

Market-oriented Development of a Digital Board Game Using Interactive Quick Response Code Sensing to Promote Healthy Eating

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In this study, we applied a design-based research methodology to develop “*Eat Healthy*,” a digital board game that promotes healthy eating. The game was designed as a digital event card system, supported by a web-based platform for card drawing. An innovative feature of this research is the integration of tablet and smartphone sensors into board gameplay, expanding the possibilities for interactive learning and user engagement. By aligning with the principles of Environmental, Social, and Governance, and Sustainable Development Goals, this approach also explores pathways for embedding sustainability into the board game industry. In this study, we endeavored to raise participants’ awareness of the six key nutrients and their optimal dietary proportions, while concurrently examining players’ attitudes toward the use of sensor-based mechanisms in board games. To evaluate the effectiveness and user satisfaction of this digital board game, we employed a five-point Likert scale questionnaire survey, selecting 38 university students as research participants, who were divided into groups, with each group provided a tablet. They scanned a QR code to access the “*Eat Healthy*” digital-event-card-drawing webpage, replacing traditional paper-based card drawing with a digital method. Questionnaire data revealed that the board game effectively promoted awareness of healthy eating among players, who also expressed considerable enjoyment of this novel gameplay approach. Future recommendations include increasing game difficulty and diversity to boost engagement and interactivity, along with adding an offline mode for drawing digital event cards without an internet connection to improve accessibility.

1. Introduction

Diet and health constantly affect people’s daily lives. The Ministry of Health and Welfare of the Republic of China⁽¹⁾ and the Health Promotion Administration^(2,3) have emphasized the

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promotion of proper eating habits and the importance of a balanced diet as key policy directions. They recommend adhering to the Dietary Guidelines for Taiwanese to ensure the adequate daily intake of essential nutrients (the six major food groups: whole grains; vegetables; dairy products; legumes, fish, eggs, and meat; fats, nuts, and seeds; and fruits) and promote the “3 Highs, 3 Lows, and 3 Balances” principle to help the public reduce the risk of chronic diseases.

In a study, the most critical factor identified was the need to understand how daily dietary habits affect one’s health.⁽⁴⁾ In the National Nutrition and Health Report, Ou⁽⁵⁾ found that the rising issue of adolescent obesity stemmed from a lack of knowledge about healthy eating. In response, a card-based board game combined with classroom teaching was designed to teach healthy dietary concepts in a fun and engaging way, helping students adjust their eating habits.

Similarly, Hwang *et al.*⁽⁶⁾ developed a nutrition-themed board game that fosters interactive competition, encouraging learners to think critically and enjoy learning about balanced diets while cultivating healthy behavioral habits. In addition, Chao *et al.*⁽⁷⁾ also highlighted the importance of dietary health and developed a board game focused on learning about the six major nutrient groups and related dietary knowledge. This game is suitable for a wide range of age groups, from children aged 10 and above to the elderly, providing an entertaining and educational approach to learning about health. Therefore, in this study, we integrated information technology into a board game design to create a product that meets market demand and enhances learners’ knowledge of health and nutrition.

The interaction modes of board games are diverse. Through cooperation, competition, probing, communication, and even conflict during gameplay, board games enhance interpersonal communication. Games that require skill and challenge encourage players to focus on game tasks, which helps activate brain functions and promotes social engagement.^(8–10) The interactive relationship between digital technology and board games can be categorized into three types: (1) Digital Boards, which rely on computer screens to present visual experiences and enhance engagement—for example, projected chess or electronic music tables. (2) Digital Accessories, which involve interactions between digital accessories and the game board to produce audiovisual effects, such as laser chess or miniature robots; and (3) Mobile Devices, which combine board games with mobile devices and technological applications to extend the experience, including apps, QR codes, or augmented reality.⁽¹¹⁾ Lu *et al.*⁽¹²⁾ designed a marine education board game that integrated QR codes and applied it to elementary and junior high school students. The results showed that the students exhibited a high level of interest in the game, indicating that QR code integration helped enhance learning motivation and participation. Similarly, Chao *et al.*⁽¹³⁾ conducted a study with nursing students using a chronic disease assessment tool that combined smartphones and QR codes. The findings revealed that the students generally felt the tool supported self-directed learning and were satisfied with the learning outcomes, affirming the value of QR code applications in healthcare education.

