A GAME-BASED LEARNING APPROACH TO IMPROVING STUDENTS' LEARNING ACHIEVEMENTS IN A NUTRITION COURSE

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ABSTRACT
The aim of this study was to explore the influence of applying a game-based learning approach to nutrition education. The quasi-experimental nonequivalent-control group design was adopted in a four-week learning activity. The participants included sixty-six third graders in two classes of an elementary school. One of the classes was assigned to be the experimental group and the other was the control group. The experimental group learned with computer games, while the control group learned with the traditional teaching approach. The result showed that the learning achievement of the students in the experimental group was significantly better than that of the students in the control group. Similar results were obtained in terms of the learning interest of the students. Moreover, most of the students revealed quite positive attitudes toward the use of the game-based learning approach in nutrition education. An in-depth analysis showed that there was no significant difference between genders in terms of nutrition knowledge and learning attitudes.
Keywords*:* game-based learning, computer-assisted learning, nutrition education, learning achievements

INTRODUCTION

With the fast development of information technology and rapid social change in the twenty-first century, the growing economy, higher education level and progress of medicine is gradually turning people's attention to health concepts and problems. Shaping healthy habits has become very important (Underbakke, McBride, & Spencer, 2006). Alexander (1994) held the view that healthy habits should be formed as early as possible. Therefore, to shape learners to have correct food and drink habits and establish a balanced diet, nutrition education needs be carried out in the early stages of school. The objective of health education is behavioral implementation, during which health concepts are acquired to form personal values. It is paramount in teaching to shape student values that can influence attitudes and behaviors.

Nutrition education has been recognized as a crucial factor in promoting good health. Researchers have indicated that healthy eating habits need to be shaped in childhood because unhealthy eating habits not only influence the normal growth of students, but also advance chronic diseases (Hang et al., 2009). Baranowski, Perry and Parcel (1997) stated that nutrition education should be a kind of experience learning, through which eating habits and nutrition knowledge can be changed. School students spend a long time at school, so the school environment can have a certain degree of influence on them. Shannon and Chen (1988) pointed out that the nutrition knowledge and attitudes of the students who take related courses are better than those of students who do not take the courses. Skinner and Woodburn (1983) also found that there is a positive correlation between the teaching of teachers' nutrition courses and change in the nutrition knowledge, attitudes and behaviors of students. Several reports have also shown that the implementation of nutrition education for is helpful in improving their eating habits (Jensen, 1985; Simith & James, 1980); in the meantime, scholars have also indicated the difficulty of conducting effective nutrition learning activities since most students show low interest in nutrition and health courses (Chu, Hwang, Tseng, & Hwang, 2006; Howison, Niedermyer, & Shortridge, 1988; Carton, Kicklighter, Jonnalagadda, & Shoffner, 2000). Therefore, it becomes an important and challenging issue to educate children

to foster good eating habits in school.

To cope with this problem, in 2004, Taiwan's Ministry of Education appointed the Medical School of National Taiwan University to put together a team consisting of experts and scholars to establish a health e-learning website (http://health.edu.tw/health/portal/about/about00/index.jsp). In this website, the curricular competence indicators of primary and secondary school students are given; various materials and information are provided to highlight the health-related topics and to support health education for the public. Moreover, several computer games developed by professionals are provided to increase students' interest in studying health-related courses. This study attempts to investigate the influence of the game-based learning approach on nutrition cognition, improving nutrition attitudes and building the food and drink habits of third graders via computer games provided in the website. The research issues are given as follows:

1. The influence of the game-based learning approach on the students' learning achievements in the nutrition course.
2. The influence of the game-based learning approach on students' learning attitudes toward the nutrition course.
3. The influence of the game-based learning approach on the food and drink habits of students.
4. The influence of the game-based learning approach on students.
5. Students' feedback regarding the game-based learning approach for nutrition education.

