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Development and Evaluation of Educational Web-Based Food Safety Game, *Potluck Panic!*

ABSTRACT

Food safety education is necessary for development of individual life skills, public health, and fulfillment of societal workforce needs for scientists dedicated to safe food production. An interactive Web-based game, *Potluck Panic!*, was developed whereby players prevent foodborne illness by mitigating risky practices throughout food systems. Post-secondary students (261) enrolled in food science courses anonymously completed pre- and post-gameplay surveys on gameplay, food safety perceptions, behaviors, and knowledge. Subjects enjoyed the game (84%) with consequent increased awareness of (89%) and interest in food safety (75%), the food science major (57%), and intent to learn more (79%). A significant shift ($P < 0.05$) in attitudes among students enrolled in an introductory course included decreased trust in families' food preparation practices, increased confidence in the food supply, recognized need for scientific knowledge to produce safe food, and recognition that companies employ people responsible for food safety. Significant improvement on knowledge-based questions was observed for students enrolled in introductory courses who scored in the lower pregameplay quartiles. Seventy percent (70%) of secondary school educators rated the game favorably for enjoyment, educational value, and willingness to recommend it to a colleague. These data support game use to increase student interest in the science of food safety.

INTRODUCTION

Young adults need a working knowledge of food safety for individual life skills, public health, and societal workforce demands. However, instruction related to food systems and food safety is not required for all secondary and post-secondary students. This contributes to limited awareness of safe food practices and related scientific professions. Young adults are generally more likely to practice risky food-handling behaviors than other age groups *(14, 22)*, and instruction in the home may not be a reliable alternative to formal food safety education *(11)*. Young adults also represent a significant percentage of foodservice employees *(28)*, with pronounced roles in food safety for public health *(5)*. Maintaining a safe food supply requires

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sufficient expertise to meet workforce needs throughout food systems *(13)*.

Although formal food safety education may be limited, the digital era provides for instantaneous access to information on food-related recalls and illness outbreaks. The public awareness and self-relevance associated with these situations present an opportunity to engage learners and thereby impact perception and understanding of scientific food safety principles and practices.

Digital devices and platforms, including educational electronic games and simulations, can support science learning by introducing concepts, applying knowledge, or assessing knowledge *(2, 9, 20, 24)*. Educational games can also support self-paced instruction, learning accessibility across diverse populations *(20)*, and distance learning. Electronic games offer multiple learning paths enhanced by sound, image, text, instant feedback, and fun gaming elements *(1, 6, 8, 26, 27)*; however, more studies are needed to elucidate the impact on science interest and conceptual understanding *(20)*.

The objectives of this research included the development of a Web-based food safety game in which players assume responsibility for the prevention of foodborne illness and the evaluation of this game for a hypothesized positive impact on young adults' interest, perceptions, and understanding of safe food systems and the professional expertise required to attain a safe food supply.

MATERIALS AND METHODS

Development and design of *Potluck Panic!* game

The food safety game was designed to illustrate the complexity of food systems and the strategies used to minimize food safety risks. Content was developed to support the following educational objectives: (i) to engage students in the topic of food safety; (ii) to increase knowledge of food safety risks and practices for risk reduction; (iii) to positively impact perception of systems dedicated to assurance of a safe food supply; and (iv) to illustrate scientific expertise and various professional career roles involved in the assurance of a safe food supply.

Potluck Panic! (Fig. 1) is an interactive Web-based game that challenges players to serve safe food at a virtual potluck party by recognizing and minimizing risky food-handling practices from production through processing, packaging, distribution, and final handing. Players are simultaneously presented up to two single- or multi-ingredient food products and three steps involved in the manufacture to final handling of the presented foods. One of the steps presented is done in error and presents a food safety risk. Food products presented include single- and multi-ingredient beverages, appetizers, salads, main dishes, and desserts, such as juice, fruit smoothie, rice, bean dip, dumpling, chicken salad, cheeseburger, seafood product, pastry, and ice cream, among others. Examples of risks presented include poor agricultural practices, cross-contamination, inappropriate