Currently, QR code technology is widely applied in daily life owing to its high versatility, ease of use, multiple application formats, and good interactivity. With just a smartphone scan,

users can access websites, videos, or multimedia content, making it more convenient than traditional digital games requiring computer hardware and screens. Taken together, these studies suggest that integrating digital technology with board game design—especially through simple tools such as QR codes—not only enhances interactive learning but also improves the integration of education and entertainment. Therefore, in this study, we adopted mobile devices and QR codes as digital tools for board game integration to align with current market trends. Furthermore, we introduced an innovative concept: the integration of tablet and smartphone sensors into the design of board games. In the context of the growing emphasis on ESG principles and the UN Sustainable Development Goals (SDGs), this study aligns with SDGs 12 and 13, which focus on reducing resource waste, conserving energy, and lowering carbon emissions to achieve ecological and environmental protection goals. It adheres to the principles of green design and the circular economy, enhances resource-use efficiency, and reduces waste and ecological damage. On the basis of these principles, digital event cards were designed to support sustainable development and overall social well-being.^(14–16) Traditional board games often rely on resource-intensive printing processes to produce aesthetically appealing cards, which not only incurs high costs but also raises environmental concerns and scalability limitations. Additionally, the loss of even a single card can render an entire game unplayable. To address these challenges, we propose a digital alternative whereby cards are generated dynamically through QR code scanning, allowing for continuous updates and adaptability. Such a mechanism has the potential to fundamentally transform board game design practices and represents a significant step forward in the evolution of the industry.

Brown⁽¹⁷⁾ proposed design-based research (DBR), emphasizing a macro perspective of the entire research process. In the preparation stage, steps such as problem identification, needs assessment, and prototype design are carried out systematically. During the implementation stage, continuous testing and revision help optimize the design, followed by evaluation and dissemination. This cycle of “design–implementation–testing–redesign” is the core feature of DBR.⁽¹⁸⁾ The DBR framework, combined with design thinking, has been applied to develop effective tools such as augmented reality board games and RPG-style digital materials on online safety for children. This approach includes four iterative design phases: analysis, design, testing, and evaluation.^(19,20) In this study, we followed the same methodology, ensuring during the testing and evaluation phases that prior steps are revisited and refined as needed. This approach ensures that the digital board game design aligns with both research objectives and market demands.

2. Research Purpose

The purpose of this study is to develop a digital board game focused on healthy eating using the DBR model. The focus of this board game is to draw players’ attention to the six major nutrients and their appropriate proportions in the diet, with an emphasis on assessing players’

attitudes. In addition, it aims to explore players' perceptions of the effects of incorporating sensors into the board game.

3. Research Method

3.1 “Eat Healthy” digital board game

Developed using the DBR approach, this digital board game was designed through literature analysis, interviews, and multiple testing phases (α and β testing) (Fig. 1). Three gameplay modes with varying complexity were created: a matching game, a puzzle game, and a full-version gameplay that integrates a game map. The gameplay procedure for the full version of the game is described as follows. Initially, a set of Nutrient Cards [Fig. 2(a)] is shuffled and placed face down at random locations on the inner spaces of the Game Map [Fig. 2(b)]. Each participant is required to select a token and position it on the designated starting point, indicated by the red square. Subsequently, each player selects a Personal Plate [Fig. 2(c)]. During each turn, a player rolls two dice and advances their token clockwise by a number of spaces equal to the sum of the dice. Upon landing on a given space, the following actions are executed:

- (1) Green Space: Two Nutrient Cards are flipped. If the two cards are identical, one corresponding Nutrient Puzzle piece (of any shape) [Fig. 2(d)] is collected by the player. If the cards do not match, they are returned face down to their original positions.
- (2) Orange Space: A Digital Event Card [Fig. 2(e)] is drawn via the tablet, and the instructions provided on the card are carried out. Digital event cards feature different themes, and each theme includes both positive and negative events. For example, under the Balanced Diet theme, a positive event can be using fresh ingredients, whereas a negative event can be frequently consuming high-fat, high-salt foods. Drawing a positive event may allow the player to earn a nutrient puzzle piece or move forward a few steps, whereas drawing a negative event may cause the player to lose a nutrient puzzle piece or move backward a few steps.

