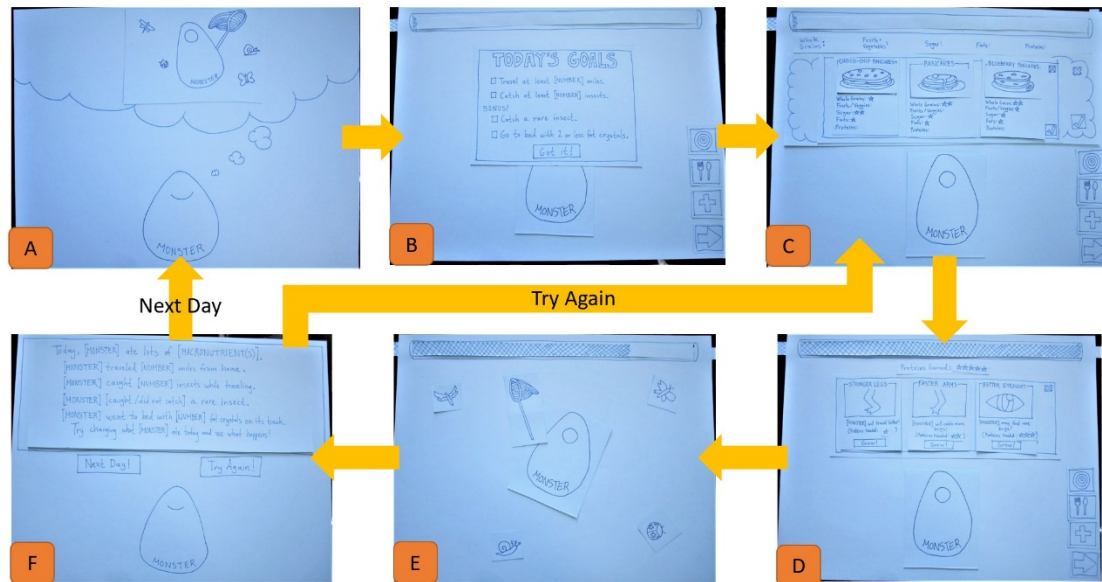
#	Behavior	Objective
1	Distinguish unrefined carbohydrates from refined carbohydrates	Students will be able to distinguish whole-grains and fiber from other carbohydrates
2	Identify the function of carbohydrates	Students will be able to recognize the function of carbohydrates as energy for the body
3	Identify the function of fats	Students will be able to recognize the function of fats as energy storage for the body
4	Identify the function of proteins	Students will be able to recognize the function of proteins as growth materials for the body
5	Identify foods containing unrefined carbohydrates	Given three food items, students will be able to identify the food that contains whole-grains or fiber
6	Identify foods containing fats	Given three food items, students will be able to identify the food that contains fat
7	Identify foods containing proteins	Given three food items, students will be able to identify the food that contains protein
8	Apply nutrition concepts to make healthy eating choices	Students will be able to apply their knowledge of nutrient functions and nutritious food sources to make decisions about food consumption
9	Analyze the impact of consumed nutrients on the body's health	Given a scenario where various proportions of nutrients are consumed, students will be able to analyze the nutrients' influence on the body's health
10	Choose nutrient-rich foods for consumption	Given multiple food choices, students will be able to choose the healthiest food to eat

Table A2*Clustering of Learning Objectives by Game Objectives*

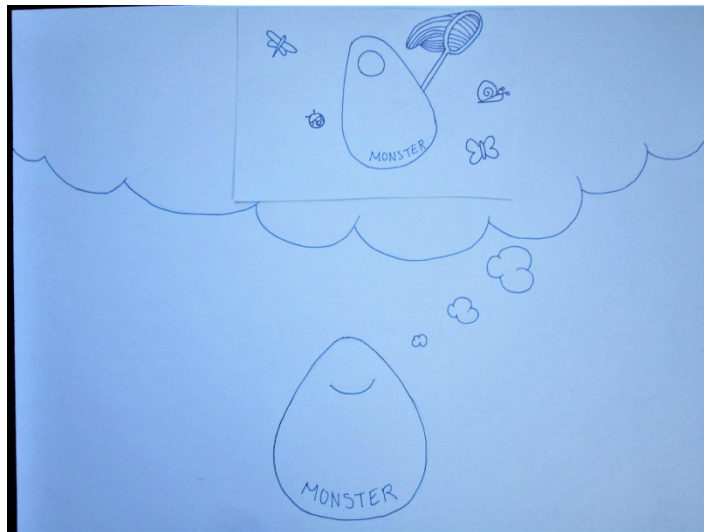
#	Game Objective	Relevant Learning Objective
1	Plan Morsel's meals to provide a balanced intake of macronutrients	8. Students will be able to apply their knowledge of nutrient functions and nutritious food sources to make decisions about food consumption
2	Collect unrefined carbohydrates, fats, and proteins by consuming foods that contain them	5. Given three food items, students will be able to identify the food that contains whole-grains or fiber 6. Given three food items, students will be able to identify the food that contains fat 7. Given three food items, students will be able to identify the food that contains protein
3	Collect more unrefined carbohydrates than refined carbohydrates to evade a sudden loss of energy	1. Students will be able to distinguish whole-grains and fiber from other carbohydrates
4	Acquire adequate carbohydrates to endure Morsel's desired activity	2. Students will be able to recognize the function of carbohydrates as energy for the body 8. Students will be able to apply their knowledge of nutrient functions and nutritious food sources to make decisions about food consumption 10. Given multiple food choices, students will be able to choose the healthiest food to eat
5	Acquire adequate fats to exploit as backup energy when Morsel consumes too few carbohydrates	3. Students will be able to recognize the function of fats as energy storage for the body 8. Students will be able to apply their knowledge of nutrient functions and nutritious food sources to make decisions about food consumption 10. Given multiple food choices, students will be able to choose the healthiest food to eat

6	Acquire adequate proteins to exploit as physical skill upgrades for Morsel	4. Students will be able to recognize the function of proteins as growth materials for the body 8. Students will be able to apply their knowledge of nutrient functions and nutritious food sources to make decisions about food consumption 10. Given multiple food choices, students will be able to choose the healthiest food to eat
7	Compare the results of Morsel's activity after eating various meal combinations	9. Given a scenario where various proportions of nutrients are consumed, students will be able to analyze the nutrients' influence on the body's health

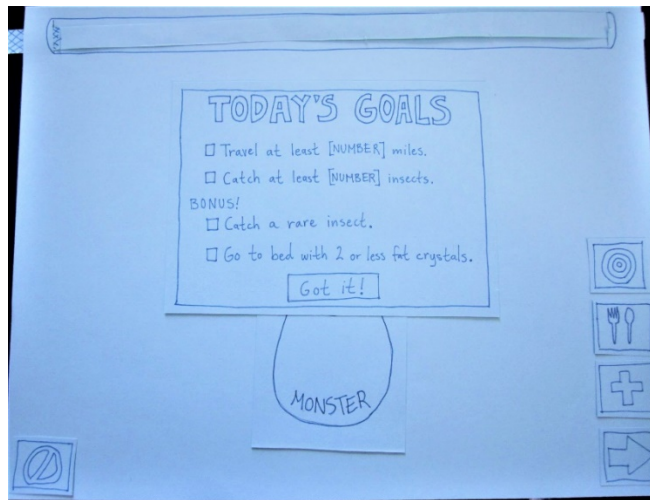
Appendix B Paper Prototype Documents

Figure B1*Gameplay Flow*

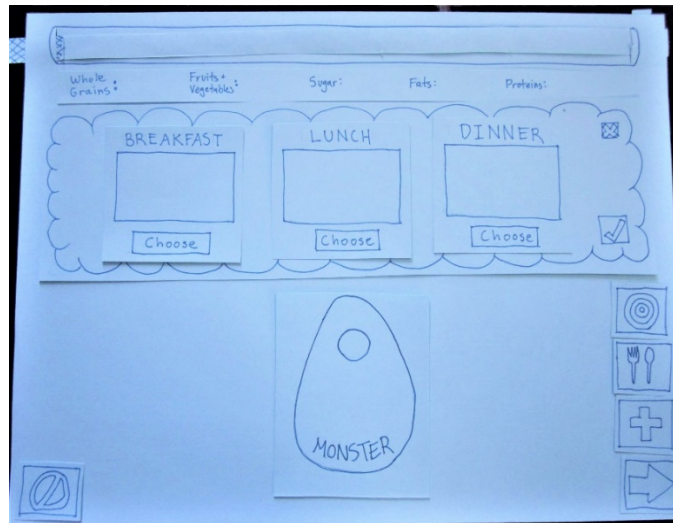
Note. As shown in Frame A of Figure B1, Morsel, played by the student, begins to dream about a fun activity. The activity in the dream is different each day. This tells the player what Morsel wants to do the following day. When Morsel awakes in Frame B, the goals for the day are displayed. Then, the player begins the preparation stage. In this stage, the player chooses Morsel's meals to fill the energy meter and develop fat crystals (Frame C). The player may also spend proteins (Frame D) to develop physical skills that help Morsel meet its goals. When preparations are complete, Morsel begins the activity that it wants to do (Frame E). The energy meter slowly drains over time, but the player can dissolve fat crystals to refill the meter and continue the activity for a short time. When the energy meter becomes empty and cannot be refilled with crystals, Morsel falls asleep. As shown in Frame F, Morsel's activity is summarized while it sleeps. If the required goals are met, players can proceed to a new day or retry the same day using different meal combinations and upgrades. Players who did not meet Morsel's required daily goals need to retry the day until they meet those goals.

