



Development of an Educational Game Based on the Conceptual Change Model to Improve Food Safety Knowledge and Attitudes

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Abstract

Foodborne diseases are a global public health issue that affects millions of people annually. Children and teenagers are vulnerable populations who are at risk of contracting these diseases due to their limited knowledge of food safety practices. Educational games have been shown to be effective in improving learning outcomes and promoting positive attitudes towards health topics. However, there is limited research on the use of the Conceptual Change Model (CCM) in developing educational games about food safety. The objective of this study is to develop an educational game about food safety using the CCM to improve the attitude and knowledge of children and teenagers towards food safety. The study surveyed 72 students from both primary and secondary schools on their understanding and attitudes towards food safety. There was a noticeable lack of understanding and undesirable attitudes about the appropriate cooking temperatures among the students. Upon the implementation of a food safety game intervention, a significant improvement ($p < .001$) was observed in the post-test scores, reflecting a notable enhancement in food safety knowledge and attitudes. This research substantiates the efficacy of an educational game in enhancing comprehension and attitudes towards food safety. Employing the CCM to create a food safety educational game represents an innovative strategy that could enhance learning results and foster positive food safety attitudes among young people. The findings of this study will contribute to the development of effective educational interventions to prevent and control foodborne diseases.

Keywords: *Conceptual Change Model, Educational Game, Food safety*

1. Introduction

Nowadays foodborne diseases, leading to significant illness and death rates annually, are escalating due to the ingestion of bacteria and fungus-contaminated food. In Thailand, an estimated 100,000 cases of Diarrhea are reported annually, largely linked to unhygienic food practices, such as consuming raw food and using contaminated water during cooking. Statistics indicate that children under the age of 10 are at the highest risk. The Ministry of Public Health, responsible for food safety, is working on several initiatives to raise awareness about the dangers of contaminated food, improve food consumption behaviors, and motivate learning about potential hazards. The Ministry of Education is also taking steps to educate young people about food safety through the distribution of instructional media.

The Conceptual Change Model (CCM) posits that learning involves the transformation of existing misconceptions and the construction of new knowledge through a series of conceptual changes [1]. This model has been widely employed in educational settings to address the challenge of conceptual misunderstandings and facilitate meaningful learning experiences. Educational games, with their interactive and engaging nature, have emerged as promising tools for facilitating learning in various domains. The growing trend of using games as teaching and learning tools has shown multiple benefits such as reducing the fear of failure, and enhancing engagement, retention, attitude, motivation, and self-efficacy [2][3][4]. When combined with the CCM, game development can provide a powerful platform for promoting conceptual change and enhancing learning outcomes.

Therefore, this research aims to develop a food safety educational game using the CCM. The game could be used to educate children and teenagers about food safety principles, improve their attitudes towards food safety, provide an enjoyable gaming experience, and ultimately reduce the negative impacts of foodborne diseases.



2. Material and Methods

2.1 Educational Game Design and Development

The design concept for the educational game in this project is based on the CCM to instruct teenagers and enhance their perspectives on food safety. The process incorporates 6 stages, as depicted in Figure 1. These stages are integral to the learning process, assisting learners in reshaping their thought processes to establish accurate understanding.