LITERATURE REVIEW

Games have been recognized as being a good tool to promote learners to actively participate in learning activities (Alessi & Trollip, 1984; Baid & Lambert, 2010; Kirikkaya, İŞERİ, & Vurkaya, 2010; Huizenga, Akkerman, Admiraal, & Dam, 2009). Researchers have indicated that game-based learning could be the best way to trigger students' learning motivation (Provost, 1990; Papastergiou, 2009a; Dickey, 2010; Huang, 2010; Tüzün, Yılmaz-Soylu, Karakuş, İnal, & Kızılkaya, 2009). In addition, it has been reported that a game-based learning approach might provide a good chance to stimulate children's abstract thinking during the process of cognitive development, and further foster their higher order thinking ability (Carbonaro, Szafron, Cutumisu, & Schaeffer, 2010). Carroll (1982) stated that computer games are able to boost motivation owing to some characteristics, such as adventure, challenge and freshness. Therefore, if teachers are able to apply computer games to teaching, students can not only have better learning achievements, but also learn happily via these games.

Several previous studies have demonstrated the ease of use and usefulness features of computer games by applying the game-based learning approach to a variety of learning activities (Bourgonjon, Valcke, Soetaert, & Schellens, 2010; Warren, Dondlinger, & Barab, 2008). For example, Terrell and Rendulic (1996) stated that using computer games for learning in elementary schools can increase the internal motivations and learning achievements of students. Yun, Jiang and Li (2010) indicated that through computer games which focus on nutritional education in primary and secondary schools, the learning motivations and learning achievements of the students can be increased, and their competences and knowledge can be promoted. Papastergiou (2009b) also pointed out that through computer games, children's learning interests are effectively promoted, and they are guided to actively improve their food and drink habits.

There are several theories that are recognized as being relevant to the game-based learning approach, such as cognitive theory and situated learning theory. Cognitive theory emphasizes that learners should master basic skills to further acquire higher-level abilities while learning new things. It also emphasizes that learning processes are progressive and move from simplicity to complexity; moreover, games that are adopted need to stimulate students' learning motivation and make learning more fun (Gagné, 1985). Situated learning theory states that learners should enter learning scenarios to acquire knowledge. The knowledge that is actively explored in the scenarios should not only be useful, but should also be analogical. Therefore, establishing a rich learning scenario enables learners to gain practical problem-solving abilities via observation and behavioral exploration, and a well designed game is able to provide such a learning scenario (Winn, 1993; Young, 1993; Cuenca López & Martín Cáceres, 2010; Kim, Park, & Baek, 2009). Some researchers believe that even the best teaching materials and techniques are not as good as having children learn happily via games (Norman, 1981). Compared with other media, games are closer to the children's world and are easily accepted by them (Kafai, 1995). Furthermore, researchers believe that games can help children develop problem-solving skills (Seonju, 2002; Chuang & Chen, 2009; Lee & Chen, 2009; Blumberg, Rosenthal, & Randall, 2008; Shih, Shih, Shih, Su, & Chuang, 2010).

RESEARCH DESIGN

This study adopted a quasi-experimental nonequivalent-control group design. The independent variable was the

different teaching media. The experimental group received nutrition education with computer game-based teaching, while the control group was taught the nutrition content with a multimedia PowerPoint. The dependent variable, nutrition education, was included in the nutrition knowledge tests, the questionnaire of nutrition attitudes and the questionnaire of food- and- drink habits.

Participants

The participants in this study included sixty-six third graders in two classes of an elementary school in southern Taiwan. One of the classes was assigned to be the experimental group and the other was appointed to be the control group. In order to avoid influences caused by different instructors, the two classes were taught by the same instructor. Both the experimental group and the control group had thirty-three students, including eighteen males and fifteen females. This study lasted for four weeks, and each week included one nutrition education class.