Figure B2*Dream Scene*

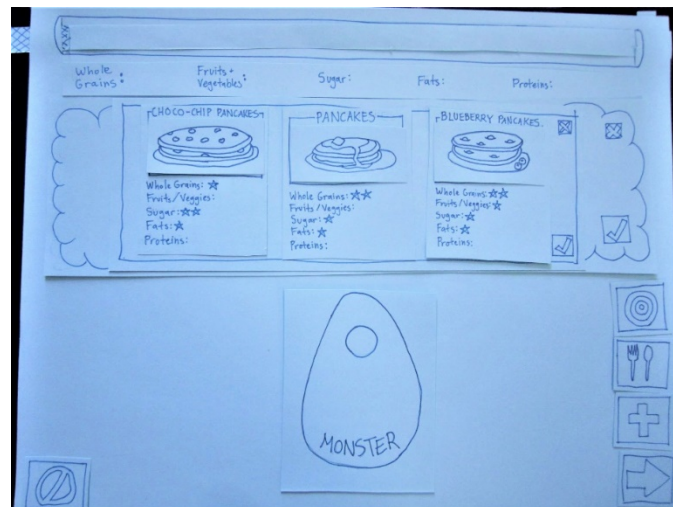
Note. The dream scene is where players are shown the premise for the day's activities.

Figure B3*Goals Scene*

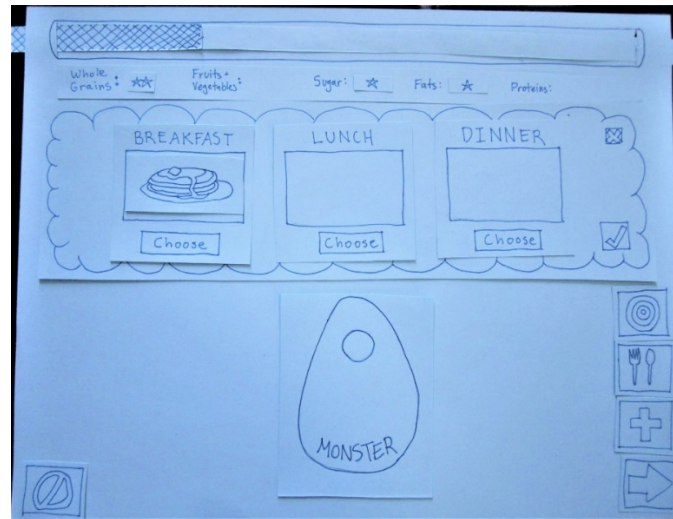
Note. The goals scene outlines the player's required objectives and optional objectives. The goals can be accessed later by clicking on the target button on the right side of the screen.

Figure B4*Meal Menu*

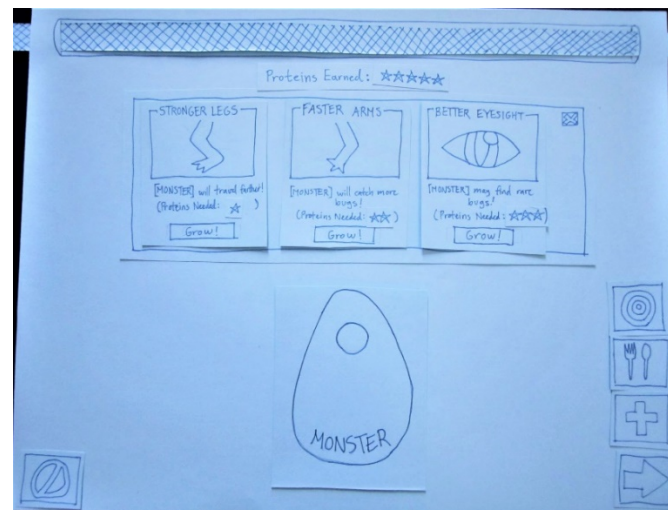
Note. The meal menu is accessed by clicking on the fork and knife button.

Figure B5*Meal Selection Scene*

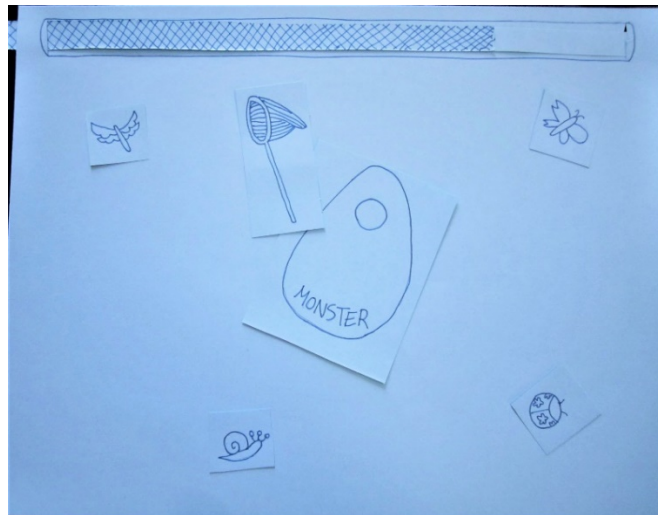
Note. This scene is accessed when the choose button on the meal menu (Figure B4) is clicked. The player can view meal options and choose one to feed Morsel.

Figure B6*Updated Meal Menu after Meal Selection*

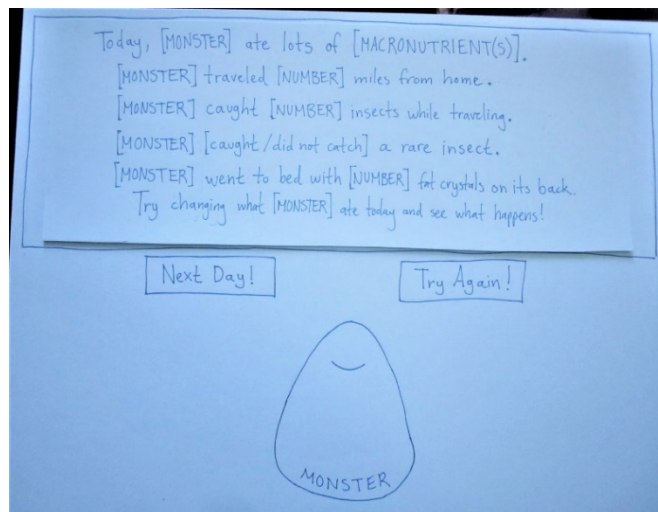
Note. The meal menu updates to reflect the player's choice from the meal selection scene (Figure B5). The stamina bar and macronutrient amounts are also updated.

Figure B7*Protein Upgrade Menu*

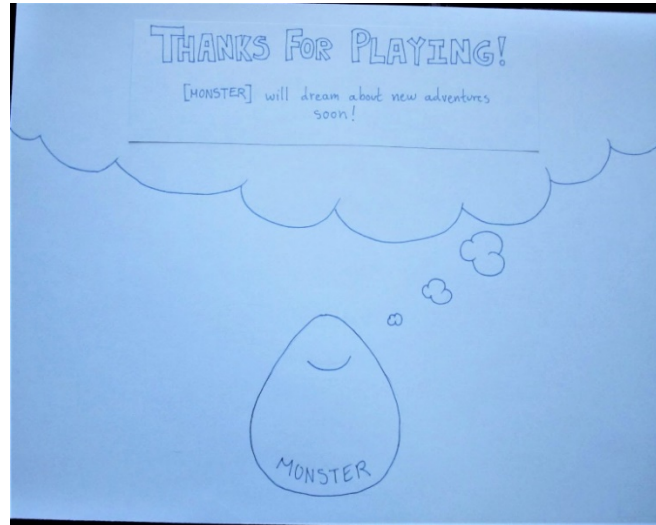
Note. This menu is accessed by clicking on the plus button. Players can choose an upgrade after consuming proteins. Only one upgrade can be applied per day.

Figure B8*Action Scene*

Note. The action scene begins when the player presses the arrow button shown in the previous screen (Figure B7). The player can move Morsel and collect items using keyboard buttons, but their performance will not be counted toward the total number of objects reported in the subsequent summary scene. Thus, player's performance during this scene will not be evaluated or rewarded. The stamina bar will slowly decrease over time. The scene ends when the stamina bar is completely empty and insufficient fat crystals are available to restore stamina.

