Development of an AR Food Education System to Support Elementary School Nutrition Education

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Abstract—**Eating behaviors are developed gradually during childhood, so it is crucial to educate students about the nutrition of snacks and drinks sold in the market from an early age. This underscores the importance of school education in shaping and cultivating children's eating habits. Numerous studies have shown that taking students to supermarkets for nutrition education can improve their awareness of nutrition labels and buying habits. However, most nutritional education courses in Taiwan's elementary schools are conducted in traditional classrooms and do not effectively incorporate real-world learning situations. To improve the effectiveness of nutrition education in elementary schools, this study developed an AR food education system that combined game design, augmented reality, and image recognition technologies to support nutrition teaching activities. An experiment was conducted in an elementary school, inviting 27 6th grade students to participate and evaluate the effect of the proposed system on nutrition education. Results showed that the system attracted students' attention and provided a sense of satisfaction after learning. Moreover, the proposed approach enhanced students' learning performance in nutrition education.**

Keywords—nutrition education, augmented reality, image recognition, learning achievement

I. Introduction

Eating behaviors are gradually developed in childhood, and school education plays a key role in cultivating students' eating habits and enhancing their awareness of choosing foods with nutritional value [1]. Research shows that teens often prioritize taste and price over nutritional information when selecting food, highlighting the need for nutrition education to teach students how to read food labels [2]. Additionally, a study on adolescents' perceptions of the healthiness of different snacks found a gap in their understanding of nutrition information, indicating a need to strengthen nutrition education [3]. Through nutrition education, students can learn to prioritize healthy eating habits and improve their ability to read food ingredient labels.

Since most consumers buy food in supermarkets, Scott and Pollard suggested in 1992 using supermarkets as a learning environment to teach participants about nutritional knowledge and food labels [4]. Additionally, literature suggests that taking students to real-world settings for nutrition education can improve their understanding of nutrition labels as well as their food consumption and purchasing habits [5]. However, in Taiwan's elementary schools, most nutrition education courses are conducted in traditional classrooms and lack real-world learning experiences that could enhance learning outcomes.

As mentioned earlier, this study aimed to enhance the effectiveness of nutrition education in elementary schools by developing an AR food education system that utilized game design, augmented reality, and image recognition technologies to support traditional nutrition teaching activities. To evaluate the effect of the proposed system on nutrition education, an experiment was conducted in an elementary school involving 27 6th student participants.

II. System Development

The AR food education system developed in this study consists of a native mobile application and a cloud database, as shown in Fig. 1. The native mobile application includes an image recognition module, an AR module, a health management module, and a health education game module.
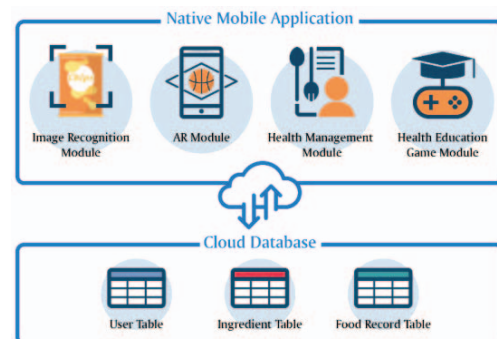

Fig. 1. The architecture of the AR food education system

Students can access the system to view their personal health status and watch educational nutrition videos, as shown in Fig. 2. Additionally, the proposed system allows students to take pictures of the outer packaging of snacks using their mobile

devices. The image recognition module can then display the nutritional information on the screen, as shown in Fig. 3. Moreover, the AR module of the system provides students with different types of healthy exercises, including sit-ups, squats, back-and-forth running, and push-ups, as shown in Fig. 4. Finally, students can learn about the importance of healthy eating by playing the health education games.
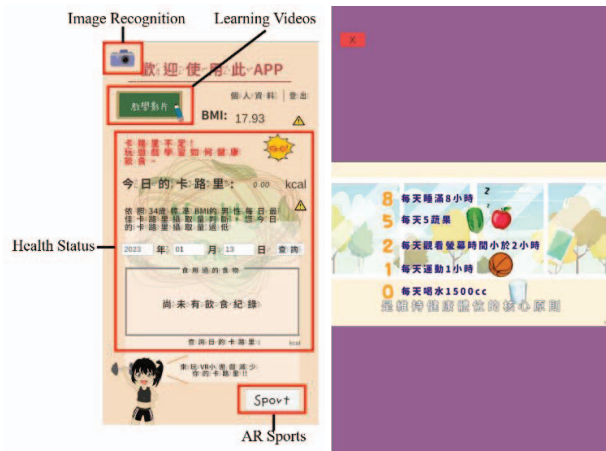