Tools

To evaluate the learning achievements of the students, the nutrition knowledge test developed by Lo (2006) was adopted. The test consisted of twenty items, each of which was awarded one point if the students gave the correct answer. The Kuder-Richardson reliability of the test was 0.71, the item discrimination values were higher than 0.25, and the item difficulty values ranged from 0.4 to 0.8.

To measure the students' learning attitudes toward the nutrition course, the questionnaire developed by Lin (2004) was adopted. It consisted of twenty items on a five-point Likert scale. The Cronbach's α value of the questionnaire was 0.85, showing good reliability in internal consistency. In the meantime, another questionnaire developed by Her (2004) was adopted to evaluate the food- and- drink habits of the students. It consisted of twenty items on a five-point Likert scale. The Cronbach's α value of this questionnaire was 0.85, showing good reliability in internal consistency.

In addition, a survey consisting of twelve items on a five-point Likert scale was conducted to collect the feedback of the students regarding the game-based learning approach, including the aspects of 'effects of computer games on nutrition knowledge,' 'effects of computer games on nutrition attitudes,' 'effects of computer games on food- and- drink habits' and 'viewpoints of computer game-based learning.; This survey has been examined and revised by ten experts who are experienced in teaching nutrition courses. The Cronbach's α values of the four aspects and the entire questionnaire were .66 .61 .62 .72 and .82, respectively.

Learning Activities

Table 1 presents the teaching activities held in the study. The teaching activities were designed based on nutrition education to have four topics, including 'Knowledge of eating functions,' 'Our eating,' 'Healthy eating habits' and 'Tracking eating habits.' Each topic was taught for forty minutes. One class was held each week to fit in with the students' physical education class. The experiment lasted for four weeks. The nutrition education for the two groups was the same, but the experimental group was taught via computer game-based instruction while the control group was instructed with multimedia PowerPoint.

Table 1. *The four units for teaching activities on nutrition education*

Class order	Topic	Purpose	Game title
First	Knowledge of eating functions	1. To experience the importance of food for psychological and physical needs 2. To list reasons that influence personal food choices 3. To classify the six types of food correctly	1. Little Dietician 2. Gifts from Heaven
Second	Our eating	1. To experience how environmental factors influence eating habits 2. To speak of factors that influence eating habits	Saving Health Kingdom
Third	Healthy eating habits	1. To understand the disadvantages of eating fastfood often and be willing to reduce the amount of fastfood 2. To choose nutritional meals for keeping fit	Health Superman's Delicacy Island
Fourth	Tracking eating habits	1. To compare personal eating habits with standard healthy rules 2. To practice good eating habits	Nutrition Supplement Battle

There were five games used in this study, as shown in Figure 1 'Little Dietician,' Figure 2 'Gifts from Heaven,' Figure 3 'Saving Health Kingdom,, Figure 4 'Health Superman's Delicacy Island' and Figure 5 'Nutrition Supplement Battle.' The first two games mainly taught the students to correctly classify the six types of food for a balanced diet. The third game, Saving Health Kingdom, enabled the learners to understand that snacks, fast food and beverages are not essential elements of a diet, and their amount should be reduced. The fourth game, Health Superman's Delicacy Island, instructed the students to combine different foods for a balanced diet via observation of a one-day diet. The last game, Nutrition Supplement Battle, made understandable that a lack of nutrients might lead to diseases by providing questions, hints and answers (Health e-learning network, 2010).