Figure B9*Summary Scene*

Note. This scene begins when the action scene (Figure B8) ends. While Morsel sleeps, feedback is displayed by summarizing the achievement of required and optional goals. The try again button allows players to replay the day using different meal combinations. By clicking on the next day button, the player restarts the gameplay cycle with a new activity and new goals. This button is disabled if the required goals are not met.

Figure B10*End Scene*

Note. This ending scene is accessed when the fifth day is completed. This is a temporary ending that will only be used for this iteration of the game.

Appendix C
Screenshots of Wireframes in Godot

Figure C1

Goals Screen Wireframe

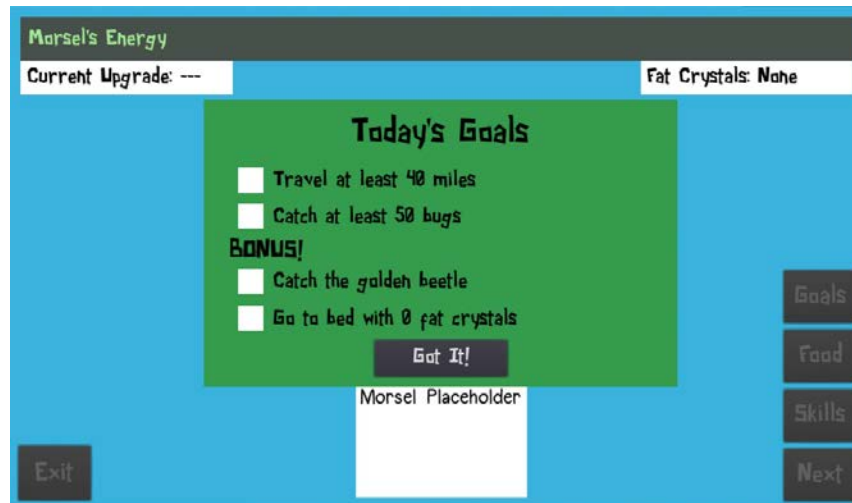


Figure C2

Wireframe for Meal Selection



Figure C3

Wireframe for Meal Menu

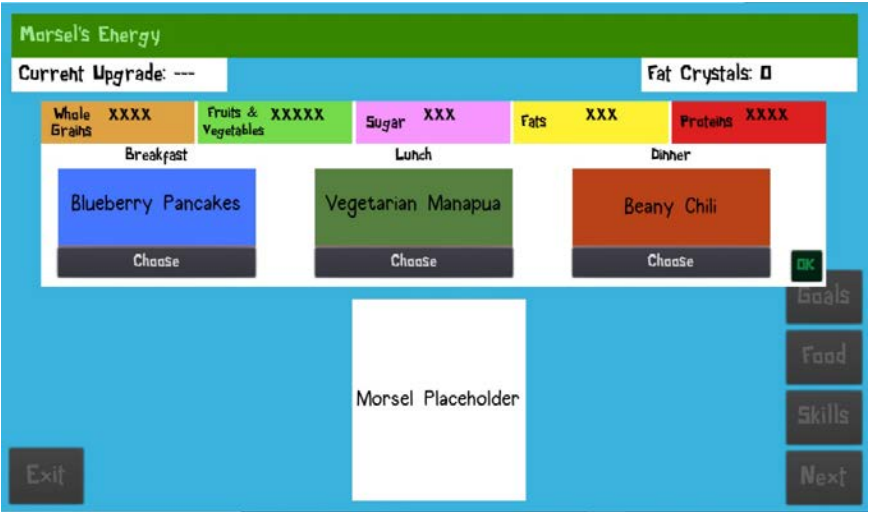


Figure C4

Wireframe for Protein Upgrade

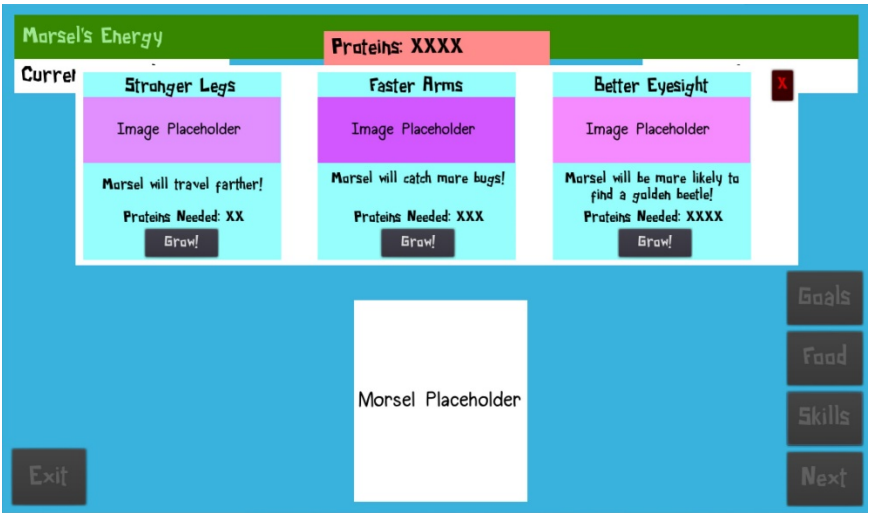
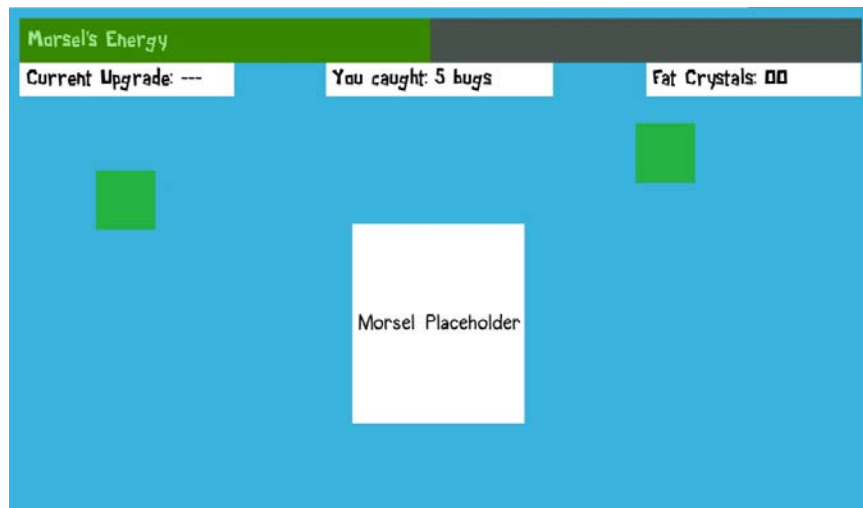
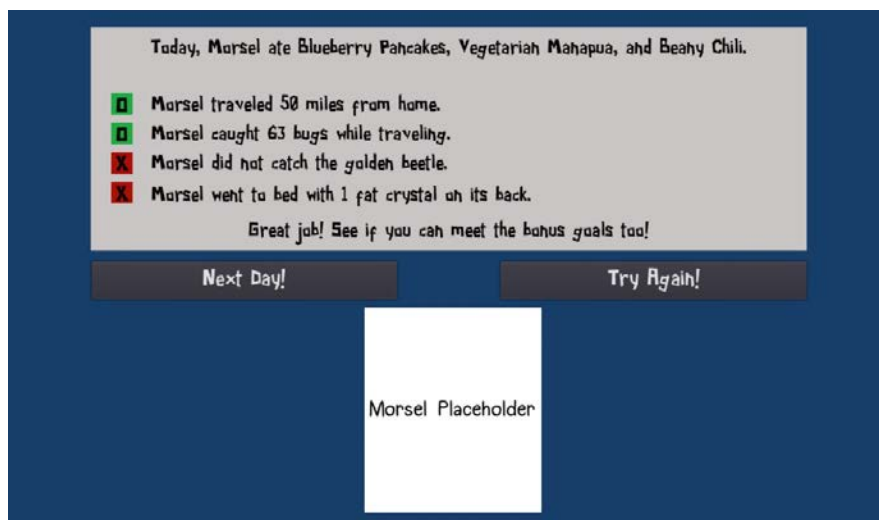
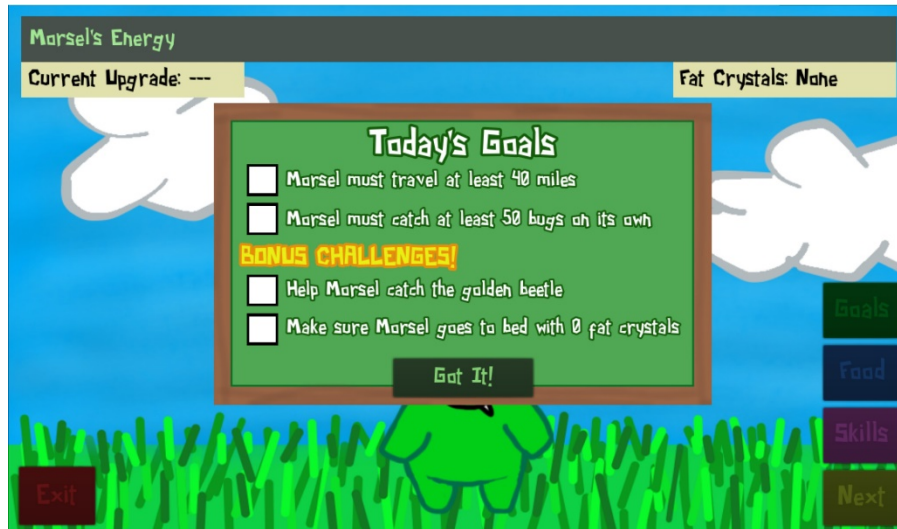


