The Design and Evaluation of *Food Villain*, A Serious Game to Promote Healthy Nutrition

Victor A. Okpanachi
University of British Columbia, Okanagan, Canada
vokpanac@student.ubc.ca

Ifeoma Adaji
University of British Columbia, Okanagan, Canada
ifeoma.adaji@ubc.ca

***Abstract*— The rise of diet-related health issues among African international students in Western countries necessitates innovative interventions to promote healthy eating. Food Villain, a serious game designed to address this challenge, combines educational content with engaging gameplay to encourage better nutritional choices. The current paper extends previous work on the development of Food Villain. In the current paper, we present the evaluation of the game with a focus on metrics such as ease of use, perceived usefulness, engagement, quality of information, and aesthetics. Developed through a literature review of persuasive strategies and serious game design, Food Villain incorporates elements like points, levels, feedback, rewards, and authority to educate and motivate players. The game spans four levels, featuring activities like adventure missions, quizzes, food categorization tasks, and recipe creation. The evaluation involved 24 African international students, assessing key metrics via a survey. Our results indicated that participants found the game useful and informative, with suggestions on improving the user interface and interactivity. These findings provide valuable insights for future iterations, highlighting the importance of ongoing user feedback.**

Keywords*— *Serious Games, Healthy Eating Habits, African International Students, Food Villain.

I. INTRODUCTION

Serious games are an emerging tool in health education, using engaging gameplay to encourage positive behavioral changes. Unlike traditional games, serious games go beyond entertainment, focusing on education, training, or health improvement [1]. Their interactive and immersive qualities make serious games particularly effective for conveying educational content, engaging users in ways traditional methods may not [2]. In healthy eating, serious games can offer a unique way to educate users on nutrition and encourage healthier dietary habits, addressing challenges like prevalent unhealthy food choices, cultural dietary norms, and limited nutritional knowledge [3]. By simulating real-life situations and providing practical tips, these games can help users make informed food choices. Features like progress tracking and instant feedback enhance learning, aiding users in internalizing and applying new knowledge.

Recent successes in using serious games to promote nutrition include "Squire's Quest!" which increased children's fruit and vegetable intake through goal-setting and storytelling [4], and "Fitter Critters," which taught elementary students to balance virtual meals [5]. However, there is a lack of serious games specifically targeted towards African international students to positively influence their nutrition behavior.

It is essential to positively influence international students' nutrition behavior because they frequently encounter particular difficulties that may interfere with their ability to eat healthily. Poor nutrition choices might result from having to adjust to new dietary options and not having access to familiar foods from their home country. A greater desire for comfort foods, which are frequently high in calories and low in nutrition, may also arise from adjusting to new environments, such as lower temperatures. These factors, along with time constraints for meal preparation and academic demands, emphasize the significance of games like Food Villain in promoting better eating habits in this target group [6].

Food Villain, a serious game developed to promote healthy eating among African international students, builds on these principles, such as engaging gameplay, educational content in interactive environments, and persuasive strategies like rewards, feedback, and authority to encourage healthy habits. Prior to Food Villain's design, an in-depth review of serious games was conducted, revealing the importance of persuasive strategies such as feedback, rewards, comparison, and authority to boost user motivation and engagement. Games like Junk Food Destroyer, which encourages players to make healthier food choices through interactive gameplay [7], and PEGASO, which promotes sustainable healthy lifestyles among adolescents by integrating persuasive strategies and mobile technology [8], exemplify serious games' potential to foster positive behavioral changes through engaging, educational gameplay.

After the design and development of Food Villain, the game was evaluated by 24 African international students to assess its effectiveness and impact on promoting healthier eating habits. This evaluation aimed to gather insights into the game's ability to engage its target audience, motivate behavior change, and align with culturally relevant dietary practices. The findings from this evaluation serve as the foundation for this paper, which seeks to critically examine the effectiveness of Food Villain as a serious game intervention for influencing positive nutrition behaviors among African international students. Through this evaluation, the study contributes to understanding how serious games can be tailored to address the unique challenges faced by this demographic, offering valuable insights for future research and practice in the field.

To achieve the aim of the paper, we set out to answer these research questions:

1. How do African international students perceive the usability and ease of use of Food Villain in promoting healthy eating habits?
2. Which impact does the Food Villain game have on users' motivation to make healthier food choices?
3. How user-friendly is the Food Villain game, and what are the perceived barriers to ease of use?
4. What are the players' attitudes toward incorporating Food Villain into their routine for consistent engagement in healthy eating habits?

2025 IEEE 15th Annual Computing and Communication Workshop and Conference (CCWC) | 979-8-3315-0769-5/25/$31.00 ©2025 IEEE | DOI: 10.1109/CCWC62904.2025.10903683

979-8-3315-0769-5/25/$31.00 ©2025 IEEE

II. Literature Review

In designing Food Villain, we conducted a systematic literature review to gather insights on the effective use of serious games for promoting healthy nutrition. This review focused on identifying persuasive strategies and game mechanics used in health-related serious games, particularly those aimed at influencing dietary behaviors. Our search included databases such as PubMed, IEEE Xplore, Springer, and ACM Digital Library, focusing on articles published after 2015 using the search terms: *nutrition, healthy habit,* and *healthy game*. A total of 1020 items were found. 900 of them were excluded after the titles were checked for relevance. After examining their abstracts, 105 of the 120 remaining articles were excluded. For this study, 15 publications were ultimately reviewed before the development of Food Villain.