Once all Nutrient Cards on the Game Map have been collected, a new set of cards is deployed, and gameplay resumes accordingly. The player who collects the most complete nutrient puzzle pieces scores the highest and wins. The board game is suitable for players aged 10 and above, including older adults, and the gameplay can be adjusted on the basis of promotion duration and specific needs (Fig. 3). Additionally, participant satisfaction with the game is assessed through questionnaire surveys.

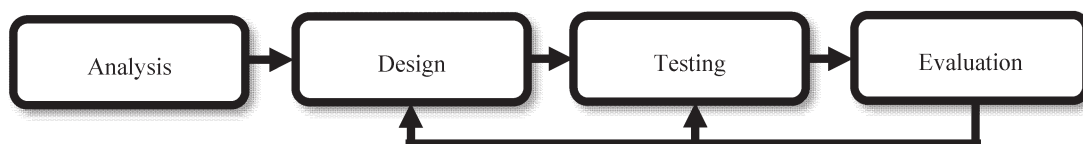


Fig. 1. DBR process.



Fig. 2. (Color online) Digital board game components. (a) Nutrient Cards. Six types of nutrient are arranged from left to right. The top row includes fats, nuts, and seeds; vegetables; and fruits; whereas the bottom row includes fish, eggs, and meat; dairy products; and whole grains. Each set comprises twelve cards, with two cards allocated to each category; these can be organized into three distinct sets. (b) Game Map. The outer track is used for player movement. The inner spaces are for placing Nutrient Cards. (c) Personal Plate. Each player receives one plate, showing different nutrient combinations with a fixed nutrient ratio. Different colors represent different nutrients [refer to Fig. 2(d) for details]. (d) Nutrient Puzzle Pieces. Nutrients are conceptualized as puzzle pieces of diverse shapes, which are assembled onto the Personal Plate to facilitate categorization and learning. Six types of nutrient are arranged from left to right. The top row includes fats, nuts, and seeds (orange-yellow); vegetables (green); and fruits (orange); whereas the bottom row includes dairy products (white); fish, eggs, and meat (blue); and whole grains (brown). (e) Digital Event Card.

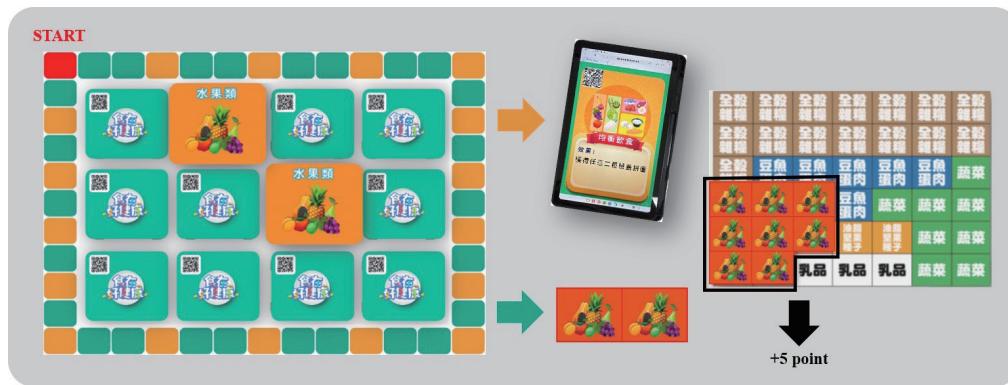


Fig. 3. (Color online) The digital board game was played according to advanced game rules.

3.2 Digital board game promotion activity

This promotional event first introduces the gameplay of the “*Eat Healthy*” game and the usage of digital event cards. Participants use a tablet to scan the QR code on the digital event card, which directs them to the card-drawing webpage. By clicking on each displayed card, they can access detailed nutritional knowledge. In the game, participants refresh the webpage to draw the next card by using the “refresh” function [Figs. 4(a) to 4(d)].