Figure C5*Wireframe for Activity Stage***Figure C6***Wireframe for Results Screen*

Appendix D
Screenshots of the Original *Monster Mealtime* Prototype

Figure D1*Goals Screen*

Note. The goals screen was highly influenced by the original goals scene (Figure B3) in the paper prototypes. The required goals are stated at the top, followed by optional challenges.

Figure D2*Game Menu for Food Selection*

Note. The alignment for each meal's nutrient values was adjusted slightly. The information was organized into two separate columns to improve readability.

Figure D3*Game Menu for Selected Meals and Nutrients*

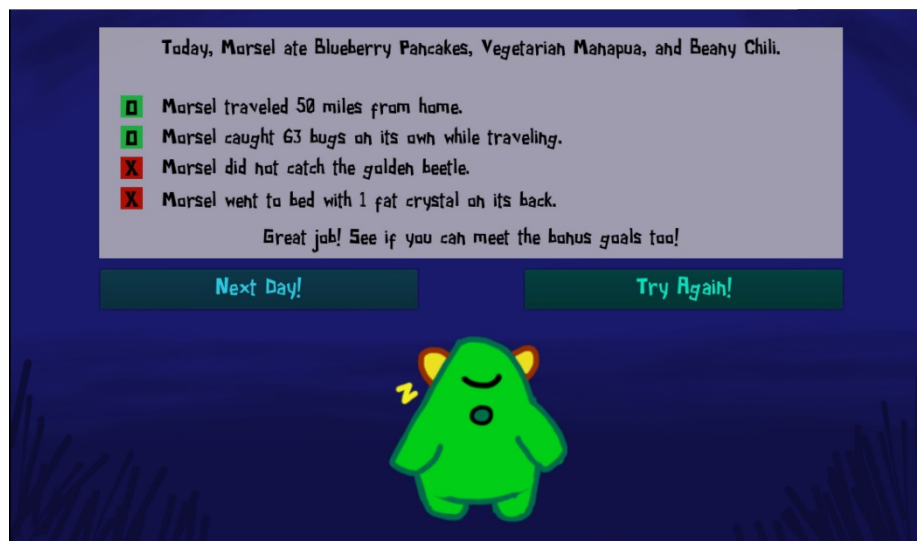
Note. This menu updates to show the player's selected meals when players choose a meal from the previous screen (Figure D2). The total nutrient amounts derived from the three meals are displayed above the meals. At the top of the screen, Marsel's energy bar and the number of fat crystals update to match these nutrient amounts. Each square in the fat crystals tab represents one crystal.

Figure D4*Game Menu for Selecting Protein Upgrades*

Note. The images for each skill upgrade were updated to match the main character's appearance.

Figure D5*Activity Screen*

Note. The background scenery and objects for the activity screen change to match the day's activity. Additionally, the selected upgrade, fat crystal amount, and the player's score are displayed at the top of the screen.

Figure D6*Daily Results Screen*

Note. The results are dependent on the meals selected at the beginning of each day. As a result, this screen reminds the player what they fed Morsel in addition to reporting the day's outcomes. This screen also provides feedback and hints to guide the player in making healthier meal choices when the meals do not provide a balanced combination of nutrients.

Appendix E Play-Tester Questionnaire

Figure E1

Play-Tester Questionnaire – Section 1: General Teaching Experience



Play-Tester Questionnaire

Thank you for agreeing to participate in this usability study! Before you begin playing the game, please fill out this questionnaire. This questionnaire will help me understand your experiences with teaching elementary education and educational computer games.

* Required

Section 1. General Teaching Experience

For each of the following questions, please select the response that BEST represents your teaching experience with elementary students.

1. How long have you worked as an elementary school teacher? *

- ☐ Less than 5 years
- ☐ 5 - 10 years
- ☐ 11 - 15 years
- ☐ 16 - 20 years
- ☐ More than 20 years

2. What grade level are you currently teaching? *

- ☐ Early elementary (Grades K - 3)
- ☐ Upper elementary (Grades 4 - 6)
- ☐ I am not teaching at this time.

3. What grade level(s) have you taught previously? *

- ☐ Early elementary (Grades K - 3)
- ☐ Upper elementary (Grades 4 - 6)
- ☐ Both early and upper elementary

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Figure E2*Play-Tester Questionnaire – Section 2: Technology and Me*

Play-Tester Questionnaire

* Required

Play-Tester Questionnaire

Section 2. Technology and Me

For each of the following questions, please select the response that BEST represents your experiences with educational technology.

1. How often have you integrated technology into your lessons? *

☐ Always

☐ Usually

☐ Sometimes

☐ Rarely

☐ Never

2. How often have you integrated educational computer games into your lessons? *

☐ Always

☐ Usually

☐ Sometimes

☐ Rarely

☐ Never

3. How often do you play video games or computer games in your personal time? *

☐ Always

☐ Usually

☐ Sometimes

☐ Rarely

☐ Never

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Figure E3*Play-Tester Questionnaire – Section 3: Beliefs about Educational Computer Games*

Play-Tester Questionnaire

* Required

Play-Tester Questionnaire

Section 3. Beliefs about Educational Computer Games

For question 1, please select the response that BEST represents your opinion. For each of the remaining questions, please write a response.

1. Computer games are valuable resources for teaching elementary students. *

1 2 3 4 5

Strongly Disagree ☐ ☐ ☐ ☐ ☐ Strongly Agree

2. In your opinion, what should a computer game do to help children understand how to play the game? *

Your answer _____

3. In your opinion, what qualities make a computer game enjoyable for children? *

Your answer _____

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Appendix F Usability Protocol

Adapted from procedures outlined in *Rocket Surgery Made Easy: The Do-It-Yourself Guide to Finding and Fixing Usability Problems* (Krug, 2010).

Preparing for the Session

1. Facilitator prepares his/her computer to facilitate sessions.
 - a. Attach charging cable to device to prevent sudden loss of power during recording.
 - b. Ensure that the computer is connected to a stable Internet source.
 - c. Disable notifications from other software to prevent interruption during session.
 - d. Gather URL links (i.e., Zoom meeting link and post-survey link) that must be sent to the participant during the session.
2. Log in to Zoom account and prepare for recording.
 - a. Test microphone and audio within Zoom. Adjust volume levels as needed.
 - b. Test the screen recording function in Zoom. Make sure audio and screen is recorded successfully.
3. Contact the participant to check if his/her computer is set up and *Monster Mealtime* is installed.

When participant confirms he/she is ready to begin:

4. Send the Zoom meeting link to the participant through email.
5. Remind the participant to turn off his/her webcam and change his/her name to a pseudonym if needed.
6. Ask the participant to test his/her microphone and audio. Help the participant adjust his/her audio if needed.
7. Ask the participant to practice sharing his/her screen. Help the participant share his/her screen if needed.
8. Ask the participant to open *Monster Mealtime* and share the title screen in Zoom. Help the participant access *Monster Mealtime* if needed.
9. **With consent to record screen and audio only:** Start the recording in Zoom when preparations are complete and the participant is ready to begin.

Facilitator Script

Welcome

Hello, [pseudonym]. My name is Bethany, and I am going to be walking you through this session today. Before we begin, I would like to share some information with you. I'm going to read it to make sure I cover everything.

First, I'd like to remind you why you are here. I'm working on an educational video game called *Monster Mealtime* to teach 4th graders about nutrition. I'd like you to try playing the game so that I can see if it works as intended. This usability session will take about 50 minutes to complete.

I want to make it very clear that I am testing the game, not you. You don't have to worry about making any mistakes.

As you play the game, please try to think out loud as much as possible. Tell me what you're looking at, what you're trying to do, and what you're thinking. This will be very helpful for me, especially because I won't be able to see anything besides your screen. Also, please don't worry about hurting my feelings. I am doing this to improve the game, so I need to hear your honest reactions.