The review revealed several effective strategies commonly employed in serious games to promote healthy eating. These strategies include the use of levels to signify progression, feedback, and rewards to reinforce positive behaviors, and scoreboards to encourage social comparison and motivation. For example, games like Squire's Quest! and Fitter Critters successfully used goal-setting, storytelling, and immediate feedback to promote healthy food choices among children [4], [5]. Moreover, persuasive elements such as *authority*, where players are provided with credible nutritional information, were shown to increase the educational value of serious games. However, despite these insights, most existing serious games were designed for children, adolescents, or individuals with specific health conditions, such as diabetes or obesity. None addressed the unique cultural and dietary challenges faced by African international students in Western countries, such as limited access to familiar foods, cultural differences, and the prevalence of processed foods that do not align with their traditional diets [9]. This gap in the literature highlighted the need to design a game specifically tailored to this demographic, drawing on established persuasive strategies while incorporating cultural relevance.

III. Methodology

A. Game Design Of Food Villain

The design of Food Villain was informed by both the literature review and the specific needs of African international students transitioning to Western food environments. The game employs several key design elements, each strategically chosen to cater to the target group's cultural and dietary challenges. As mentioned previously, a literature review was conducted that showed that (45%) of most games were web-based, followed by mobile (35%), motion controllers (15%), and virtual reality (5%), guiding us to develop Food Villain as a web-based game. Food Villain was designed as a web-based game to ensure maximum accessibility and usability for African international students. The choice of a web-based platform was informed by the need for device-agnostic accessibility, allowing users to engage with the game on various devices, including desktops, laptops, and tablets, without requiring any specialized hardware or software installations. This cross-platform compatibility is particularly important for the target demographic, ensuring that students with varying device access can participate fully.

Food Villain features four distinct levels, each representing a different aspect of healthy nutrition. The decision to use levels as a progression mechanic was based on evidence from prior studies showing that levels provide players with a sense of accomplishment and motivate continued gameplay [10]. For African international students, these levels mirror real-life dietary challenges they face in Western environments, such as distinguishing between healthy and unhealthy food choices. Persuasive strategies like rewards, feedback, and social comparison were prevalent, and we integrated these into Food Villain. Although most reviewed games were multiplayer, Food Villain is currently single-player, with plans for a multiplayer version in future updates. This comprehensive literature review informed the effective design and development of Food Villain, ensuring it leverages proven strategies and technologies to promote healthy eating habits.

The game incorporates points, immediate feedback, and rewards—strategies proven to enhance user motivation and learning retention [11]. In the context of Food Villain, players earn points for correctly identifying healthy foods and making better dietary decisions. Immediate feedback reinforces learning, ensuring players understand the rationale behind their choices. For African international students, this feedback is particularly important as it provides real-time guidance on how to adapt their food choices to a Western context, offering culturally relevant advice where applicable.

The visual design of Food Villain incorporates African food items and ingredients to make the game more relatable for African international students. Research indicates that culturally relevant content significantly enhances engagement and perceived usefulness in educational tools [12]. By including familiar foods alongside Western options, Food Villain helps bridge dietary gaps, facilitating a smoother transition to healthier eating habits. The game features culturally resonant elements, including a diverse set of Black avatars in the player-selection menu and popular African dishes like *eba, egusi, moi-moi, adalu*, and *jollof rice* in the Food Recipe level, enhancing engagement and personal connection. This targeted design approach uses familiarity and adaptation to support African students in making healthier food choices in their new environment. By aligning the game's elements with cultural and dietary needs, Food Villain promotes sustainable healthy eating habits while easing students' adjustment to Western food options.

To enhance the credibility of the nutritional information presented, Food Villain integrates links to reputable sources such as the World Health Organization (WHO) and the National Health Service (NHS). This strategy, known as *authority*, is often used in serious games to ensure that players trust the educational content being delivered [13]. For African international students, having access to credible, evidence-based nutritional advice is crucial in helping them navigate unfamiliar food systems and make informed dietary decisions.

B. The Development And Architecture Of Food Villain

Food Villain is a first-person shooter game developed to promote healthy eating among African international students, who often face dietary challenges in Western countries. These challenges include limited access to familiar foods, cultural differences in diet, and exposure to processed and fast foods that may conflict with traditional dietary practices. Food Villain seeks to bridge this gap by educating players about nutrition and encouraging healthier food choices in an interactive, engaging way. In the game, players combat

"villains" symbolizing unhealthy eating habits across multiple levels, making dietary decisions that reflect real-life scenarios. Players must select balanced meals, understand nutritional values, and avoid unhealthy choices to advance, with the game's narrative and interactive features reinforcing learning through experiential play. Developed in Unity 3D, Food Villain leverages the platform's immersive capabilities with scripting in C# for efficient game logic, player interactions, and real-time feedback. Additional libraries, including Newtonsoft.Json for JSON parsing and Unity UI Toolkit for responsive interfaces, enhance functionality and user experience. The Unity Standard Assets package adds depth to the game environment with pre-built assets, accelerating development.