Figure 1. *Potluck Panic!* game: (A) home screen; (B and C) storyline; (D) instructions; (E) challenge levels; (F) main play screen; (G) Ask-a-Scientist feature; (H) corrective feedback for errors; and (I) summary screen for risks minimized and game progress.

product pH, inadequate verification of thermal processes, faulty food package seals, and inaccurate food labels. The player mitigates the various risks by selecting an action card randomly presented from a deck of three cards per hand and then overlaying the correct action card on the identified risky practice. Some examples of action cards presented include good agricultural practices, clean contact surfaces, verifying the correct temperature, recall product, and correct biosecurity. The player has a limited number of hands to play before the food is served at the potluck. Gameplay features nine challenge levels of content complexity for food safety risks and prevention strategies. Consumer safe food-handling practices are emphasized at the lower game levels, and the impact of food intrinsic properties for safe food production and processing are introduced at the higher levels.

The game familiarizes the player with various risks throughout food systems and builds the ability to anticipate problems, mitigating them before the food is served. The player is given the opportunity to learn, fail with feedback, and identify when they need to learn more by using the "ask an expert" feature. Gaming features include visual and textual prompts, music, sound effects, random distribution of corrective action cards that necessitate a player strategizing for success, bonus cards to incentivize play, limited attempts, and scoring features on the basis of foods served safely. Additional embedded learning supports include repetition of concepts across commodities and the food safety continuum and a visual summary of foods served safely or with unmitigated risks. *Potluck Panic!* was honored by the Association for Communication Excellence in Agriculture, Natural Resources, and Life and Human Sciences with the 2018 Silver Award in the Interactive Media Program and is available for public use (https://potluckpanic.anr.udel.edu/).

Evaluation of *Potluck Panic!* game

Researchers used formative and summative evaluation studies to assess the impact of *Potluck Panic!* during and after game development, respectively. Studies were conducted in accordance with institutional review board requirements for research with human subjects. Evaluation studies sought to determine if the game (i) engaged students, (ii) increased knowledge, (iii) changed personal attitudes toward food safety, and (iv) introduced players to food safety careers.

Formative evaluation

Game development pilot study

Game developers observed 17 high school students as they used game prototypes at the New Mexico State University Learning Games Lab *(4)*. Design of the user-testing protocols refined in the lab provided for immediate and recurring feedback to improve games in development. Testing protocols included one-on-two observation during gameplay, opportunities for users to "talk aloud" during gameplay, post-gameplay interviews, and specific annotating and reflection of findings after observation. Formative testing revealed specific recommendations on gameplay, user interface, and educational content. Feedback informed modifications to the artwork, text, game mechanics, and story line for the final iteration of game design.

Pre-assessment validation of evaluation tool

The primary purpose of this portion of formative evaluation was to test and validate knowledge-based questions to be used for the final summative evaluation studies; however, student subjects were also asked opinions of the game. University of Delaware students *(41)* in a Foodborne Diseases course used the game and responded to pre- and post-gameplay survey questions on perception of the food supply and profession, and food safety knowledge (food microbiology, risk, recall, and processing and handling practices). Post-gameplay knowledge-based questions were different from the pre-gameplay survey questions to avoid repetition bias. Knowledge-based questions were analyzed for difficulty and discrimination to develop the summative evaluation tool. Post-gameplay questions also addressed evaluation of the game by students indicating the extent of agreement with provided statements about gameplay and its impact on engagement with the subject.

Summative evaluation

Researchers conducted summative evaluation studies with two groups of subjects: undergraduate students enrolled in food science courses and secondary school science educators. University of Delaware undergraduate students (261) used *Potluck Panic!* over 2 years in three animal and food sciences (ANFS) courses taught by two faculty members. Students (97) in ANFS 102 Food for Thought and ANFS 305 Food Science (23 students) completed a pre-gameplay online survey and were subsequently provided the game link and post-gameplay survey. Students who completed both surveys (response rate 23.4% from a total of 513 students) were entered into a gift card drawing. ANFS 111 Animal and Food Science Laboratory (141 students, response rate 95.3% from total of 148) students were provided class time to complete the online pre-gameplay survey, self-guided use of *Potluck Panic!*, and post-gameplay survey. Participation was voluntary; the identity and responses of participants were anonymous to investigators. Unique user-generated identifiers linked pre- and post-gameplay surveys, and researchers used *t*-test to analyze differences *(23)*. Consistent with voluntary participation, subjects could skip survey questions; thus, the reported response rate varied for questions on demographics, duration of gameplay time, and game evaluation. However, questions that evaluated a change in response (perception, knowledge) from pre- to post-gameplay were based on subjects who rendered complete responses for both surveys.