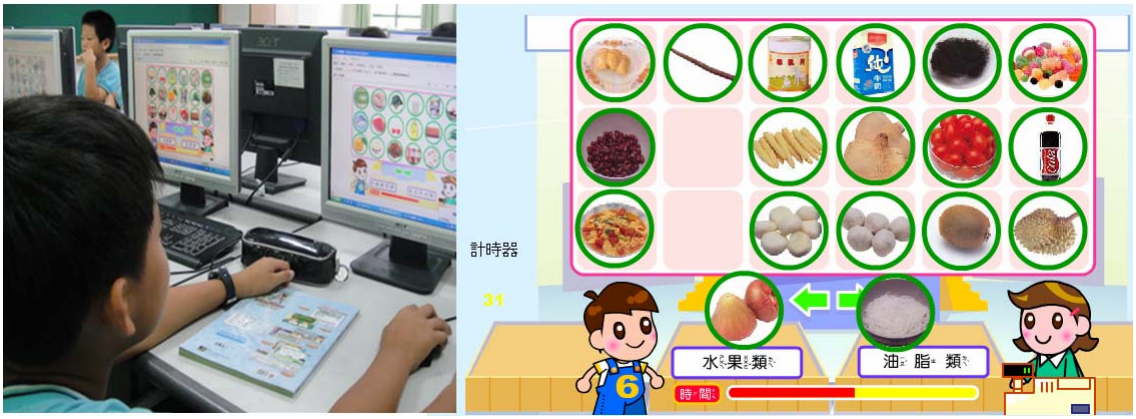

Figure 1. Learning to correctly classify six types of food via the computer game 'Little Dietician'

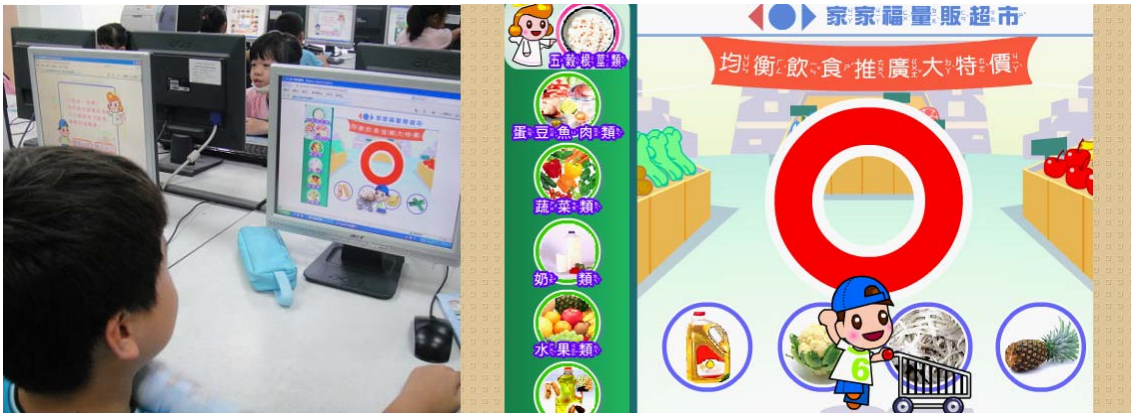

Figure 2. Following hints to use a cart to gather certain foods in 'Gifts from Heaven'

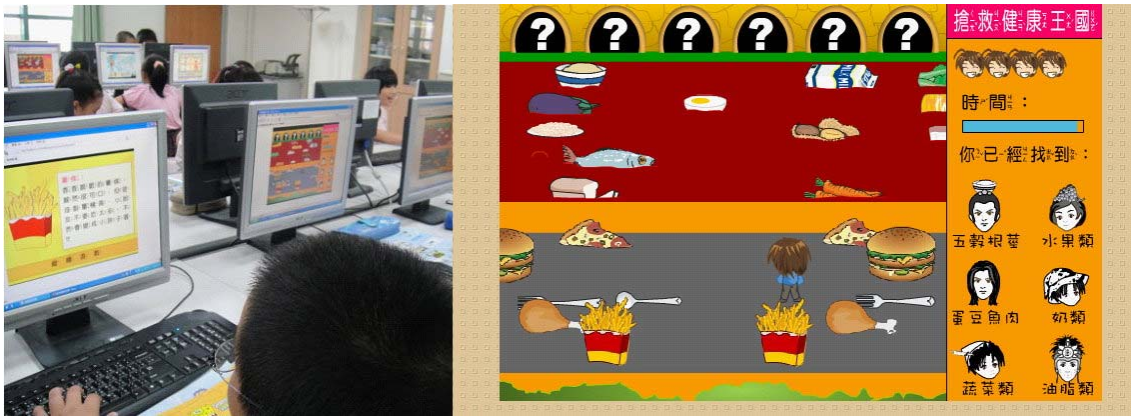

Figure 3. Learning the fact that snacks, fast food and drinks are not necessary nutrients via 'Saving Health Kingdom'