Food Villain also uses MongoDB for storing game data, including login information, registration, and scores, organized in an MVC (Model-View-Controller) structure (Figure 1). The Player schema represents the model, storing data like usernames, hashed passwords, and scores in MongoDB. Unity manages the view, displaying user information and capturing input, while a Node.js server handles the controller, managing requests for registration, login, and score updates. This architecture maintains a modular, secure codebase where the model manages data, the view handles user interaction, and the controller coordinates application logic and database interactions.

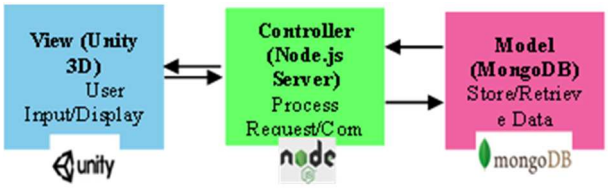

Fig. 1. MVC Architecture for Food Villain

The architecture of Food Villain integrates the GPT-3.5 Turbo model into three levels: the Nutrition Quiz, Food Group, and Food Recipe levels (Figure 2a). The model processes both user-generated and code-generated prompts to provide relevant outputs. The game's four levels, each designed to impart nutrition lessons in an engaging way, use persuasive strategies such as points, feedback, rewards, and authority to enhance motivation and learning retention, as research shows these strategies encourage positive behavior change [11].

In level one, players embark on an adventure shooter game where they identify healthy foods and eliminate junk food enemies. Tips throughout the game prepare them for the next level. Level two introduces a nutrition quiz, where the GPT-3.5 Turbo model offers support by pausing the timer and allowing users to access hints, with incorrect answers prompting detailed explanations (Figure 2b). A passing score is required to progress to the next level.

Level three features a timed food categorization game, where players sort items into groups like carbohydrates, proteins, and fats. GPT-3.5 Turbo model enhances this level by providing post-level fun facts about one of the food groups, randomly selected to enrich players' knowledge (Figure 2b).

The fourth level, a food recipe game, allows players to create a dish within a set time. GPT-3.5 Turbo model offers guidance by generating recipes based on user-selected items from a menu dropdown, enhancing engagement and providing practical skills (Figure 2b). Each level progressively increases interactivity and complexity, which research suggests improves learning outcomes and engagement [10]. The culturally relevant content, such as Black avatars and African food items, further enhances relatability and behavior change potential among African international students [12].

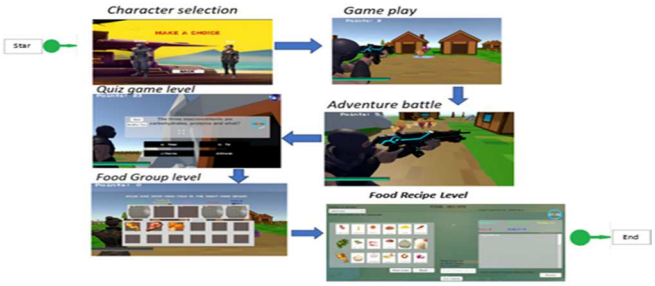

Fig. 2a. Game Levels of Food Villains

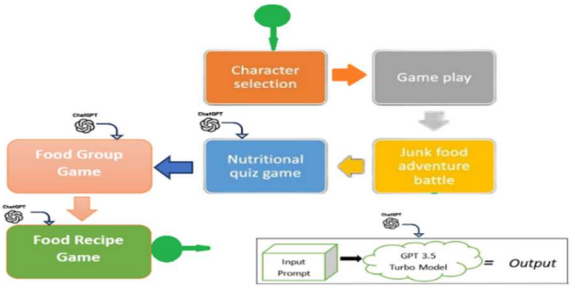

Fig. 3b. Architecture of Food Villains

IV. Evaluation Of Food Villain

The evaluation of Food Villain was a comprehensive process aimed at understanding user experiences and perceptions of the game. This evaluation was crucial for assessing the game's effectiveness in promoting healthy eating habits among African international students and identifying areas for improvement. To carry out the evaluation, a detailed survey was administered to participants who played the game. The survey was designed to capture various aspects of the user experience, focusing on key metrics such as ease of use with questions such as *"I think that I would like to use this game frequently"* [14], perceived usefulness with questions such as "*Using Shadow/SHADE in my therapy would enable me to learn strategies more quickly*" [14], engagement with questions such as "*I lose track of time*" [14], aesthetics with questions such as *"The playing environment was visually appealing."* [15], and quality of information with questions such as "*The game scenario had relevance to the issue of communication skills development*" [15]. The study was approved by the ethics board of our University.

A. Survey Design And Development

The survey includes both quantitative questions, using 5-point Likert scales to measure agreement, and qualitative questions for detailed feedback. The survey was administered through Qualtrics, an online tool that efficiently distributed the survey to participants who had played the game. Qualtrics also provided secure data collection, storage, and analysis, ensuring participant privacy and confidentiality throughout the process. This approach enabled comprehensive insights into user experiences with the game. All questions were adapted from existing, previously validated scales [14], [15].

A. Inclusion Criteria

Only responses from the 24 participants who completed both the gameplay session and the survey were included in the analysis. This ensured that the feedback provided was based on firsthand experience with the game. Additionally, participants were required to provide consent for their responses to be used for research purposes in accordance with ethical guidelines.