Fig. 2. Screenshot of personal health status

Fig. 3. Screenshots of image recognition and nutritional information

Fig. 4. Screenshots of AR sport games

This study applied image recognition and augmented reality combined technologies with the AR sport games to support nutrition education. This study used Unity to develop the native android mobile application and used AR Foundation SDK to develop the AR sport games.

III. EXPERIMENT

To evaluate the effectiveness of the proposed system in nutrition education, an experiment was conducted in an elementary school with 27 sixth-grade students. The experimental process is illustrated in Fig. 5, and the total duration of the experiment was 150 minutes. Before the course began, the students took a prior knowledge test to evaluate their knowledge of nutrition education. The teacher then provided 50 minutes of traditional classroom instruction to deliver nutrition knowledge to the students. After this, the teacher asked the students to review the relevant knowledge using the proposed system for 30 minutes. Following the teaching activities, the students were asked to fill out a learning motivation questionnaire (10 minutes) and take a learning achievement test (30 minutes).
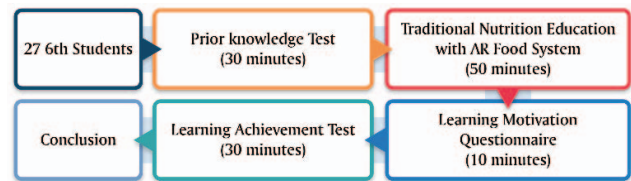

Fig. 5. The experimental process

In order to understand the difference in the nutritional knowledge of the students before and after participating in the experiment, a prior knowledge test and a learning achievement test were designed. Both tests consisted of 10 multiple-choice questions, with a total score of 100 points. In addition, in order to evaluate the students' learning motivation, this study used the learning motivation questionnaire based on the ARCS motivation model developed by Keller in 2010 [6]. The ARCS motivation model is divided into four constructs which are attention, relevance, satisfaction, and confidence. The Cronbach's alpha of the learning motivation questionnaire is 0.901.

IV. RESULTS

A. Learning achievement analysis

To evaluate the difference in the nutritional knowledge of the students before and after participating in the experiment, a paired sample t-test was adopted to conduct the analysis, as shown in Table I. The result revealed that there is a significant difference between the students' nutritional knowledge before and after participating in the experiment, indicating that the AR food system is helpful to students' nutritional knowledge.

TABLE I. THE PAIRED SAMPLE T-TEST RESULT FOR THE STUDENTS' LEARNING ACHIEVEMENTS.

	Mean	SD	t	p
Nutritional knowledge test	-16.667	18.397	-4.707	.000*

*$p < .05$

B. Learning motivation analysis

To analyze the students' learning motivation after participating in the nutritional learning activity, descriptive

statistics were used to conduct this analysis, as shown in Table II. The mean of the overall questionnaire and each construct is higher than the median of 3, indicating that the proposed approach can arouse students' learning motivation in nutritional education. The result also found that the mean of attention and satisfaction was the highest and second highest, respectively, indicating that the proposed approach can attract students' attention and students are satisfied with participating in nutrition education by using the system.

TABLE II.   DESCRIPTIVE STATISTICS RESULT OF STUDENTS' LEARNING MOTIVATION

	Mean	Standard Deviation
Overall	3.56	0.62
Attention	3.65	0.69
Relevance	3.56	0.65
Confidance	3.46	0.58
Satisfaction	3.63	0.89

V. CONCLUSIONS

This study developed an AR food education system and applied it to nutrition education in elementary schools to improve students' learning performances. An experiment was conducted to evaluate students' learning motivation and nutritional knowledge. The results show that the use of the proposed system in nutrition education learning activities can enhance students' learning achievement, arouse their learning motivation, attract their attention, and satisfy them.

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