Figure 4. Observing and recording one day's diet via 'Health Superman's Delicacy Island'

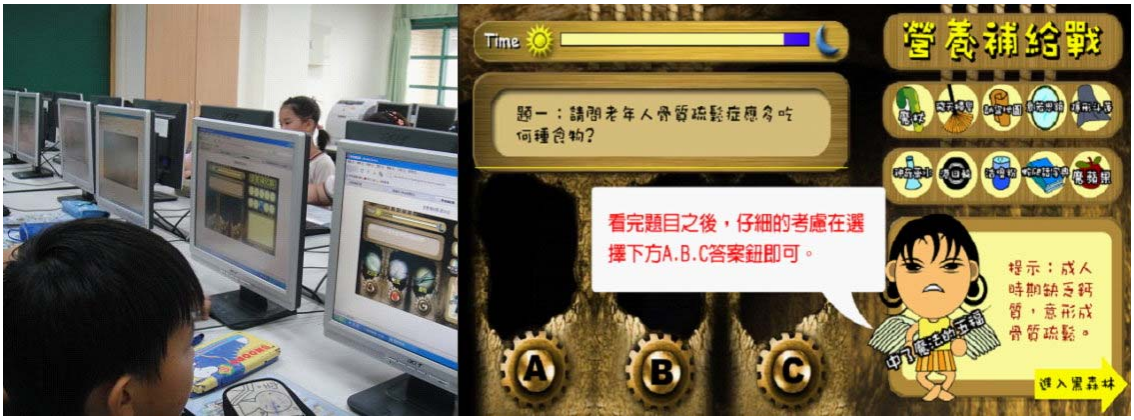

Figure 5. Learning the fact that a lack of nutrients may cause diseases via 'Nutrition Supplement Battle'

RESULTS

Learning Achievements

This study adopted the pretest scores of the nutrition knowledge test as the covariate for analysis of covariance (ANCOVA) to avoid the influence of the pretest on nutrition knowledge learning. One assumption of ANCOVA is that the regression coefficient of each regression line needs to be homogeneous. The interaction effect between the independent variable and the covariate of the nutrition knowledge test was not significant ($F=1.93$, $p>.05$), suggesting that the relationship between the covariate (the pre-test scores) and the dependent variable (the post-test scores) was not different by the levels of the independent variable. Therefore, further ANCOVA analysis was appropriate.

Table 2 shows the descriptive data and ANCOVA for the results of the nutrition knowledge posttest. The influence of the pretest scores on the nutrition knowledge test was excluded, and the learning achievements between the two groups were significantly different ($F =20.01$, $p < .001$). The adjusted mean of the experimental group was 17.39 while that of the control group was 14.64, implying that the learning achievement of the experimental group was significantly higher than that of the control group, showing that computer game-based instruction can effectively promote students' nutrition knowledge.

Table 2. *ANCOVA for the post-test results of the nutrition knowledge test*

Variable	Group	N	Mean	S.D.	Adjusted Mean	Std. Error.	*F*
Post-test	Experimental group	33	16.94	2.38	17.39	.43	20.01***
	Control group	33	15.09	3.39	14.64	.43	

*** $p<.001$

Learning Attitudes

The pretest scores of the questionnaire of nutrition attitudes were used as the covariate for ANCOVA. The interaction effect between the independent variable and the covariate of the questionnaire was not significant ($F=1.37$, $p=.25$, $p>.05$), suggesting that the relationship between the covariate (the pre-test scores) and the dependent variable (the post-test scores) was not different by the levels of the independent variable; therefore, the ANCOVA could be further conducted.