The survey targeted participants who are at least 18 years old and are African International Students who occasionally play games to take part in the survey. Participants were recruited from the network cycle of the authors who belong to the black community such as in worship centres, Africans in Kelowna group, and via email. Since Food Villain is specifically targeted toward Black African international students, the only demographic criterion for participation in the study was identification as Black and of African descent. This focus allowed the game design to center on cultural relevance and inclusivity without tailoring the study based on gender or age, as these factors were not expected to significantly impact the effectiveness of the game's content or objectives.

B. Metrics Measured

The survey measured several key metrics to evaluate the user experience with Food Villain, as shown in Table 1. These metrics are:

Ease of Use: This metric assessed how easily participants could navigate and interact with the game. Questions focused on the intuitiveness of the game controls, the clarity of instructions, and the overall user-friendliness of the game interface. Understanding ease of use was critical for identifying any potential barriers to gameplay and ensuring that the game was accessible to all users [14].

Perceived Usefulness: This metric evaluated the extent to which participants believed that the game was beneficial for their understanding of healthy eating. Questions in this category explored whether participants felt that the game provided valuable information about nutrition and if they believed it could positively influence their dietary habits. Assessing perceived usefulness helped determine the game's effectiveness as an educational tool [14].

Engagement: Engagement measured how involved and interested participants were while playing the game. Questions assessed the level of interest, motivation, and immersion experienced by participants during gameplay. High levels of engagement are essential for ensuring that players remain interested in the game and absorb the educational content effectively [14].

Aesthetics: This metric focused on the visual and auditory appeal of the game. Questions evaluated participants' perceptions of the game's graphics, design, and overall aesthetic quality. Aesthetics play a significant role in creating an enjoyable and immersive gaming experience, which can enhance the overall effectiveness of the game [15].

Quality of Information: This metric assessed the accuracy, relevance, and comprehensiveness of the nutritional information presented in the game. Questions explored whether participants found the information credible and if it enhanced their knowledge of healthy eating. High-quality information is crucial for ensuring that the game meets its educational objectives and provides reliable guidance to players [15].

C. Data Analysis

Once the survey responses were collected, the data were analyzed using various statistical and qualitative analysis techniques. The quantitative data from Likert scale questions were analyzed using descriptive statistics to summarize the central tendencies and distributions of participants' responses. Additionally, inferential statistics were employed to identify significant differences and relationships between different metrics. The qualitative data from the open-ended questions were analyzed using thematic analysis. This involved identifying common themes and patterns in participants' feedback, which provided deeper insights into their experiences and suggestions for improvement. The combination of quantitative and qualitative analysis allowed for a comprehensive evaluation of Food Villain and informed recommendations for enhancing the game. The detailed survey and rigorous analysis provided a thorough understanding of how Food Villain was perceived by African international students. This evaluation was crucial for identifying strengths and areas for improvement, ultimately guiding the development of more effective and engaging serious games for health education.

V. RESULT

To evaluate the effectiveness of Food Villain, we employed a five-point Likert scale, with responses ranging from 1 (strongly disagree or very unappealing) to 5 (strongly agree or very appealing). The constructs of interest were assessed using validated measures tailored to capture user perceptions, including engagement, appeal, and overall effectiveness. The insights derived from the survey results were analyzed to inform decisions on future improvements and refinements of the game. The Likert scale, as introduced by [16] was adopted, remains a widely used approach for gauging attitudes and perceptions in research settings.

A. Metrics Measured

The Ease of Use results, as seen in Table 1, provide insights into users' perceptions of the game's accessibility and complexity. For frequent use, 28.0% strongly agree, and 52.0% agree, indicating a high willingness to use the game regularly. Regarding the game's complexity, 8.0% strongly agree that it was unnecessarily complex, while 32.0% agree, suggesting some users found the game somewhat complex, though 44.0% disagree with this statement, implying most do not find it overly complicated. In terms of ease of use, 40.0% strongly agree and 28.0% agree that the game was easy to navigate. Only 8.0% strongly agree and 24.0% agree that they would need technical support, with 24.0% disagreeing and 12.0% strongly disagreeing, indicating that most users feel capable of using the game independently. For confidence in using the game, 36.0% strongly agree and another 36.0% agree, reflecting a general comfort with its interface. In general, most find the game easy to use, well-integrated, and feel confident navigating it independently.