During the group game, the use of tablets allows for smooth digital card drawing and ensures that all participants can clearly view the card content (Figs. 5). Through this process, they learn correct dietary and nutritional concepts, which help enhance their health and immunity. After the activity, participants are also asked to complete a feedback questionnaire, providing valuable insights for this study.

4. Research Tools

A questionnaire survey was used to collect players’ testing opinions, and a five-point Likert scale was used, with “1” to “5” representing “strongly disagree” to “strongly agree,” and the higher the score, the higher the degree of agreement. There were 12 questions in this scale. The preliminary reliability analysis yielded a Cronbach’s alpha of .974, demonstrating the excellent internal consistency of the scale.

5. Participants

This study involved 38 university students, all of whom had prior experience playing board games. More than two-thirds of the participants were female (Table 1).

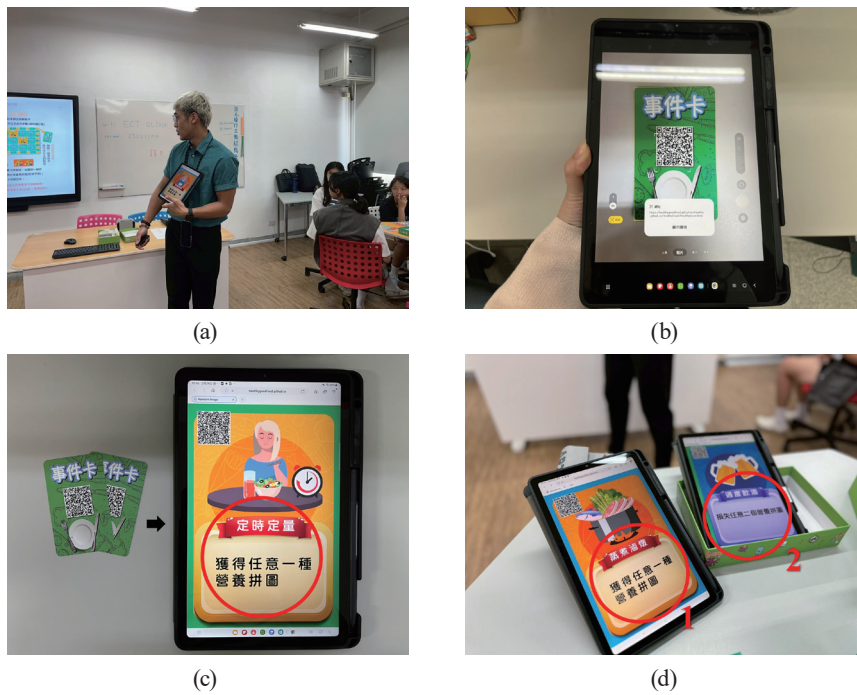


Fig. 4. (Color online) Tablet scans digital event card instructions. (a) Scan Digital Event Card instructions. (b) Scan a Digital Event Card. (c) A Digital Event Card is scanned using a tablet, which directs the player to the corresponding webpage. Chinese in red circle: Regular and balanced meals: Gain any one nutrition puzzle piece. (d) Tablet displays Digital Event Card content. Chinese in red circles: (1) Steaming, boiling, braising, or stewing: Gain any one nutrition puzzle piece. (2) Excessive alcohol consumption: Lose any two nutrition puzzle pieces.



Fig. 5. (Color online) Tablet replaces board game event cards.

Table 1
Gender distribution of research object.

Gender	<i>N</i>	%
Male	11	28.9
Female	27	71.1
Total	38	100.0

6. Results

In this study, we used a five-point Likert scale to assess participants' satisfaction with the board game. Among the 38 participants, 28 valid responses were collected after excluding invalid questionnaires. The results showed an overall satisfaction score of 4.71 out of 5. Players found the font and graphics in the game easy to read (4.82), believed the game was helpful in enhancing their health and nutrition knowledge (4.79), and felt that the gameplay was not difficult, requiring neither excessive time nor effort (4.79) (Table 2).

Participant feedback from the open-ended questionnaire highlighted the benefits of the game's design, including digitalization ("I think digitalizing the cards is great"), convenience ("I find scanning the event cards on the tablet very convenient! No need to handle so many props"), educational engagement ("I think this method is very interesting and hope it can incorporate more aspects, allowing everyone to learn through the game"), diversity and entertainment ("I feel that this scanning board game combines diversity and entertainment"), and accessibility ("The simple and easy-to-use design makes it suitable for all groups").