As shown in Table 3, the learning achievements between the two groups were not significantly different ($F=.19$, $p=.66$, $p>.05$) after the influence of the nutrition knowledge pretest scores were excluded. The adjusted mean for the experimental group was 88.98 whereas the adjusted mean for the control group was 88.36. The score of the experimental group was higher than that of the control group, but there was no significant difference between the two. Computer game-based instruction was not shown to enhance the nutrition attitudes of the students any more than multimedia PowerPoint instruction.

Table 3. *ANCOVA result on the ratings of the attitudes toward the nutrition course*

Variable	Group	N	Mean	S.D.	Adjusted Mean	Std.Error.	*F*
Post-test	Experimental group	33	88.82	7.28	88.98	1.00	.19
	Control group	33	88.52	9.01	88.36	1.00	

Food and Drink Habits

The pretest scores of the questionnaire of food and drink habits were used as the covariate for ANCOVA. The interaction effect between the independent variable and the covariate of the questionnaire was not significant ($F=1.59$, $p=.21$, $p>0.05$). This suggests that the relationship between the covariate (pretest scores) and the dependent variable (posttest scores) was not different by the levels of the independent variable; therefore, the ANCOVA could be further conducted.

Table 4 shows the descriptive data and ANCOVA for the post-test results of the food and drink habit questionnaire. The influence of the pretest scores of the food and drink habit questionnaire was excluded, and the learning achievements between the two groups were significantly different ($F=4.17$, $p=.05$, $p<0.05$). The adjusted mean of the experimental group was 89.28 whereas that of the control group was 86.05. The learning achievement of the experimental group was better than that of the control group, showing that computer game-based instruction can effectively enhance student food and drink habits.

Table 4. *ANCOVA result on the ratings for the food and drink habit questionnaire*

Variable	Group	N	Mean	S.D.	Adjusted Mean	Std.Error.	*F*
Post-test	Experimental group	33	88.46	10.36	89.28	1.12	4.17*
	Control group	33	86.88	8.25	86.05	1.12	

*$p<.05$

Learning Achievements between Genders

An analysis was made to further compare the nutrition knowledge, attitudes toward the nutrition course and food and drink habits between genders after participating in this learning activity. Table 5 shows the ANCOVA results on the posttest scores of the nutrition knowledge test and the post-questionnaire ratings for nutrition attitudes and food and drink habits between the two genders by excluding the influence of corresponding pr-test scores and pre-questionnaire ratings. It was found that there is no significant difference between genders in terms of the three aspects, implying that the game-based learning approach is helpful to both genders in improving their learning achievements and learning attitudes.

Table 5. *ANCOVA results on the post-test results of different genders*

Variable	Group	N	Mean	S.D.	Adjusted Mean	Std.Error.	*F*
Nutrition knowledge test	male	17	17.47	2.00	17.29	.50	1.00
	female	16	16.38	2.68	16.57	.51	
Nutrition attitude questionnaire	male	17	89.65	6.62	88.81	1.44	.00
	female	16	87.94	8.05	88.83	1.49	
Food and drink habit questionnaire	male	17	87.29	11.96	87.97	1.86	.14
	female	16	89.69	8.56	88.97	1.92	

Feedback on the Game-based Learning Approach

Table 5 presents the survey of teaching viewpoints on computer game-based learning. In Part 1 'Influence of computer games on nutrition knowledge', 1.1 'I can better understand which types of food are helpful for health' scores the highest (4.97), while 1.2 'I am much clearer about different nutrients contained within different kinds of foods' scores the lowest (4.79), showing that the students highly confirm the influence of computer games on nutrition knowledge learning.

In Part 2 'Influence of computer games on attitudes toward nutrition', 2.3 'I want to learn more about how to choose helpful food for myself' scores the highest (5.00), whereas 2.2 'I have become more careful in choosing food, scores the lowest (4.76), indicating that the students are positive toward the influence of computer games on nutrition attitudes.