Table 1: METRICS MEASURED

	Questions	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Ease of Use	I think that I would like to use this game Frequently.	28%	52%	12%	4	4%
	I found the game was unnecessarily complex.	8%	32%	8%	44%	8%
	I thought the game was easy to use.	40%	28%	20%	12%	0%
	I think that I would need the support of a technical person to be able to use this game.	8%	24%	32%	24%	12%
	I felt very confident using the game.	36%	36%	28%	0%	0%
	I found that the various functions in the game were well-integrated.	36%	32%	20%	12%	0%
Engagement	I really got into the game while playing.	16.7%	58.3%	25%	0%	0%
	I lose track of time while playing the game.	8.3%	33.3%	45.8%	12.5%	0%
	I get wound up while playing the game.	8.3%	16.7%	37.5%	33.3%	4.2%
	My thoughts go fast while playing the game.	12.5%	29.2%	45.8%	8.3%	4.2%
	I can't tell that I'm getting tired while playing the game.	12.5%	25%	33.3%	29.2%	0%
	I play longer than I meant to.	12.5%	20.8%	41.7%	25%	0%
Perceived Usefulness	Using the game for healthy nutrition would enable me to achieve the target behavior more quickly.	37.5%	54.2%	4.2%	0%	4.2%
	Using the game would make it easier to participate in frequent healthy eating.	50%	37.5%	8.3%	0%	4.2%
	I would find the game useful in my routine for healthy eating.	41.7%	37.5%	8.3%	8.3%	4.2%
	Using the game frequently would enhance my knowledge of healthy eating.	37.5%	54.2%	0%	4.2%	4.2%
	Using the game would improve my motivation to make healthier food choices.	29.2%	58.3%	8.3%	0%	4.2%
	Using the game frequently would be a helpful tool in promoting healthy eating habits.	29.2%	62.5%	4.2%	0%	4.2%
Aesthetics	Is the arrangement and size of buttons/icons/menus/content on the screen appealing?	12.5%	45.8%	20.8%	16.7%	4.2%
	How high is the quality/resolution of graphics used for buttons/icons/menus/content?	16.7%	50%	16.7%	12.5%	4.2%
	How good does the game look?	12.5%	66.7%	16.7%	0%	4.2%
	The playing environment was visually appealing.	20.8%	62.5%	8.3%	4.2%	4.2%
	I can identify with the characters in the game, and it appeals to me.	29.2%	33.3%	25%	4.2%	8.3%
	I can identify with the story/scenario in the game, and it appeals to me.	25%	50%	16.7%	4.2%	4.2%
Quality of Information6	Does the game contain what is described?	54.2%	29.2%	12.5%	4.2%	0%
	Does the game have specific, measurable, and achievable goals?	20.8%	66.7%	8.3%	4.2%	0%
	Is the game content correct, well-written, and relevant to the goal/topic of the game?	37.5%	50%	4.2%	8.3%	0%
	Is the visual explanation of concepts in the game– through images – clear, logical, correct?	25%	58.3%	8.3%	8.3%	0%
	Is the extent of coverage of healthy eating within the scope of the game comprehensive and concise?	16.7%	70.8%	0%	12.5%	0%
	Did you find the nutritional information provided within the game helpful?	41.7%	37.5%	20.8%	0%	0%

The engagement results, as seen in Table 1, show that Food Villain captures players' interest to a significant degree, with a majority agreeing they were absorbed in the game (58.3% "Agree" or "Strongly Agree" on getting into the game). However, a more varied response was observed for other engagement indicators. About 33.3% reported losing track of time, while a large proportion (45.8%) felt neutral about this, indicating moderate immersion. For items relating to emotional arousal, like getting wound up and thoughts going fast, only a small percentage strongly agreed, suggesting lower levels of intense engagement. A noticeable portion of participants were neutral on these measures, and there were also notable percentages of disagreement, particularly for the items about playing longer than intended (25% disagreed) and not feeling tired while playing (29.2% disagreed). This implies that while Food Villain engages players, it may not create a strong sense of flow or time-distortion effects typically associated with deeply immersive games.

The perceived usefulness results, as seen in Table 1, show that users have distinct levels of agreement regarding the game's impact on healthy nutrition practices. Specifically, 37.5% strongly agree that using the game would help them achieve the target behavior more quickly, while 54.2% agree with this statement. For making frequent healthy eating easier, 50.0% strongly agree and 37.5% agree. In terms of the game's usefulness in users' routines for healthy eating, 41.7% strongly agree and 37.5% agree. For promoting healthy eating habits over time, 29.2% strongly agree that the game would be a helpful tool, with 62.5% agreeing. These results indicate that the majority of users find the game valuable across various aspects of supporting healthy nutrition, with a slightly higher proportion agreeing rather than strongly agreeing across most statements.

Aesthetics were well-received. The majority found the arrangement and size of on-screen elements, graphic resolution, and overall visual quality appealing, with 45.8% to 66.7% rating these aspects as either "Appealing" or "Very appealing" as seen in Table 1. The playing environment was especially well-received, with 62.5% of participants rating it as visually appealing. Some participants (25%) remained neutral or found these elements less engaging. While the game's visual appeal is strong, further refinement in character and storyline relatability could enhance player connection with the game.

The quality of information provided by Food Villain was highly regarded as seen in Table 1. Most participants responded positively, especially to statements regarding the helpfulness of nutritional information (Statement 6), the comprehensiveness of healthy eating coverage (Statement 5), and the clarity of visual explanations (Statement 4). For example, 70.8% of respondents agreed or strongly agreed with the extent of healthy eating coverage, and 66.7% agreed or strongly agreed with the helpfulness of nutritional information. However, responses to goal-setting (specificity, measurability, and achievability) were slightly less favorable, with fewer participants strongly agreeing (20.8%) and some expressing neutrality. This indicates a need to clarify game objectives for players. Food Villain appears to be well-received for its quality of information, particularly in its nutritional content and visual explanations. Improving clarity in the game goals and enhancing interactivity could further optimize user experience and engagement.

B. Word-Cloud and Sentiments Analysis of Open-Ended Questions

As stated earlier, the Qualtrics survey tool was used for this study. It has an inbuilt functionality capable of performing statistical evaluation, and Word-cloud seeding from user responses.