Table 2
Descriptive statistics of digital board game satisfaction.

	<i>N</i>	Min	Max	Mean	<i>SD</i>
1. I believe digital board games focusing on health and nutrition have valuable educational significance.	28	4	5	4.71	.460
2. Playing this digital board game increases my interest in learning more about health and nutrition.	28	4	5	4.64	.488
3. This digital board game helps clarify how health and nutrition are connected for me.	28	3	5	4.68	.548
4. This digital board game supports my learning in health and nutrition topics.	28	4	5	4.79	.418
5. This game motivates me to further explore information about health and nutrition.	28	3	5	4.71	.535
6. The instructions for the digital board game are straightforward and simple to follow.	28	3	5	4.68	.548
7. I find this digital board game easy to use, and it doesn't require much time or effort.	28	3	5	4.79	.499
8. The text and visual design of this digital board game are generally clear and easy to read.	28	4	5	4.82	.390
9. I enjoy playing this digital board game and would be happy to play it again.	28	4	5	4.71	.460
10. I would suggest this digital board game to friends or enjoy playing it with them.	28	3	5	4.71	.535
11. I'd recommend that relevant organizations adopt this digital board game for use in health and nutrition education.	28	4	5	4.75	.441
12. I'm interested in joining other health- and nutrition-related learning activities in the future.	28	3	5	4.57	.634
Valid N (listwise)	28			4.71	.496

7. Discussion

In this study, we developed and evaluated a market-oriented digital board game aimed at promoting healthy eating through interactive QR code sensing. The primary goals—enhancing nutritional knowledge and assessing user perceptions of sensor integration—were met, as reflected in highly positive participant feedback. The overall satisfaction score of 4.71 out of 5 highlights the game’s strong appeal, while specific ratings for font readability (4.82), usefulness in improving nutrition knowledge (4.79), and ease of gameplay (4.79) confirm its educational effectiveness and user-friendly design.

Qualitative responses further illuminate these findings. Participants praised the digitalization of game elements, particularly the convenience of scanning cards on a tablet, which minimized physical setup and enhanced portability. This aligns with modern digital learning practices and underscores the game’s relevance in contemporary education. Users also valued its ability to blend learning with entertainment, foster engagement, and remain accessible across different age groups and learning styles. The progression of rules from simple to complex was noted as a design strength, ensuring adaptability for diverse learners. This study, similar to that of Chao *et al.*,⁽⁷⁾ emphasizes the importance of healthy dietary nutrients for individuals and finds that integrating board games with technology (such as QR codes and augmented reality) can enhance students’ learning motivation and attitudes. These findings are consistent with the positive results reported by Lu *et al.*,⁽¹²⁾ Chao *et al.*,⁽¹³⁾ and Chao *et al.*⁽¹⁹⁾

The study carries implications for future health education strategies. The positive reception of sensor integration suggests potential for more immersive and impactful learning tools. Results indicate that gamified approaches, when designed for both usability and educational depth, can effectively communicate complex health concepts. Future research should examine long-term effects on dietary behaviors, explore adaptability to other educational contexts, and identify design features most critical for engagement and retention. Overall, this study establishes digital interactive games as promising tools for advancing public health literacy.

8. Conclusions

In this study, we highlighted the innovative and feasible integration of sensors in digital board games to enhance nutrition education. QR code sensing not only streamlined gameplay and increased portability but also demonstrated strong user acceptance, reflected in high satisfaction scores. Participants valued the blend of learning and entertainment, confirming the game’s educational effectiveness. These findings suggest that sensor-based gamification holds significant promise for scalable, engaging, and impactful health education interventions.

Participants also suggested increasing the game’s challenge level and diversity to enhance engagement and interactivity. Additionally, they recommended optimizing the offline mode so that players can still draw digital event cards without an internet connection, improving usability. Overall, this study’s digital board game not only enhanced the gaming experience but also

effectively promoted healthy eating knowledge, demonstrating strong potential for practical application and wider adoption.

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