If you have any questions during the session, just ask them. However, in some situations, I may not be able to answer your question because I am interested in how students will do when they don't have someone to help them nearby. If you still have questions after playing the game, I'll try to answer them at that time. Also, if you need to take a break at any time, just let me know.

If consent was given to record screen and audio: As a reminder, I will be recording your screen and your voice through Zoom. I will only use these recordings to improve the game, and it won't be seen by anyone except others who are involved with this project.

Do you have any questions so far?

Preliminary Questions

Okay! Before we begin playing the game, I'd like to ask you a few quick questions.

1. Do you prefer to teach early elementary students or upper elementary students?
2. How do you feel about using educational computer games in the classroom?
3. Do you consider yourself a gamer? If so, how much time do you feel you spend playing games per week?

Thank you for answering those questions. Now we can move on to the fun part: playing the game! Please open the game by double-clicking on the *Monster Mealtime* application file in your computer. Once you see the title screen, please share your screen with me through Zoom by clicking on "Share Screen" at the bottom of the Zoom meeting screen and selecting the game's window.

During Gameplay

Great! Now that we're on the title screen of *Monster Mealtime*, I'd like you to take a few minutes to tell me what you make of it. What stands out to you the most? Who do you think this game is for? What do you think the game is about? For now, please do not click on any buttons that you see. Just look around and share your thoughts.

Thank you for sharing your first impressions! Now, you're going to start playing the game. You will play the game for 20 minutes. I will let you know when 20 minutes has passed. Again, as much as possible, please remember to think aloud as you play. When you're ready to begin, press the button that says "New Game" to start the game.

If participant reaction warrants a response: Facilitator uses the following table to select an appropriate response to the participant.

Participant Action:	Responses:
The participant becomes quiet and you don't know what he/she is thinking.	"What are you thinking?" "What are you looking at?" "What are you doing right now?"
The participant verbally expresses their surprise when something happens in the game.	"Is that what you expected to happen?"
The participant asks for a hint when trying to play the game.	"What would you do if I wasn't here?" "I'd like you to try whatever you're thinking of doing."
The participant says a comment and you're not sure why they expressed it.	"Was there something in particular that made you think of that?"
The participant expresses concern about being unhelpful.	"No, this is very helpful." "This is exactly what I need."
The participant asks you to explain how something in the game works.	"How do you think it works?" "I can't answer that right now because I need to know what you would do when you don't have someone around to answer questions for you. But if you still want to know when we're done, I'll be happy to answer your question then."

After Gameplay

Alright, 20 minutes have passed. Thank you very much for playing the game! This was very helpful for me. You can stop sharing your screen now by pressing the "Stop Share" tab at the top of your screen. You may also close the game.

Now that you have played the game, I would like you to imagine how this game might be played by 4th graders. While imagining this, please answer the following questions.

1. What aspects of the game (e.g., menus, messages, etc.) do you think will be most helpful in teaching 4th graders how to play the game?

2. Based on your experience with the game, what parts of the game do you think 4th graders will struggle to complete?
3. What should be added to the game to help 4th graders understand how to play the game?
4. What do you think 4th graders will enjoy most about this game?
5. What do you think 4th graders will enjoy least about this game?
6. What should be added to the game to make it more satisfying for 4th grade students?
7. Do you have any other suggestions for improving this game?

Okay, thank you! That was the final question.

If consent was given to record screen and audio: I am going to stop the recording now.

Before we begin the final portion of this usability session, do you have any questions for me?

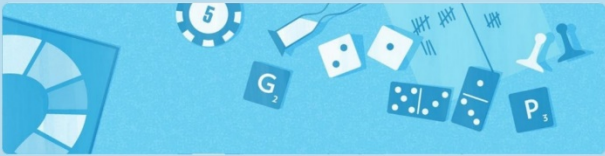
Great! Thank you very much for participating in this study. I am very grateful for your contributions. They will help *Monster Mealtime* become a worthwhile learning experience for students. To conclude this usability session, I would like you to complete a short survey. It should take no longer than five minutes to complete. This survey will also help me understand how to improve the game for 4th graders. I'd like you to complete the survey now because you have played the game recently. I will send you a link to the survey now through Zoom's chat window. Please let me know when you have successfully opened the survey.

Upon confirmation: Great! You may leave this Zoom meeting to complete the survey, or you may leave once you have finished it. Thank you again for participating!

Appendix G Post-Survey

Figure G1

Post-Survey – Section 1: Task Learnability



Post-Survey

Thank you very much for play-testing the game! Now, based on your play experience, I would like you to consider how this game would be played by 4th graders. By completing this survey, you will help me understand how I can make this game more engaging and enjoyable for 4th grade students!

This survey was adapted from Phan, Keebler, and Chaparro's (2016) Game User Experience Satisfaction Scale.

** Required*

Section 1. Task Learnability

Please rate each statement using the provided options. Select the rating that BEST represents your opinion of each statement.

1. 4th graders will find the controls of the game simple and easy to learn. *

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
My Response:	☐	☐	☐	☐	☐

2. 4th graders will find the game's menus to be user friendly. *

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
My Response:	☐	☐	☐	☐	☐

3. 4th graders will always know their next goal when they finish an event in the game. *

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
My Response:	☐	☐	☐	☐	☐

4. 4th graders will always know how to achieve their goals/objectives in the game. *

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
My Response:	☐	☐	☐	☐	☐

5. 4th graders will feel that the game provides them the necessary information to accomplish a goal within the game. *

Strongly Disagree Disagree Neutral Agree Strongly Agree

My Response: ☐ ☐ ☐ ☐ ☐

6. 4th graders will feel the information provided in the game (e.g. onscreen messages, help) is clear. *

Strongly Disagree Disagree Neutral Agree Strongly Agree

My Response: ☐ ☐ ☐ ☐ ☐

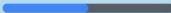
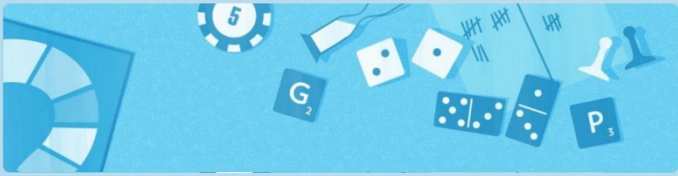
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Figure G2*Post-Survey – Section 2: Satisfaction*

Post-Survey

* Required

Post-Survey

Section 2. Satisfaction

Please rate each statement using the provided options. Select the rating that BEST represents your opinion of each statement.

1. 4th graders will enjoy playing the game. *

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
My Response:	☐	☐	☐	☐	☐

2. 4th graders will likely encourage their classmates to play this game. *

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
My Response:	☐	☐	☐	☐	☐

3. If given the chance, 4th graders will want to play this game again. *

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
My Response:	☐	☐	☐	☐	☐

4. 4th graders will feel successful when they overcome the obstacles in the game. *

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
My Response:	☐	☐	☐	☐	☐

5. 4th graders will want to do as well as possible during the game. *

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
My Response:	☐	☐	☐	☐	☐

6. 4th graders will feel the game motivates them to proceed further to the next stage or level. *

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
My Response:	☐	☐	☐	☐	☐

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Appendix H Recruitment and Follow-Up Email Messages

Recruitment Email

Hello [prospective participant's name],

This semester, I will be conducting a research project as part of the requirements for earning my master's degree. This project will focus on an educational computer game that teaches 4th graders about nutrition. I just finished making the game last semester, so I am looking for teachers who can help me improve it before it is used within the classroom. Since you have teaching experience with elementary students, I would like to invite you to participate in this study. If you participate, you will need to play the game and share feedback as you play. You will also need to complete two surveys. All these tasks will take place online, and it should take no more than an hour of your time.

Please respond to this email if you are interested in participating in my study. I will provide more detailed information through a consent form if you would like to participate.

Thank you!

Sincerely,
Bethany

Consent Form Email

Hello [prospective participant's name],

Thank you very much for responding to the previous email! I appreciate your willingness to help me develop this game. In this email, you will find a link to a digital consent form that tells you more about my study. Please read this form carefully. It will help you understand what this study is about, and it explains your rights as a participant. At the end of the form, you will be asked to provide consent for recording procedures that will happen during this study. Please select “Yes” or “No” for each procedure. Then, please sign the form by typing your first and last name in the signature space provided.

You can access the consent form [here](#). Once you press the “Submit” button, the form will automatically be returned to me. If you have provided consent, I will follow up with another email to schedule your meeting session with me.

Thank you again for your interest in participating in the study. I hope to work with you soon!

Sincerely,
Bethany

Scheduling Email

Hello [participant's name],

Thank you for providing consent to participate in this study. I am excited to work with you! Now, I would like to set up a meeting date and time with you to conduct the usability session. Currently, these appointment dates and times are available.

- [List the available dates and times]

Please select three of these appointment slots based on your preference. I will respond to your email to confirm your meeting day and time. If you are unavailable on these dates and times, please email me and I will let you know when the next set of appointments are available.