The first open-ended question (OEQ1) asked the participants "What aspects of Food Villain in their opinion need to be improved?"

Fig. 8. Word Cloud of OEQ1 (Open-Ended Question 1)

Figure 8, captures the word cloud of the sentiments from OEQ1 expressed by the participants e.g. a respondent mentioned "Graphics", "The calculation of calories of each food could be automated rather than click of each ingredient", "I think a user needs an introduction to the game, a step-by-step guide on how to pay it and what they stand to get out of the game..." which suggest that it needs to be improved. Furthermore, based on the word cloud and responses from OEQ1, participants have highlighted various aspects of Food Villain that they believe need improvement. Beyond graphics, they emphasized aspects such as user interaction and guidance, suggesting enhancements to enhance the overall user experience. The mention of "player" may imply a desire for more personalized features, indicating a need for player-centric elements within the game.

Fig. 9. Word Cloud of OEQ2 (Open-Ended Question 2)

The second open-ended question (OEQ2) asked the participants "What are their overall thoughts and impressions about Food Villain?"

Figure 9 captures the word cloud from OEQ2 expressed by the participants. The sentiments from OEQ2 were more positively inclined e.g. respondents mentioned that "I like it and all of the food information", "It's very appealing", and "It's fascinating and addictive for correctional health purposes" which suggests that it educates its audience, it is aesthetically appealing and for health behavioral change. The word cloud from OEQ2 shown in Figure 9, suggests that participants generally hold positive views about Food Villain, emphasizing its benefits, usefulness, and contribution to nutrition education. The presence of words like "good," "healthy," and "useful" indicates that participants perceive the game positively and appreciate its value in promoting healthy eating habits. Additionally, the mention of "benefit" suggests

that participants recognize the advantages or advantages of using the game.

VI. Discussion

The findings from the study indicate a mixed reception among participants, revealing both positive and negative sentiments towards the serious game Food Villain. Participants appreciated the educational content and perceived usefulness of the game in promoting healthy eating habits. This aligns with previous research that highlights the effectiveness of serious games in fostering behavior change, especially in nutrition education [17]. However, concerns were raised about certain aspects, such as graphics and user interface, echoing similar challenges reported in studies focusing on user experience and engagement in health-related serious games [18]. The analysis of the open-ended questions provided additional insights into specific areas for improvement and emphasized the need for enhancements in user interaction, guidance, and the information provided within the game. This is consistent with findings from studies like [19], which emphasizes the importance of usability and clear guidance in health applications to improve user satisfaction and adherence. The positive sentiments expressed in response to the educational content highlight the potential of Food Villain as an effective tool for nutrition education and behavior change. However, addressing the identified areas for improvement, such as visual enhancements and content enrichment, is crucial to maximizing the game's effectiveness and enhancing user engagement. Implementing feedback mechanisms within the game, such as user surveys and in-game feedback options, could facilitate ongoing improvements and ensure that future updates align with user expectations and preferences. This approach is supported by findings from [20], which suggests that continuous user feedback is vital for the iterative development of digital health tools.

A. Comparison of Results with Previous Studies

The results of Food Villain demonstrate both alignment with and divergence from previous studies on serious games for health and nutrition education. Similar to games like Junk Food Destroyer and PEGASO, Food Villain effectively utilized persuasive strategies such as feedback, rewards, and goal-setting to encourage healthier dietary habits among players. Studies on Junk Food Destroyer highlighted its ability to engage users by rewarding healthy food choices, while PEGASO leveraged gamification to motivate long-term behavior change through personalized dietary feedback [8] [7]. In line with these findings, participants in Food Villain reported high levels of perceived usefulness and found the nutritional information educational, reinforcing the value of integrating these strategies into serious games. However, while previous studies often achieved strong engagement through immersive storytelling and highly interactive gameplay [21], Food Villain showed moderate engagement levels. For instance, a significant portion of participants remained neutral about losing track of time during gameplay, suggesting that the game lacked the deep immersion observed in titles like Re-Mission or Squire's Quest! [22] [4]. This difference may stem from the simpler narrative structure and fewer interactive elements in Food Villain, highlighting areas for potential enhancement.

B. Limitations of the Study

One significant challenge was the difficulty in recruiting participants from the target demographic of African international students. This group often experiences competing academic priorities and time constraints, which limited their availability to participate fully in the study. As a result, the sample size was relatively small, potentially impacting the generalizability of the findings. Additionally, the limited timeframe for gameplay sessions may not have allowed participants to fully explore and engage with the game's features. Studies have shown that prolonged exposure to educational games often leads to deeper learning and more reliable behavior changes [23]. Despite these limitations, the study provides meaningful insights into the potential of culturally relevant serious games to promote healthy eating habits. Future research will aim to address these constraints by exploring alternative recruitment strategies, expanding the participant pool through platforms like Amazon Mechanical Turk to enhance data reliability and impact.