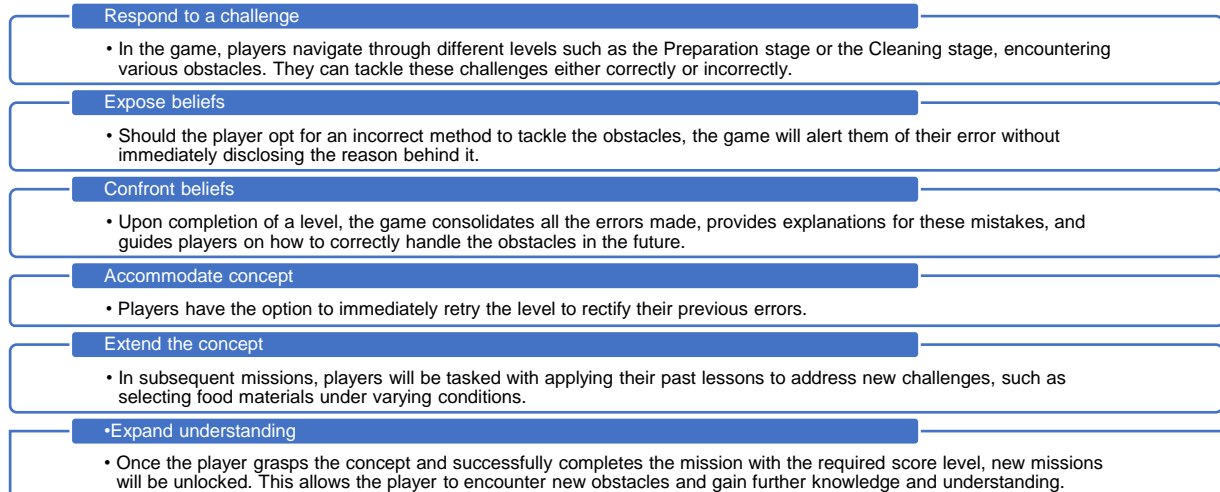


Fig. 1. Conceptual Change Model (CCM)

The game has been also designed employing 4 elements of game design: Narrative, Aesthetics, Mechanics, and Technology [5][6] to ensure the game not only promote learning and improve attitude towards food safety concepts but also offer an enjoyable gaming experience.

The Unity game engine, a popular tool in the game development industry was utilized for creating the game. The game was designed as a 2D role-playing experience where players become a chef who must prepare meals for a family. Its objective is to facilitate players' understanding and practice of food safety. To this end, players must complete 3 missions: Minced Pork Omelette, Fried Tilapia with Herbs, and Stir-Fried Squid with Salted Egg. Each mission involves different cooking materials and cooking sequences, structured into 6 stages as depicted in Figure 2.



Fig. 2. The game loop shows 6 stages. (1) Supermarket stage: the player must buy the right materials from the supermarket according to the shopping list. (2) Preparation stage: the player must prepare and clean the cooking materials according to the concept of food safety. (3) Cooking stage: the player must cook the food right such as using the appropriate heat level. (4) Storing stage: the player must preserve the cooked food correctly. (5) Cleaning stage, the player must clean all the cooking tools appropriately. (6) Microwave & rationing stage: the player must use the microwave the right way.



Fig. 3. Examples of gameplay screenshots

In the depicted gameplay shown in Figure 3, players will progress through various stages of the cooking process. For instance, they will be required to select ingredients that are in good condition and suitable for safe food preparation. Should players make a mistake, the game will provide tutorial windows to guide them, emphasizing the importance of checking expiration dates before purchasing items to ensure freshness and safety for consumption. Throughout each stage, players can accumulate points by accurately executing the cooking process, while points will be deducted for errors. Successfully completing a mission will unlock a new one, allowing for further progression in the game. The game is available for download on Google Play Store for use on smartphones and tablet devices at <https://play.google.com/store/apps/details?id=com.Phun.BrightChefSafeFood>.

2.2 Participants and procedure

The participants in this study were fourth to ninth-grade students in Bangkok, selected through convenience sampling from various schools. All participants were surveyed regarding their demographics, knowledge, and perceptions of food safety. Approximately 2 weeks after the initial surveys, the participants engaged with the game and immediately afterwards completed post-game knowledge and perception questionnaires.

2.3 Data Analysis

Responses to the knowledge and attitude questions were coded on a 2-point scale, with 0 indicating an incorrect or undesirable response and 1 denoting a correct or desirable one. The knowledge section had a potential scoring range of 0 to 11, while the attitude section's range was 0 to 7. The overall score was calculated by summing up the points achieved from correct answers. To analyze scores for each knowledge and attitude questions, along with demographic factors, we utilized frequencies and descriptive statistics. The average score for both attitude and knowledge was derived by dividing the sum of the scores by the total number of questions. Paired samples t-tests were used to determine any significant differences between pre-test and post-test scores. The level of statistical significance was established at $p < 0.05$.