Thank you!

Sincerely,
Bethany

Scheduling Follow-Up Email

Hello [participant's name],

Thank you for your patience! Your usability session will take place on [date] at [time].

About a week before your session is scheduled to take place, I will send you an email with instructions on how to prepare for the usability session. Please look for this email as your appointment date gets closer.

I look forward to meeting with you on [date].

Sincerely,
Bethany

Meeting Preparations Email

Hello [participant's name],

Your usability session is about a week away! Before the meeting takes place, please complete the following steps before your scheduled meeting date to prepare for your session.

1. Please download the Monster Mealtime.zip folder from this [Google Drive folder](#) to install the game on your computer. If you are using a macOS (Apple) device,

please download the folder called “Monster_Mealtime_for_MACOSX” to install the game. Otherwise, please download the folder called “Monster_Mealtime_for_WINDOWS” if you are using a Windows (PC) device. Once you have downloaded the folder, extract its contents into your computer. Then, double-click on the application file called “Monster Mealtime” and see if you can open the game. You should see the following title screen if the game was installed properly.



2. Please practice joining a Zoom meeting using [this Zoom webpage](#). Additional resources for using Zoom can be found [here](#). You **DO NOT** need to make a Zoom account.
*Note: You may be prompted to install the Zoom Client if this is your first time using Zoom. Please install the client prior to your scheduled session to participate in our meeting.
3. Please complete this [Play-Tester Questionnaire](#). This questionnaire will help me understand your teaching experience and your beliefs about educational technology and educational computer games. Your responses will automatically be sent to me when you press the “Submit” button.

Please email me if you need help completing any of these three steps.

Sincerely,
Bethany

Meeting Preparations Follow-Up Email

Hello [participant's name],

This is just a friendly reminder to complete the steps in the previous email. Please make sure that you have Monster Mealtime and Zoom installed before the meeting. Also, if you have not already done so, please make sure to complete the Play-Tester Questionnaire before our meeting.

On the day of our meeting, I will send you a link to my Zoom room through email. To join the meeting, you will simply click on this link.

I am looking forward to meeting with you in a few days on [date] at [time]!

Sincerely,
Bethany

Zoom Meeting Email

Hello [participant's name],

We will begin your usability session shortly! Please join me in my Zoom meeting room by clicking on the following link.

[copy and paste meeting link here]

When you join the meeting, please use a pseudonym (fake name) to identify yourself. Please turn off your webcam as well. This is to protect your privacy while the session is being recorded.

See you soon!

Sincerely,
Bethany

Appendix I CITI Training Certificates

Figure I1*CITI Human Subjects Research Certificate***Figure I2***CITI Information Privacy Security Training Certificate*

Appendix J Usability Session Checklists

Adapted from checklists provided in *Rocket Surgery Made Easy: The Do-It-Yourself Guide to Finding and Fixing Usability Problems* (Krug, 2010)

Before Completing Any Steps in this Checklist:

1. Recruit potential participants using pre-written recruitment emails.
2. Send consent form with pre-written email message to potential participants who respond to the recruitment email.
3. Ensure that participant signs and returns the consent form to you through email.

About Two Weeks Before Intended Session Dates

1. Contact at least three participants to schedule their usability session using a pre-written email.
2. Ensure that three usability sessions are scheduled to take place in two weeks.

One Week Before Scheduled Session Dates

1. Send participants a pre-written email that provides preparatory instructions for the usability session
 - a. Share instructions for accessing and installing *Monster Mealtime*
 - b. Share instructions for accessing Zoom
 - c. Share instructions for completing the pre-survey
2. Double-check that each scheduled participant has completed the consent form.

One or Two Days Before Scheduled Session Dates

1. Send participants a pre-written email reconfirms the scheduled usability session and reminds them to complete the steps described in the previous email.
2. Ensure that necessary technology (i.e., computer with charging cable, microphone, headphones, etc.) will be available during the scheduled usability sessions.
3. Print a copy of this checklist and the protocol if it is the first usability test group.
4. Print a set of data collection sheets to use for each usability session.

On Test Day

Before the Session Begins

1. Begin preparing the recording device as described in the protocol an hour before the session is scheduled to begin.
2. Log in to Zoom at least 15 minutes before the scheduled start time. Test all settings as described in the protocol.
3. Contact the participant when preparations are complete at least 5 minutes before the scheduled start time.
4. Complete participant preparation steps as described in the protocol.
5. Start recording the session once participant preparations are complete.

During the Session

6. Read the facilitator script to guide the participant through the usability session.
7. Document preliminary question responses using the data collection sheets.
8. Document observations while participant plays the game using the data collection sheets.

After the Session

9. Continue reading the facilitator script to conclude the session.
10. Document responses to interview questions posed after playing the game using the data collection sheets.
11. Stop recording after the participant has answered the final interview question in the protocol.
12. Send participant the link to the post-survey.
13. End the meeting for all in Zoom.
14. Ensure that the recording was saved properly in your device. Store the video file in a folder designated for the session.

Appendix K Consent Form



University of Hawai'i Consent to Participate in a Research Project

Dr. Daniel Hoffman, Principal Investigator

Bethany Yoshimura, Student Investigator

Project title: Making Health Education Palatable: A Usability Study of a Digital Game about Nutrition

Aloha! My name is Bethany Yoshimura and I am a graduate student from the Department of Learning Design and Technology at University of Hawai'i at Mānoa's College of Education. As part of the requirements for earning my graduate degree, I am doing a usability study on an educational computer game that I created. This game is for 4th graders who are learning about nutrition. I would like to invite you to take part in this study.

What am I being asked to do?

If you participate in this project, I will meet with you for an online interview on a day and time that is convenient for you. During this interview, you will be asked to play the computer game and share feedback about its ability to help students understand how to play the game. I will also ask you to share feedback about the game's ability to satisfy 4th grade students.

Taking part in this study is your choice.

Your participation in this project is completely voluntary. You may stop participating at any time. If you stop being in the study, there will be no penalty or loss to you.

Why is this study being done?

The purpose of my project is to evaluate and improve the design of my computer game so that students can learn how to play the game easily and feel satisfied by playing the game. I am asking you to participate because you have worked as an elementary school teacher. As a teacher, you know what children need to learn effectively, so you will be able to share feedback that will help me improve this game for elementary students.

What will happen if I decide to take part in this study?

A week before the interview takes place, you will be asked to complete an online questionnaire that consists of nine questions. This should take about 10 minutes to complete. The questionnaire contains questions like "How long have you worked as an elementary school teacher?" and "In your opinion, what qualities make a computer game enjoyable for children?"

The interview will take about 50 minutes to complete. You will meet with me through Zoom, a web-conferencing application. First, you will answer three questions about your experiences with teaching and gaming. Then, you will play the game while thinking-aloud for 20 minutes. After playing the game, you will answer seven questions based on your experience with the game. This portion of the interview will include questions like "Based on your experience with the game, what parts of the game do you think 4th graders will struggle to complete?" and "What do you think 4th graders will enjoy most about this game?" You will also complete an online survey to rate the game's ability to satisfy and help 4th graders learn how to play the game. This survey should take about 5 minutes to complete.

Only you and I will be present during the usability session. With your permission, I will audio-record the session and record your screen so that I can find areas in the game that need improvement. You will be one of about 15 people I will interview for this study.

What are the risks and benefits of taking part in this study?

I believe there is little risk to you for participating in this research project. You may become

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University of Hawai'i
Consent to Participate in a Research Project

Dr. Daniel Hoffman, Principal Investigator

Bethany Yoshimura, Student Investigator

Project title: Making Health Education Palatable: A Usability Study of a Digital Game about Nutrition

stressed or uncomfortable while playing the game or answering interview questions. If you do become stressed or uncomfortable, you can take a break or skip the question. You can also stop the interview or you can withdraw from the project altogether.

There will be no direct benefit to you for participating in this study. The results of this project may help improve health education for elementary students by creating an effective educational computer game that supports classroom instruction.

Privacy and Confidentiality:

I will keep all study data secure in a password protected computer. Only my University of Hawai'i advisor and I will have access to this information. Other agencies that have legal permission have the right to review research records. The University of Hawai'i Human Studies Program has the right to review research records for this study.

After I write a copy of the interviews, I will erase or destroy the audio-recordings and screen recordings. When I report the results of my research project, I will not use your name. I will not use any other personal identifying information that can identify you. I will use pseudonyms (fake names) and report my findings in a way that protects your privacy and confidentiality to the extent allowed by law.

Compensation:

There will be no compensation offered for your participation in this study.

Future Research Studies:

Even after removing identifiers, the data from this study will not be used or distributed for future research studies.