C. Implication Of Results

The survey analysis of Food Villain identified key improvements to enhance user experience, engagement, and educational value, supporting healthier eating habits among African international students. User Interface (UI) updates were highlighted as essential, as some participants found navigation challenging. Studies show an intuitive UI is crucial for serious games' success [21] [22]. Recommended updates include refined navigation, clearer instructions, and a tutorial to reduce frustration. Engagement improvements are also critical, as some players found the game less immersive. Research suggests adding mini-games, personalized challenges, and evolving storylines can boost user engagement [23]. Visuals could be enhanced with better graphics and animations to increase immersion, as high-quality visuals improve educational appeal [24]. Expanding Educational Content would further enrich learning with updated, culturally relevant nutrition information providing a comprehensive experience [25]. Feedback Mechanisms like in-game options and periodic surveys would capture user preferences for ongoing improvement [26]. Personalization options, allowing players to choose avatars, set goals, and track progress, are also recommended to boost relevance, as personalized experiences can enhance digital interventions [27]. Adding Community Features such as leaderboards, forums, and challenges would strengthen motivation through social support, which is essential in behavior change [28]. Addressing Technical Issues via regular updates and optimizing game performance across devices is crucial for user satisfaction [29]. These updates are anticipated to enhance Food Villain's impact on promoting healthy eating, fostering long-term engagement, and improving health outcomes among African international students' life.

VII. Conclusion

The evaluation of Food Villain in the study provided valuable insights into the game's effectiveness in promoting healthy eating habits among African international students. Through the analysis of user reviews and survey responses, several key findings emerged. Participants expressed positive sentiments regarding the perceived usefulness and educational content of the game, highlighting its potential as a tool for nutrition education and behavior change. However, concerns were raised about aspects such as ease of use, engagement, and aesthetics, indicating areas for improvement to enhance the

overall user experience. The results of the survey, particularly the averages of the five distinct metrics (Ease of Use, Perceived Usefulness, Engagement, Aesthetics, and Quality of Information), further emphasized the need for refinements in user interface design, interactive features, and visual appeal. Recommendations were made for enhancing Food Villain, including user interface enhancements, introduction of additional interactive features, visual improvements, content enrichment, and implementation of feedback mechanisms. By addressing these recommendations and continuously refining the game based on user feedback, developers can ensure that Food Villain remains a valuable resource for promoting healthy eating habits among African international students.

REFERENCES

[1] A. A. Tori, R. Tori, and F. D. L. D. S. Nunes, "Serious Game Design in Health Education: A Systematic Review," *IEEE Trans. Learning Technol.*, vol. 15, no. 6, pp. 827–846, Dec. 2022, doi: 10.1109/TLT.2022.3200583.

[2] F. Bellotti, R. Berta, and A. De Gloria, "Designing Effective Serious Games: Opportunities and Challenges for Research," *International Journal of Emerging Technologies in Learning (iJET)*, vol. 5, no. SI3, p. 22, Nov. 2010, doi: 10.3991/ijet.v5s3.1500.

[3] K. Tiedje *et al.*, "A focus group study of healthy eating knowledge, practices, and barriers among adult and adolescent immigrants and refugees in the United States," *Int J Behav Nutr Phys Act*, vol. 11, no. 1, p. 63, Dec. 2014, doi: 10.1186/1479-5868-11-63.

[4] D. Thompson, R. Bhatt, M. Lazarus, K. Cullen, J. Baranowski, and T. Baranowski, "A Serious Video Game to Increase Fruit and Vegetable Consumption Among Elementary Aged Youth (Squire's Quest! II): Rationale, Design, and Methods," *JMIR Res Protoc*, vol. 1, no. 2, p. e19, Nov. 2012, doi: 10.2196/resprot.2348.

[5] K. L. Schneider *et al.*, "Acceptability of an Online Health Videogame to Improve Diet and Physical Activity in Elementary School Students: 'Fitter Critters,'" *Games for Health Journal*, vol. 1, no. 4, pp. 262–268, Aug. 2012, doi: 10.1089/g4h.2012.0009.

[6] B. Pilli and J. Slater, "Food Experiences and Dietary Patterns of International Students at a Canadian University," *Canadian Journal of Dietetic Practice and Research*, vol. 82, no. 3, pp. 100–106, Sep. 2021, doi: 10.3148/cjdpr-2021-006.

[7] P. Hatzigiannakoglou, "Junk-Food Destroyer: Helping Adolescents with Down Syndrome to Understand Healthy Eating through Serious Game," in *2015 7th International Conference on Games and Virtual Worlds for Serious Applications (VS-Games)*, IEEE, Sep. 2015, pp. 1–5. doi: 10.1109/VS-GAMES.2015.7295778.

[8] M. Caon *et al.*, "PEGASO e-Diary: User Engagement and Dietary Behavior Change of a Mobile Food Record for Adolescents.," *Front Nutr*, vol. 9, p. 727480, 2022, doi: 10.3389/fnut.2022.727480.

[9] C. W. E. Chai, B. T. Lau, M. K. T. Tee, and A. Al Mahmud, "Evaluating a serious game to improve childhood cancer patients' treatment adherence," *DIGITAL HEALTH*, vol. 8, p. 205520762211344, Jan. 2022, doi: 10.1177/20552076221134457.

[10] J. Hamari, J. Koivisto, and H. Sarsa, "Does Gamification Work? -- A Literature Review of Empirical Studies on Gamification," in *2014 47th Hawaii International Conference on System Sciences*, Waikoloa, HI: IEEE, Jan. 2014, pp. 3025–3034. doi: 10.1109/HICSS.2014.377.