Researchers recruited secondary school science educator subjects through a voluntary visit to a University of

Delaware food safety exhibit and workshops at a National Science Teaching Association annual meeting. Consenting participants played *Potluck Panic!* (15-min minimum) and completed a post-gameplay survey. Participation was voluntary and anonymous to investigators. Subjects were compensated with a gift card for survey completion.

RESULTS

Formative evaluation

Formative evaluation studies were conducted to select knowledge-based questions to be used for the summative evaluation and to balance the questions for difficulty for pre- and post-gameplay use; therefore, student success with knowledge-based questions for this phase of evaluation are not reported. Student perception of the game was favorable, with Foodborne Diseases students (77.5%) reporting agreement or strong agreement with provided statements that *Potluck Panic!* was enjoyable, increased awareness of food safety issues (90.0%), and increased their interest to learn more about food safety (75.0%). These students also indicated intent to learn more about food safety (75.0%) and an increased interest in the food science major (55.0%).

Summative evaluation

Post-secondary school students

Students enrolled in Food for Thought, Food Science, and Animal and Food Science Laboratory were primarily in the first or second year of the college program, learned food safety at home, and altered behavior as a result of foodborne illness outbreaks *(Table 1)*. Students reported playing *Potluck*

TABLE 1. Demographics and behaviors of student subjects who Used *Potluck Panic!*

	Food for Thought (% subjects; $n = 97$)[a]	Food Science (% subjects; $n = 23$)	Animal and Food Science Laboratory (% subjects; $n = 141$)[a]
Age			
18 to 19 yr	48.5	21.7	89.4
20 to 21 yr	43.3	73.9	9.9
22 to 25 yr	7.2	4.4	0.7
Year in college program			
First	35.1	4.4	83.6 ($n = 140$)
Second	36.1	69.6	9.3 ($n = 140$)
Third	17.5	21.7	7.1 ($n = 140$)
Fourth	11.3	4.4	0.0 ($n = 140$)
I was introduced to food safety concepts in high school.	39.2	34.8	55.3
I was taught food safety at home.	74.2	78.3	73.1
I have taken at least one course on campus that discussed food safety.	93.8	100.0	39.0
My major is in the life sciences.	28.9	52.2	66.7
In the past 12 mo, I have heard about a foodborne illness outbreak.	84.4	91.3	68.1
News of a foodborne illness outbreak has influenced my food purchasing or consumption behavior.	68.8	91.3	64.5
I have stopped consuming a food as a result of learning about a foodborne illness outbreak connected to the food.	58.3	39.1	41.8
I avoid certain foods because I am concerned about safety.	66.7	47.8	55.3
I play games on a phone.	74.2	60.9	76.6
I play games on a computer.	51.6	39.1	59.6
I have used games to support concepts taught in class.	38.1	47.8	73.8

[a]Number of respondents for each group of students unless otherwise indicated.