Questions:

If you have any questions about this study, please email me at byosh27@hawaii.edu. You may also contact my advisor, Dr. Daniel Hoffman, at dan.hoffman@hawaii.edu. You may contact the UH Human Studies Program at 808.956.5007 or uhirb@hawaii.edu to discuss problems, concerns and questions; obtain information; or offer input with an informed individual who is unaffiliated with the specific research protocol. Please visit <http://go.hawaii.edu/jRd> for more information on your rights as a research participant.

If you agree to participate in this project, please sign and date this signature page and return it to: byosh27@hawaii.edu

Keep a copy of the informed consent for your records and reference.



University of Hawai'i
Consent to Participate in a Research Project
Dr. Daniel Hoffman, Principal Investigator
Bethany Yoshimura, Student Investigator

Project title: Making Health Education Palatable: A Usability Study of a Digital Game about Nutrition

Signature(s) for Consent:

I give permission to join the research project entitled, "*Making Health Education Palatable: A Usability Study of a Digital Game about Nutrition.*"

Please initial next to either "Yes" or "No" to the following:

___ Yes ___ No I consent to be audio-recorded during this study.

___ Yes ___ No I consent to have my screen recorded during this study.

Name of Participant (Print): _____

Participant's Signature: _____

Signature of the Person Obtaining Consent: _____

Date: _____

Mahalo!

Appendix L
Data Collection Sheets for In-Session Data

Usability Session Group (circle one): 1 2 3

Date: _____

Preliminary Questions

Instructions for Facilitator: Summarize the participant's verbal response for each preliminary question.

1. Do you prefer to teach early elementary students or upper elementary students?

2. How do you feel about using educational computer games in the classroom?

3. Do you consider yourself a gamer? If so, how much time do you feel you spend playing games per week?

Observations During Gameplay

Instructions for Facilitator: Take notes on participant's think-alouds, in-game actions, and reactions for each round of gameplay.

Title Screen Observations:

Gameplay Observations:

In-Game Day:	Participant Think-Aloud Note information shared verbally by participant that expresses what they are doing or thinking while playing the game.	Participant Actions Note actions taken by the participant in the game. For example, document incorrect actions, lack of action when action is expected, and voluntarily replaying a round.	Participant Reactions Note feelings expressed by the participant. Pay close attention to confusion, frustration, and disapproval. Also, note any reactions that require a response from the facilitator.
1			
2			
3			
4			

5			
---	--	--	--

Post-Gameplay Questions

Instructions for Facilitator: Summarize the participant's verbal response for each post-interview question.

1. What aspects of the game (e.g., menus, messages, etc.) do you think will be most helpful in teaching 4th graders how to play the game?
2. Based on your experience with the game, what parts of the game do you think 4th graders will struggle to complete?
3. What should be added to the game to help 4th graders understand how to play the game?
4. What do you think 4th graders will enjoy most about this game?

5. What do you think 4th graders will enjoy least about this game?
6. What should be added to the game to make it more satisfying for 4th grade students?
7. Do you have any other suggestions for improving this game?

Appendix M
Demographic Data from the Play-Tester Questionnaire

Table M1*Participants' Teaching Experience in Elementary Education*

Characteristic	Number (n = 12)	Percent (%)
<i>Years of Experience</i>		
Less than 5 years	4	33.33
5 – 10 years	4	33.33
11 – 15 years	1	8.33
15 – 20 years	1	8.33
More than 20 years	2	16.67
<i>Current Grade Level</i>		
Early elementary (Grades K – 3)	6	50
Upper elementary (Grades 4 – 6)	3	25
Not currently teaching	3	25
<i>Previous Grade Level(s)</i>		
Both early and upper elementary	7	58.33
Early elementary (Grades K – 3)	4	33.33
Upper elementary (Grades 4 – 6)	1	8.33

Table M2*Participants' Use of Technology*

Usage	Number (n = 12)	Percent (%)
<i>Uses Technology for Teaching</i>		
Always	3	25
Usually	7	58.33
Sometimes	2	16.67
Rarely	0	0
Never	0	0
<i>Uses Educational Computer Games for Teaching</i>		
Always	1	8.33
Usually	1	8.33
Sometimes	6	50
Rarely	2	16.67
Never	2	16.67
<i>Uses Video Games or Computer Games for Personal Use</i>		
Always	2	16.67
Usually	2	16.67
Sometimes	4	33.33
Rarely	2	16.67
Never	2	16.67

Table M3*Participants' Beliefs about Educational Computer Games*

Belief	Number (n = 12)	Percent (%)
<i>Computer Games as Valuable Teaching Resources</i>		
Strongly Agree	4	33.33
Agree	4	33.33
Neutral	4	33.33
Disagree	0	0
Strongly Disagree	0	0
<i>Computer Game Characteristics that Support Learnability</i>		
Clear instructions	3	25
Encourages critical thinking	1	8.33
Gameplay matches the player's skill level	2	16.67
Gameplay motivates students to play	1	8.33
Graphic/auditory instructions	6	50
In-game goals	1	8.33
Monitors student understanding	1	8.33
Practice opportunities	1	8.33
Tutorial	3	25
<i>Computer Game Characteristics that Support Satisfaction</i>		
Challenges/goals	6	50
Competition	2	16.67
Encourages critical thinking	1	8.33
Engaging content	4	33.33
Gameplay matches the player's skill level	2	16.67
Good character design	2	16.67
Good sound design	1	8.33
Good visual design	1	8.33
Incorporates play with others	1	8.33
Integration of specific gameplay styles (e.g., shooting, racing)	1	8.33
Motivates students to play	1	8.33
Repetitive play that supports learnability	1	8.33
Rewards	6	50
User-Friendly	1	8.33
Text is easy to read	1	8.33

Note. Some participants identified multiple game characteristics that support learnability and satisfaction.

Appendix N
Usability Problems Identified through Play-Testing

Table N1*Usability Problems by Game Design Dimension: Round 1*

Usability Problem	Number (<i>n</i> = 3)	Percent (%)
<i>Content</i>		
One nutrient is prioritized over others during food selection	2	66.67
<i>Game Mechanics</i>		
Required goals are thought to be achieved based on performance in the activity stage	3	100
The rare object collection goal is thought to be achieved by finding and capturing the rare object during the activity stage	2	66.67
Fat crystal function/use is misunderstood	2	66.67
Bonus goals are not pursued before proceeding to the next day	2	66.67
Energy depletion is thought to be determined by movement during the activity stage	2	66.67
A critical error causes the game to crash	1	33.33
<i>Visual Design</i>		
Fat crystal amount is misinterpreted due to symbol	2	66.67
Feedback is not noticed in the results screen	2	66.67

Table N2*Usability Problems by Game Design Dimension: Round 2*

Usability Problem	Number (n = 4)	Percent (%)
Content		
One nutrient is prioritized over others during food selection	2	50
Food is selected based on personal preference instead of nutritional value	2	50
Game Mechanics		
Strategies for achieving required goals are unclear	3	75
Other areas of the screen are examined or interacted with before the tutorial has presented all instructions	3	75
Cause of nutrient-based movement penalties is not understood	2	50
Tutorial will not maintain students' attention	2	50
The rare object collection goal is thought to be achieved by finding and capturing the rare object during the activity stage	2	50
Protein skill upgrades are unintentionally skipped	2	50
Procedure for redeeming fat crystals is unclear	2	50
Visual Design		
Buttons are difficult to locate during the preparation tutorial	2	50
Nutrient amounts are difficult to interpret using symbols	2	50
Text formatting during meal selection explanation is disliked	2	50
Animations occasionally do not match story text	2	50

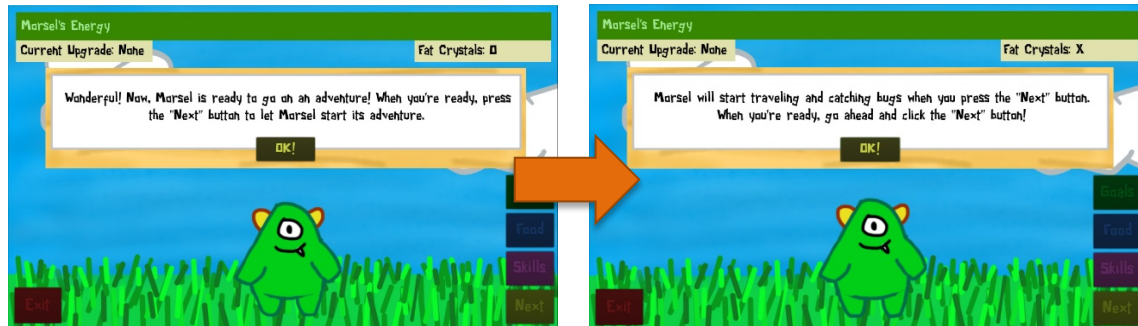
Table N3*Usability Problems by Game Design Dimension: Round 3*