[11] M. Sailer, J. Hense, H. Mandl, and M. Klevers, "Psychological Perspectives on Motivation through Gamification," *IxD&A*, no. 19, pp. 28–37, Dec. 2013, doi: 10.55612/s-5002-019-002.

[12] O. Oyebode and R. Orji, "Persuasive strategy implementation choices and their effectiveness: towards personalised persuasive systems," *Behaviour & Information Technology*, vol. 42, no. 13, pp. 2176–2209, Oct. 2023, doi: 10.1080/0144929X.2022.2112612.

[13] R. B. Cialdini and N. J. Goldstein, "The Science and Practice of Persuasion," *Cornell Hotel and Restaurant Administration Quarterly*, vol. 43, no. 2, pp. 40–50, Apr. 2002, doi: 10.1177/001088040204300204.

[14] G. Hookham, K. Nesbitt, and F. Kay-Lambkin, "Comparing usability and engagement between a serious game and a traditional online program," in *Proceedings of the Australasian Computer Science Week Multiconference*, Canberra Australia: ACM, Feb. 2016, pp. 1–10. doi: 10.1145/2843043.2843365.

[15] J. Moizer *et al.*, "An approach to evaluating the user experience of serious games," *Computers & Education*, vol. 136, pp. 141–151, Jul. 2019, doi: 10.1016/j.compedu.2019.04.006.

[16] K. Batterton and K. Hale, "The Likert Scale What It Is and How To Use It," *Military Operations Research Society*, vol. 50, pp. 32-39 (8 pages), Jun. 2017.

[17] T. Baranowski, C. Ryan, A. Hoyos-Cespedes, and A. S. Lu, "Nutrition Education and Dietary Behavior Change Games: A Scoping Review," *Games for Health Journal*, vol. 8, no. 3, pp. 153–176, Jun. 2019, doi: 10.1089/g4h.2018.0070.

[18] R. De Croon, D. Wildemeersch, J. Wille, K. Verbert, and V. Vanden Abeele, "Gamification and Serious Games in a Healthcare Informatics Context," in *2018 IEEE International Conference on Healthcare Informatics (ICHI)*, New York, NY: IEEE, Jun. 2018, pp. 53–63. doi: 10.1109/ICHI.2018.00014.

[19] L. Sardi, A. Idri, and J. L. Fernández-Alemán, "A systematic review of gamification in e-Health," *Journal of Biomedical Informatics*, vol. 71, pp. 31–48, Jul. 2017, doi: 10.1016/j.jbi.2017.05.011.

[20] J.-W. Liu, C.-Y. Ho, J. Y. T. Chang, and J. C.-A. Tsai, "The role of Sprint planning and feedback in game development projects: Implications for game quality," *Journal of Systems and Software*, vol. 154, pp. 79–91, Aug. 2019, doi: 10.1016/j.jss.2019.04.057.

[21] M. J. Gomez, J. A. Ruipérez-Valiente, and F. J. G. Clemente, "A Systematic Literature Review of Game-Based Assessment Studies: Trends and Challenges," *IEEE Trans. Learning Technol.*, vol. 16, no. 4, pp. 500–515, Aug. 2023, doi: 10.1109/TLT.2022.3226661.

[22] A. Sutcliffe, "Designing for User Experience and Engagement," in *Why Engagement Matters*, H. O'Brien and P. Cairns, Eds., Cham: Springer International Publishing, 2016, pp. 105–126. doi: 10.1007/978-3-319-27446-1_5.

[23] Z. Menestrina, A. Pasqualotto, A. Siesser, P. Venuti, and A. De Angeli, "Engaging Children in Story Co-Creation for Effective Serious Games," *Sustainability*, vol. 13, no. 18, p. 10334, Sep. 2021, doi: 10.3390/su131810334.

[24] J. Byun and C. S. Loh, "Audial engagement: Effects of game sound on learner engagement in digital game-based learning environments," *Computers in Human Behavior*, vol. 46, pp. 129–138, May 2015, doi: 10.1016/j.chb.2014.12.052.

[25] G. Li and J. Liu, "Improving physical education through innovative multimedia learning platform and data-driven instruction," *Soft Comput*, vol. 28, no. 2, pp. 1567–1584, Jan. 2024, doi: 10.1007/s00500-023-09436-7.

[26] Y. X. Lukic, C.-H. (Iris) Shih, A. Hernandez Reguera, A. Cotti, E. Fleisch, and T. Kowatsch, "Physiological Responses and User Feedback on a Gameful Breathing Training App: Within-Subject Experiment," *JMIR Serious Games*, vol. 9, no. 1, p. e22802, Feb. 2021, doi: 10.2196/22802.

[27] B. J. Fogg, Gregory Cuellar, and David Danielson, "Motivating, influencing, and persuading users: An introduction to captology.," pp. 159–173, 2007.

[28] D. King, F. Greaves, C. Exeter, and A. Darzi, "'Gamification': Influencing health behaviours with games," *J R Soc Med*, vol. 106, no. 3, pp. 76–78, Mar. 2013, doi: 10.1177/0141076813480996.

[29] V. Kasapakis and D. Gavalas, "Pervasive gaming: Status, trends and design principles," *Journal of Network and Computer Applications*, vol. 55, pp. 213–236, Sep. 2015, doi: 10.1016/j.jnca.2015.05.009.