3. Results

3.1 Influence of demographic factors on food safety knowledge and attitude

The final sample comprised 72 Thai students, including 40 (55.6%) females and 32 (44.4%) males. Out of these students, 43 (59.7%) were in primary school, and 29 (40.3%) were in secondary school, as depicted in Table 1. Female students showed better knowledge than males, but the difference was not statistically significant ($p > 0.05$). The students' level of education significantly ($p < 0.05$) influenced their knowledge and attitude scores. As expected, high school students demonstrated a deeper understanding of food safety and a more positive attitude towards it compared to their primary school counterparts.



Table 1. Pre-test food safety knowledge and attitude scores of students as per the demographic characteristics (n = 72).

Characteristic	n (%)	Knowledge		Attitude		
		Mean ± SD	p-value	Mean ± SD	p-value	
Gender	Female	40 (55.6)	7.1 ± 2.2	0.248	4.9 ± 1.5	0.959
	Male	32 (44.4)	6.5 ± 2.2		4.9 ± 1.5	
Highest Education level	Primary	43 (59.7)	6.1 ± 2.3	<.001**	4.4 ± 1.4	<.001**
	Secondary	29 (40.3)	7.9 ± 1.6		5.7 ± 1.3	

*/** Mean difference statistically significant at $p < 0.05$ and <0.001 , respectively.

3.2 Knowledge about food safety before and after playing the game

While the respondents demonstrated substantial knowledge about food safety, less than half of them (31.9%) understood that pre-cooked food should generally be reheated to an internal temperature of at least 74°C to ensure its safety and to eliminate any potentially harmful bacteria that may have grown during storage. However, after playing the game, an average increase of approximately 84% in the rate of correct responses was noted for these questions.

3.3 Attitude towards food safety before and after playing the game

A third of the participants believed that all types of meat could be cooked at the same temperature and did not see a link between improperly prepared food and the transmission of disease-causing pathogens. However, after playing the game, a significant improvement was noted in the overall attitude scores of the respondents.

3.4 Effect of playing the game on food safety knowledge and attitude

Table 2 presents the food safety knowledge and attitude scores of students before and after playing the game. Both the knowledge and attitude scores towards food safety showed a significant increase post-game ($p < .001$). This suggests that educational games on food safety can be a crucial tool for enhancing learning outcomes and fostering positive attitudes towards food safety among children and teenagers. This finding is consistent with other research studies, which have highlighted the impact of educational games on knowledge, attitude, and behavior changes in children and teenagers [7][8][9].

Table 2. Comparison of knowledge and attitude of pre-test and post-test

Variables	Pre-test	Post-test	p-value
Overall food safety knowledge scores	6.87 ± 2.24	9.91 ± 1.03	<.001**
Overall food safety attitude scores	4.95 ± 1.53	5.98 ± 0.92	<.001**

Data presented as mean ± SD.

Scores range for knowledge and attitude are 0–11 and 0–7, respectively.

*/** Mean difference statistically significant at $p < 0.05$ and <0.001 , respectively.

4. Discussion

Foodborne illnesses continue to pose a significant global public health concern, affecting millions of people each year. Among vulnerable populations, such as children and teenagers, the risk of contracting these diseases is heightened due to their limited awareness of proper food safety practices [10]. Research has demonstrated the effectiveness of educational games in enhancing learning outcomes and fostering positive attitudes towards health-related subjects [11]. However, there is a scarcity of studies exploring the utilization of the CCM in the development of educational

games focused on food safety. Therefore, the aim of this study is to create an educational game utilizing the CCM to enhance the knowledge and attitudes of children and teenagers regarding food safety.

To achieve this objective, the study conducted a survey among 72 students from primary and secondary schools to evaluate their comprehension and attitudes towards food safety. The findings exposed a concerning gap in understanding and attitudes concerning the appropriate cooking temperatures, a fundamental aspect of food safety. This deficit in knowledge resonates with the previous finding emphasizing the need for targeted educational interventions [12]. After introducing our CCM-based educational game, a significant improvement in the post-test scores pertaining to food safety knowledge and attitudes was observed. This substantiates existing literature highlighting the efficacy of educational games in promoting knowledge acquisition and positive attitudes [7].

