Gamification of Food Selection and Nutrition Education in Virtual Reality

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Figure 1: Buffet setting and point displays in VR gameplay.

Abstract

The increasing global prevalence of obesity and related health issues underscores the need for innovative dietary interventions. This paper explores the potential of combining gamification and Virtual Reality (VR) to promote healthier eating habits among young adults. By creating an interactive VR food environment with engaging game elements, we aim to assess the impact of gamified VR intervention on nutritional knowledge and attitudes. Preliminary results show an increase in nutritional understanding and awareness, though further research is necessary for statistical validation. This study suggests that VR-based gamified interventions could be a promising tool for nutrition education, behavior modification, and virtual food selection.

CCS Concepts

• **Human-centered computing** → **Virtual reality**; • **Applied computing** → **Consumer health**; **Interactive learning environments**.

Keywords

Virtual reality, food choice, nutrition education, gamification

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1 Introduction

With rising rates of chronic disease tied to eating habits [10], there is a growing need for early lifestyle interventions and healthier diets. Young adults are particularly susceptible to adopting unhealthy eating habits [1]. Various nutrition interventions, including digital tools such as video games and mobile apps, have been effective in promoting healthier eating habits [6]. Additionally, Virtual Reality (VR) has shown promise in interventions targeting unhealthy habits and addictions, including those related to nutrition and chronic disease risk factors [9]. VR is often employed to study people's responses in simulated environments and influence behavior through modeling and educational elements. This research aims to merge the concepts of VR, digital intervention, and gamified nutrition education. This pilot study tests how interactive VR food environments may be used to improve nutritional knowledge and encourage healthy eating habits through gamification (the incorporation of game-like elements such as achievements, prizes, or rewards). This VR game is intended to encourage healthy habits by positively highlighting the value of nutrients in various foods, creating a sense of fun, and improving self-efficacy, rather than shaming or scaring consumers away from certain options.

2 Related Work

2.1 Nutrition Education and Digital Gaming

Previous research has explored how digital and gamified nutrition education processes can help improve real-world eating habits. A

2021 systematic review analyzed "the effect of game-based interventions (gamification) for improving nutritional habits, knowledge, and changes in body composition" across 23 different studies [8]. The review found that gamified interventions increased post-game consumption of fruits and vegetables, resulting in increased intake of key nutrients, such as vitamin C, beta carotene, potassium, and fiber. Participants also showed improvement in nutritional knowledge based on quiz scores. These results indicate that gamification may be an effective method to teach nutrition information and improve diet quality [8]. However, none of the 23 nutrition games included in the review used VR. We hope to expand on nutrition education research by incorporating immersive VR spaces, a relatively unexplored form of gamified digital nutrition intervention. This gamelike experience will appeal to the young adult target audience and expand on the ways in which VR is used to observe, model, and modify dietary behavior.

2.2 Virtual Reality and Dietary Behavior

In recent years, VR has shown promise as a tool for gaining insight into people's daily habits, including dietary choices, by studying how consumers behave in simulated food environments. Previous relevant studies have examined how youth and adults behave in a simulated buffet-style restaurant [5], food court [1], supermarket [3], and cafeteria [7]. Research using virtual food environments [1] [2], reported high levels of usability and presence, and concluded that virtual reality shows promise as a tool to study food choice and pursue training interventions. The food court simulation in Allman-Farnelli et al. was built using the Unity game engine, with representative menu items and prices formulated through observations of 14 real-world food outlets. We plan to follow similar procedures to build an accurate food selection environment in Unity for our intervention. Furthermore, Cheah et al. analyzed ethnically diverse young adults' food choices at a VR buffet compared to their later real-world buffet selections, and found that the nutritional content of simulated food selections were positively correlated with real-life selections [5]. Most prior research results of realness and effectiveness were gathered from post-experiment questionnaires, which we also plan to employ. However, game elements, which can be effective in improving nutrition education and promoting healthy eating, have yet to be incorporated into dietary VR research. Given the promising potential of realistic virtual food environments, we aim to expand on these findings by incorporating gamified aspects into the simulated food selection experience in VR and assessing how these elements influence participants' attitudes and knowledge about healthy eating.

3 Methods

Human subjects research approval was obtained from the CUNY IRB. Protocol number 2024-0511-Hunter.