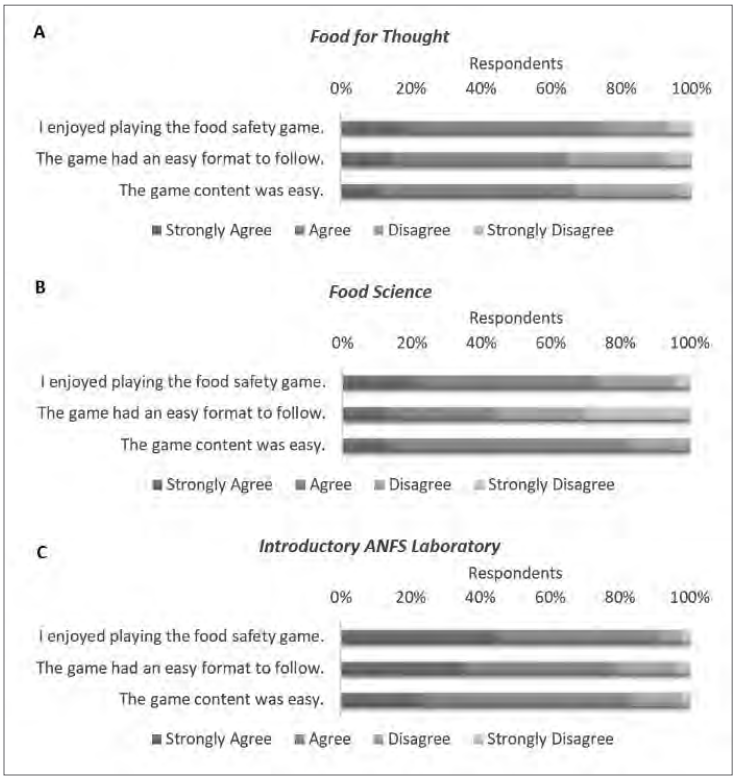

Figure 2. Evaluation of *Potluck Panic!* gameplay by student subjects enrolled in courses: (A) Food for Thought ($n = 93$); (B) Food Science ($n = 23$); and (C) Animal and Food Science Laboratory ($n = 140$).

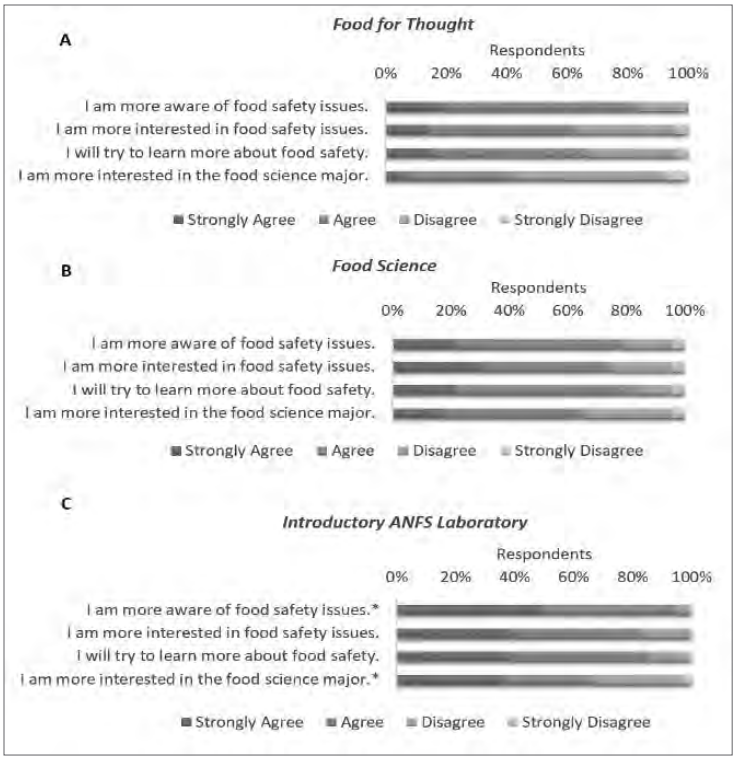

Figure 3. Impact of *Potluck Panic!* on food safety interest of student subjects enrolled in courses: (A) Food for Thought ($n = 93$); (B) Food Science ($n = 23$); and (C) Animal and Food Science Laboratory ($n = 140$; *$n = 139$), as evaluated by agreement with responses to complete the prompt "As a result of playing *Potluck Panic!* . . . ."

Panic! 15 min or less (11.2%), 16 to 30 min (67.9%), 31 to 45 min (14.1%), or 46 to 60 min (6.0%), with an average playing time of 25 to 31 min for all groups.

Students enjoyed the game (84%), reported they were consequently more aware of (89%) and interested in (75%) food safety and the food science major (57%), and would try to learn more about food safety (79%; *Figs. 2 and 3*). Students volunteered that *Potluck Panic!* was interesting or enjoyable (33.8% of comments, 17.2% of subjects) and informative or educational (21.5% of comments, 10.9% of subjects). Students also indicated initial confusion with gameplay (47.7% of comments, 24.2% of subjects) or frustration if unable to access the needed card before the limit of opportunities was reached (26.9% of comments, 13.7% of subjects). Enjoyment of gameplay was positively associated with reported ease of use of the game for student subjects enrolled in the 100-level courses (chi-square analyses, $P < 0.0001$).