In Part 3 'Influence of computer games on food and drink habits', 3.1 'I will pay more attention to eating hygiene, has the highest score (4.91) and 3.3 'I am willing to share the nutrition knowledge with my family, has the lowest score (4.73). This reveals that the students hold positive views toward the influence of computer games on food and drink habits.

In Part 4 'Viewpoints on computer game-based learning', 4.2 'I hope that other courses can also adopt computer game-based learning, scores higher (4.94), while 4.1 'I think that computer game-based learning is helpful to me, scores lower (4.73). This suggests that the students confirm the influence of computer games on their food and drink habits and hope to apply game-based learning to other subjects.

Table 6. *Survey of the game-based learning approach*

Question	N	Mean	S.D.
1.Influence of computer games on nutrition knowledge		4.85	.22
1.1. I can better understand which types of food are helpful for health.	33	4.97	.17
1.2. I am much clearer about different nutrients contained within different kinds of foods.	33	4.79	.55
1.3. I am better able to understand that the lack of certain nutrients causes diseases.	33	4.82	.53
1.4. I can know more about the importance of food hygiene and food preservation methods	33	4.82	.39
2. Influence of computer games on attitudes toward nutrition		4.89	.20
2.1. I will focus more on my eating habits and attitudes.	33	4.91	.38
2.2. I have become more careful in choosing food.	33	4.76	.50
2.3. I want to learn more about how to choose helpful food for myself.	33	5.00	.00
3.Influence of computer games on food and drink habits		4.84	.24
3.1. I will pay more attention to eating hygiene.	33	4.91	.29
3.2. I will further improve my incorrect eating habits.	33	4.88	.42
3.3. I am willing to share the nutrition knowledge with my family.	33	4.73	.63
4.Viewpoints on computer game-based learning		4.89	.15
4.1. I think that computer game-based learning is helpful to me.	33	4.73	.67
4.2. I hope that other courses can also adopt computer game-based learning.	33	4.94	.24

CONCLUSIONS

This study aims at investigating the learning achievements of the students in nutrition education via computer game-based learning and multimedia PowerPoint instruction. The experimental results reveal that computer game-based learning can improve the learning achievements and learning attitudes of students.

Moreover, it was found that the game-based learning approach is equally helpful to both male and female students in terms of nutrition knowledge, learning attitudes and food and drink habits. This finding is quite different from those of some previous studies that reported a difference between genders in using computers and networks (Dabaj, 2009; Pamuk & Peker, 2009; Imhof, Vollmeyer, & Beierlein, 2007; Delialioglu, Cakir, Bichelmeyer, Dennis, & Duffy, 2010).

Although the findings of this study are quite positive, longer experiments with larger samples need to be conducted in the future to further investigate the effectiveness of the game-based learning approach for nutrition education. It is expected that the innovative approach not only improves the students' nutrition knowledge, but also fosters their food and drink habits in their daily lives.

In addition to the nutrition courses, this approach can be applied to other courses in the future. Moreover, as mobile and wireless communication technologies are becoming more popular, it has become an interesting and challenging issue to use mobile devices for conducting game-based learning activities in real-world learning

environments, so that the students can be situated in real-world scenarios with support or hints from the learning system (Chu, Hwang, Tsai, & Tseng, 2010; Hwang & Chang, 2011; Hwang, Tsai, & Yang, 2008; Hwang, Chu, Shih, Huang, & Tsai, 2010).The nutrition knowledge can be obtained from both real-world and digital-world contexts, which has been recognized by researchers as being a good way of shaping good habits (Chu, Hwang, & Tsai, 2010; Hwang, Shih, & Chu, 2010).

ACKNOWLEDGEMENT

This study is supported in part by the National Science Council of the Republic of China under contract numbers NSC 99-2511-S-011-011-MY3 and NSC 99-2631-S-011-002.

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