3.1 Participants

Twelve participants between the ages of 18 and 33 were recruited through flyers and personal outreach on the Hunter College campus, 6 identifying as female and 6 as male. 16.7% of participants self-identified as White, 41.7% Asian, 16.7% Hispanic and/or Latino, 33.3% African American, and 8.3% Other. All gave informed consent to participate, but were not initially informed of the study aim to avoid social desirability bias.

3.2 Procedure

Participants were first informed of potential risks such as motion sickness and were reminded that all participation could be paused or terminated at any time. They were asked to respond to a 14-question pre-survey questionnaire related to their eating habits and attitudes. Questions used a Likert scale, and most were directly taken from or followed the format of NEMS-P, a validated survey instrument. This questionnaire also included control questions such as demographic information, hunger level, and any relevant dietary restrictions. A 10-question nutrition quiz assessed knowledge about the nutritional content of foods in the buffet and the health effects associated with each nutrient. Participants received brief technical instructions on how to use the VR hardware and up to 5 minutes to familiarize themselves with the controls. Then they were given their task for the buffet simulation, to freely choose foods to add to their plates as if this were a real buffet. Participants were given a reasonable limit of 1 kg of food and 20 minutes to make their selections. On average, participants selected 849 g of food and spent 3:14 minutes in the simulation. After the VR experience, participants filled out a 14-question post-study questionnaire to assess their subjective VR experience and change in attitudes, and the 10-question multiple choice nutrition quiz.

3.2.1 *Nutrition Knowledge Quiz.*

(1) Which of the following is a prominent health effect of lutein and zeaxanthin?
(2) Which of the following is a prominent health benefit of dietary fiber?
(3) Which of the following are antioxidants?
(4) Which of the following is one benefit of antioxidants?
(5) Consuming too much added sugar increases your risk of which of the following health issues?
(6) The body can convert beta carotene into which of the following?
(7) What is one of the effects of saturated fatty acids on health?
(8) Which of the following is the most prominent in tomato products like ketchup or salads?
(9) Which of the following has the highest levels of Vitamin E per serving?
(10) Which of the following contains the highest levels of saturated fat per serving?

3.3 Simulation Overview

The VR program was built in Unity3D and deployed on a MetaQuest 2 headset. Button selection, grab interaction, and movement functionalities were managed using hand controllers. Nutrition information was sourced from the USDA FoodData Central database. 3D models were purchased from the Unity Asset Store and sound effects from the Zapsplat sound library. The VR environment had prepared food laid out in dishes designed to simulate an urban buffet-style hot food bar. Each food option had an informational panel above it including the name and description. Food options were chicken salad, side salad, salad dressing, teriyaki salmon with broccoli, banana, apple, cheeseburger, french fries, ketchup, hot dog,

doughnut, chocolate milkshake, fountain soda, and bottled water. Players could navigate freely and interact with the food items using the controllers. The game had a nutrient-based point system, where virtual point bars were updated based on the nutritional content of a food item once it is selected. Seven point bars represented beta carotene, fiber, lutein and zeaxanthin, lycopene, saturated fat, sugar, and vitamin E. These nutrients were chosen following the recommendation of a consulting Health and Nutrition Sciences professor to represent the healthy and unhealthy components of different dishes. Background music enhanced the gaming experience, while sound cues signaled achievements. By hovering over each point bar, players could learn about each nutrient and its health effects. Players were allowed to change selections and remove food items from their plates to promote healthy behavior change and self-efficacy.

4 Results and Analysis

All participants completed the game session without issue and filled out the post-survey within a day of completing the simulation. The most selected food items (70% of participants) were teriyaki salmon with broccoli and bottled water.

The mean nutrition knowledge score was 3.33 before and 4.25 after the VR experience (out of 10), increasing by 0.92 points. Out of the 12 participants, 6 had higher post-intervention scores (positive ranks), 3 had lower post-intervention scores (negative ranks), and 3 had the same scores pre and post-intervention (ties). The sum of positive ranks (36.00) was greater than the sum of negative ranks (9.00), suggesting a trend toward an increase in scores following the intervention. However, the results of the Wilcoxon Signed Ranks Test indicated that the difference in the scores is not statistically significant (Z = -1.630, p = 0.103, with a significance threshold of p < 0.05).