Usability Problem	Number (n = 5)	Percent (%)
Content		
One nutrient is prioritized over others during food selection	3	60
Food is selected based on personal preference instead of nutritional value	2	40
Sugar is thought to be essential to the diet	2	40
Game Mechanics		
Required goals are thought to be achieved based on performance in the activity stage	4	80
The Stronger Legs upgrade is thought to improve movement speed during the activity stage	4	80
Bonus goal are not pursued before proceeding to the next day	3	60
Nutrient explanation in preparation tutorial feels overwhelming to participant	3	60
Nutrient functions are forgotten after viewing the preparation tutorial	3	60
Other areas of the screen are examined or interacted with before the tutorial has presented all instructions	2	40
Cause of nutrient-based movement penalties is not understood	2	40
Limitations related to purchasing skills are misunderstood	2	40
The rare object collection goal is thought to be achieved by finding and capturing the rare object during the activity stage	2	40
The activity stage for Day 2 causes stress for participants	2	40
The goals screen is thought to be viewable only once per day	2	40
A movement bug prevents the player from jumping during the activity stage	1	20
Visual Design		
Tutorial screenshots distract participants from the reading the instructions	3	60
Tutorial screenshot is thought to be the main game screen	2	40
Readability of text in tutorial screenshot is poor	2	40
Animations occasionally do not match story text	2	40

Appendix O Revision Screenshots

Figure O1

Text-Based Revisions in Tutorial after Round 1



Note. In Round 1's design (left), the final tutorial message simply told players to proceed to the activity stage. The fat crystal amount was also shown using an "O" for each crystal. In Round 2's design (right), the tutorial message was revised to emphasize that Morsel travels and catches bugs on its own prior to the start of the next stage. In addition, the symbol used to represent the fat crystal amount was changed to "X" for clarity.

Figure O2

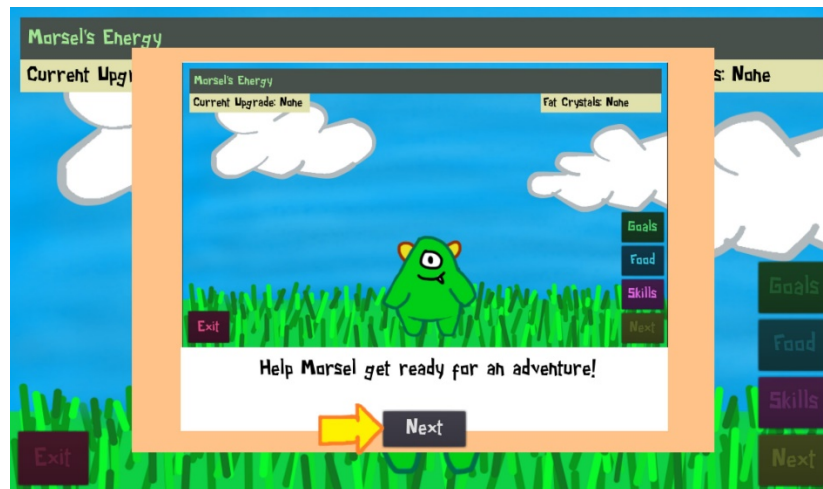
Volume Adjustment Setting Added after Round 1



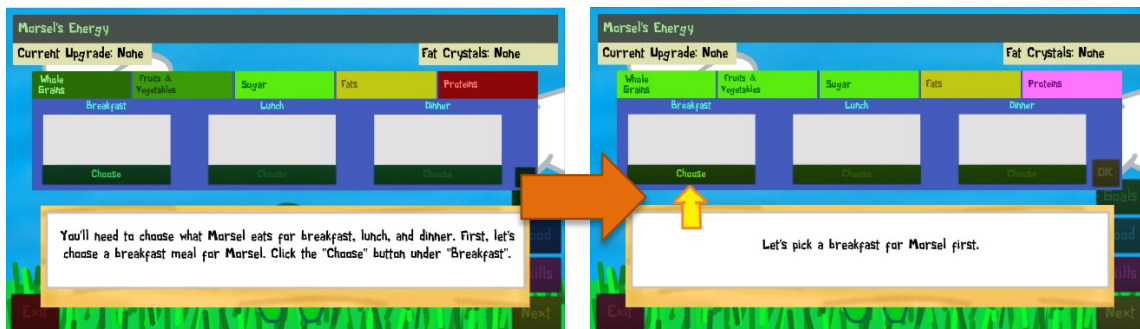
Note. A volume adjustment menu was added to the title screen of *Monster Mealtime* after Round 1 to reduce sound-based distractions.

Figure O3*Feedback Revision after Round 1*

Note. In Round 1's design (left), the feedback text was placed inconspicuously in the results screen. In Round 2's design (right), a white frame was placed around the feedback text to make it more noticeable.

Figure O4*Sample Generalized Tutorial Added after Round 2*

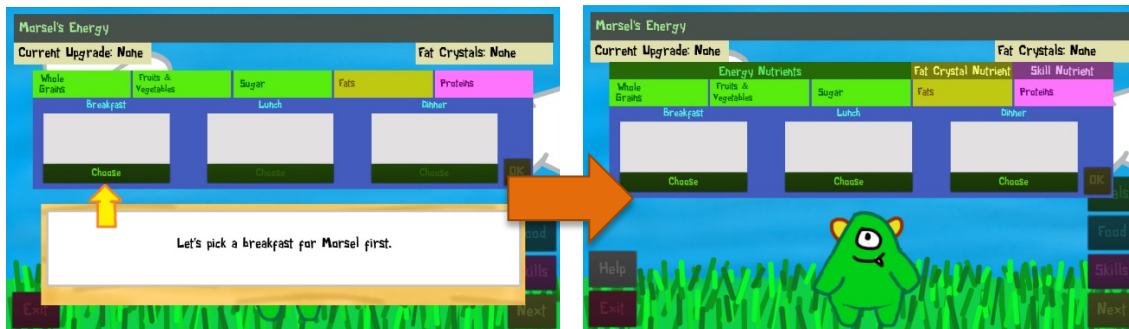
Note. This is the generalized tutorial designed for the preparation stage of the game. It was added after Round 2. It gives a brief overview of how to play the preparation stage.

Figure O5*Navigational Tutorial Revisions after Round 2*

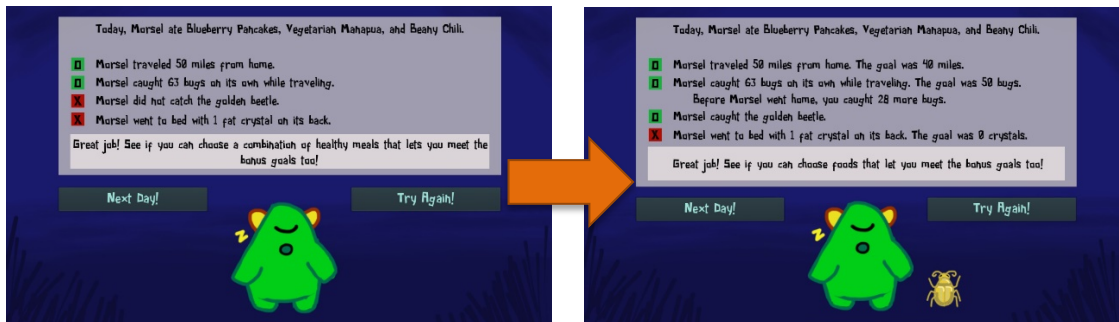
Note. In the design used in Round 2 (left), the tutorial was wordy and there were no visual supports to help the player locate the buttons. Additionally, each nutrient in the nutrient counter was shown in a different color. In the design for Round 3 (right), animated arrows were added to direct players to specific buttons so less words could be used to communicate instructions. The nutrient counter colors were also revised. Colors were adjusted to match the nutrients' functions in the game. For example, since carbohydrates provide Morsel with energy, the color used for these nutrients was changed to the same shade of green that appears in the energy bar.

Figure O6*Generalized Tutorial Revisions after Round 3*

Note. For Round 3's design (left), the generalized tutorial screen had no header, and the instructions were displayed below the picture. This was revised in the final prototype's design (right) where a title was added to communicate the screen's purpose. The words were also displayed above the image to encourage the player to read the words before examining the picture.

Figure O7*Reminder for Nutrient Functions in Meal Menu Added after Round 3*

Note. In Round 3's design (left), the nutrients were color-coded to communicate each nutrient's function. To assist players in remembering the functions of each nutrient, headings were added to describe the nutrient functions in the final prototype's design (right).

Figure O8*Revisions to the Results Screen after Round 3*

Note. In Round 3's design (left), the player's captured items were not displayed in the results screen. To help players differentiate between the objects collected based on their nutritional choices and the objects collected during the activity stage, the player's total captured objects were added to the reported results in the final prototype's design (right). Additionally, if the player captures the rare object through their nutritional choices or a skill, the object will appear next to Morsel to establish a visual reward for meeting the goal.