The application of CCM in designing our game appears to be an innovative strategy, aligning with the steps of CCM, and facilitating a transformative learning experience for the students [1]. This highlights the potential of interactive and engaging learning methods in effectively promoting knowledge and fostering positive attitudes towards health-related topics. Our study makes a valuable contribution to the rapidly expanding field of interactive health education interventions designed to prevent and control foodborne diseases. Future research should focus on refining the game design based on user feedback and broadening the game's scope to cover more food safety aspects. Further exploration of the integration of the CCM principles into educational games for different health topics is also recommended.

In conclusion, this study affirms the potential of innovative educational approaches like CCM-based games in enhancing learning outcomes and fostering positive attitudes among young populations towards critical public health issues like food safety.

References

- [1] Posner, G.J., Strike, K.A., Hewson, P.W., & Gertzog, W.A. "Accommodation of a scientific conception: Toward a theory of conceptual change", *Science Education*, 1982, 66, 211-227.
- [2] Escribano, B.B., Torrente, J., Borro, J.M., & Manjon, B.F. "Educational Game Development Approach to a Particular Case: The Donor's Evaluation", *Transplantation Proceedings*, 2015, 47, 13-18.
- [3] Lester, J.C., Spires, H.A., Nietfeld, J.L., Minogue, J., Mott, B.W., & Lobene, E.V. "Designing game-based learning environments for elementary science education: A narrative-centered learning perspective", *Journal Information Sciences*, 2014, 264, 4-18.
- [4] Star, J.R., Chen, J.A., Taylor, M.W., Durkin, K., Dede, C., Chao, T. "Evaluating Game-Based Learning Environments for Enhancing Motivation in Mathematics". In: Torbeyns, J., Lehtinen, E., Elen, J. (eds) *Describing and Studying Domain-Specific Serious Games. Advances in Game-Based Learning*, 2015, 209-230.
- [5] Gibson, J. "Introduction to Game Design, Prototyping, and Development: From Concept to Playable Game with Unity and C#", Addison-Wesley Professional, 2014.
- [6] Schell, J. "The Art of Game Design: A Book of Lenses", Elsevier, 2008.
- [7] Alblas, E.E., Folkvord, F., Anschütz, D.J., van 't Riet, J., Granic, I., Ketelaar, P., & Buijzen, M. "Investigating the impact of a health game on implicit attitudes towards food and food choice behaviour of young adults", *Appetite*, 2018, 128, 294-302.
- [8] Tan, A.J.Q., Lee, C.C.S., Lin, P.Y., Cooper, S., Lau, L.S.T., Chua, W.L., & Liaw, S.Y. "Designing and evaluating the effectiveness of a serious game for safe administration of blood transfusion: A randomized controlled trial", *Nurse education today*, 2017, 55, 38-44.
- [9] Van 't Riet, J.P., Alblas, E., Crutzen, R., & Lu, A. "The effects of active videogames on BMI among young people: A meta-analysis", *Handbook of research on holistic perspectives in gamification for clinical practice Hershey*, 2016, 277-292.
- [10] Scallan, E., Hoekstra, R.M., Angulo, F.J., Tauxe, R.V., Widdowson, M.A., Roy, S.L., Jones, J.L., & Griffin, P.M. "Foodborne illness acquired in the United States--major pathogens", *Emerging infectious diseases*, 2011, 17(1), 7-15.
- [11] Girard, C., Ecalle, J., & Magnan, A. "Serious games as new educational tools: how effective are they? A meta-analysis of recent studies", *Journal of Computer Assisted Learning*, 2012, 29(3), 207-219.
- [12] Ali, M.T., Mahmud, S., Mohsin, M., Mian, A.U., Islam, A., & Ahmed, F.F. "Knowledge, attitude, and practices toward food safety among students in Bangladesh: A cross-sectional web-based study", *Heliyon*, 2023, 9(4), e14762.