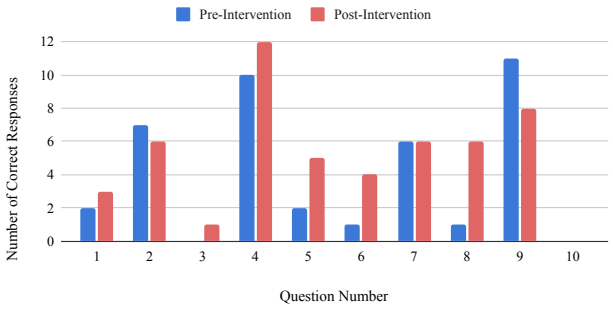

Figure 2: Number of Correct Responses on Knowledge Quiz Questions Before and After Intervention

Additionally, 41.67% of participants reported being more mindful about the nutritional content of the foods they eat after the game. Perceived importance of nutrients when eating out or ordering takeout food increased according to paired t-test results. Changes in attitudes towards dietary fiber (p = 0.039), lutein and zeaxanthin (p = 0.042), and vitamin E (p = 0.025) were statistically significant (p < 0.05). While the mean importance scores for beta carotene lycopene, saturated fat, and sugar also increased after the intervention, these changes were not statistically significant.

5 Discussion

Although there is an observable trend of increased knowledge scores following the VR game experience indicated by the higher post-intervention mean and the greater sum of positive ranks, further research is needed to confirm the significance of this trend. Overall, the intervention raised awareness and improved knowledge about the importance of certain nutrients. However, only 50% of subjects demonstrated improved knowledge and most subjects reported neutral feelings toward changing their real-world eating behavior after the intervention.

In user evaluations, the Informational Panels were identified as the most effective educational feature, with a median score of 4.5 for enhancing the learning experience and 4 for enjoyment (out of 5). Interactive Elements, such as picking up food items, were rated highest for enjoyment, with a median score of 4.5, and 4 for learning. Sound Components, Point Feedback, and Food Options also received positive ratings, with median scores of 4 for both learning and enjoyment. The Physical Setting Design had the least impact overall, scoring a median of 3 for learning and 4 for enjoyment. This feedback should guide future iterations, though it may be specific to this implementation of the game.

The results of this study indicate that integrating gamified displays into VR may be effective in increasing knowledge and awareness of nutrient content and health effects, though statistical significance was not confirmed. These findings align with previous research on VR's potential for examining and influencing behavior in virtual food environments and the effectiveness of interactive digital tools for learning. Participants' knowledge scores did not increase as much as expected, suggesting a need to reassess the format of the knowledge quiz and the educational game aspects. Based on participant feedback, one factor that may have contributed to the lack of score improvement in some participants is their dietary restrictions. 80% of participants with no dietary restrictions had higher knowledge scores after the game, while only 28.6% of the seven participants with dietary restrictions (e.g. food allergies, vegetarianism) showed improvement. Though more investigation is needed, it is possible that having a more limited set of viable food options in the simulation impeded their learning.

5.1 Limitations

In addition to the limited food options, there are other important limitations to consider. The sample size for this study was small and, although diverse, may not be representative of the broader population. The specific nature of the VR game also limits the generalizability of the results. Placements of food items and point bars within the game were not randomized, potentially influencing participant decisions [3]. Moreover, the reliance on self-reported data introduces potential biases, as participants may have consciously or unconsciously altered their responses. Finally, the absence of a control group makes it difficult to attribute changes in knowledge and attitudes solely to the gamified VR intervention. Future studies should address these limitations by including larger samples, randomizing simulation elements, and considering a broader range of dietary needs to better understand the game's impact and improve its design.

6 Conclusions and Future Work

This pilot study highlights the potential of integrating gamified elements with VR environments to enhance nutritional knowledge and awareness. While the increase in knowledge scores was not statistically significant, the observed improvement in assessed knowledge and positive shifts in attitudes towards specific nutrients indicate that VR holds promise for nutrition education. Future research should focus on expanding and refining game components to address identified areas for improvement. Personalizing the educational experience, such as incorporating individualized feedback based on user data, could further enhance its effectiveness, as evidence suggests that computer-personalized education models improves knowledge retention and dietary change motivation [4]. Additionally, investigating real-life behavioral changes, rather than self-reported knowledge and intent, could offer deeper insights into the impacts of VR nutrition education experiences. Gamified food selection experiences in VR also have the potential to translate directly into healthier eating habits by applying them to online food ordering processes. In all, this study lays the groundwork for developing more effective VR interventions for nutrition education and supports the exploration of viable applications.

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