Students' change in perceptions after playing *Potluck Panic!* (*Table 2*) included increased confidence in imported foods and U.S. food regulatory agencies, decreased trust in food prepared by family, increased recognition for the necessity of scientific knowledge to produce safe food, and that food processing companies employ people responsible for food safety. Responses shifted both from agreement to strong agreement, as well as disagreement to agreement with provided statements. Students' rankings of the reliability of five food safety information sources in order from most to least reliable for both surveys were U.S. food regulatory agencies (such as U.S. Department of Agriculture and the Food and Drug Administration), the Centers for Disease Control and Prevention, physicians, news media, and social media.

TABLE 2. Students' perceptions before and after using *Potluck Panic!* [a]

	Food for Thought ($n = 96$):			Food Science ($n = 23$):			Animal and Food Science Laboratory ($n = 141$):		
	Before	After	Change	Before	After	Change	Before	After	Change
I am confident that the domestic U.S. food supply is safe to eat.	3.23	3.21	–0.02	3.30	3.30	0.00	3.13	3.24	0.11
I am confident that foods imported into the U.S. are safe to eat.	3.05	2.96	–0.09	2.87	2.83	–0.04	2.79	3.06	0.26[b]
I trust the U.S. food industry to provide safe food products.	3.13	3.15	0.02	3.48	3.39	–0.09	3.13	3.22	0.09
I trust the U.S. government to assure a safe supply.	3.10	3.17	0.06	3.43	3.30	–0.13	3.06	3.23	0.17[b]
Food safety is a professional career.	3.63	3.63	0.00	3.83	3.87	0.04	3.68	3.79	0.11
Extensive scientific knowledge is needed to produce safe food.	3.51	3.49	–0.02	3.39	3.52	0.13	3.55	3.71	0.16[b]
Scientific study is required for expertise in food safety.	3.56	3.54	–0.02	3.65	3.74	0.09	3.71	3.77	0.06
Food safety is an important issue.	3.76	3.73	–0.03	3.91	3.96	0.04	3.88	3.82	–0.06
I care about food safety.	3.64	3.60	–0.03	3.83	3.91	0.09	3.75	3.79	0.04
I trust the food prepared by family members.	3.70	3.48	–0.22b	3.70	3.52	–0.17	3.53	3.35	–0.18[b]
I trust food prepared by friends.	3.27	3.09	–0.18b	2.96	3.00	0.04	3.09	2.97	–0.11
I am confident in my ability to prepare safe food.	3.39	3.30	–0.08	3.57	3.57	0.00	3.33	3.32	–0.01
Food processing companies employ people responsible for food safety.	3.19	3.15	–0.04	3.00	3.35	0.35	3.01	3.25	0.24[b]

[a]Values represent averages among subjects enrolled in each of three courses. Response code: 4 = strongly agree; 3 = agree; 2 = disagree; 1 = strongly disagree.
[b]$P < 0.05$.

TABLE 3. Students' performance on knowledge-based food safety questions before and after using *Potluck Panic!* [a]

Topic	Question (multiple choice response)	Food for Thought (n = 93) correct responses (% subjects)	Food Science (n = 23) correct responses (% subjects)	Animal and Food Science Laboratory (n = 140) correct responses (% subjects)
Pre-gameplay				
Risk	Which of the following foods would most likely cause potential foodborne illness?	81.5	95.7	92.9
Consumer practices	Which of the following consumer food preparation practices is correct?	90.2	95.7	87.9
Consumer practices	Which of the following consumer food preparation practices is improper?	83.7	91.3	87.1
Consumer practices	Which of the following consumer food preparation practices is not essential for safely preparing a hamburger?	73.9	60.9	37.1
Processing	The food industry relies on which of the following practices to protect consumer safety from the bacterium that produces the botulinum toxin?	25.0	56.5	9.3
Processing	Which of the following is not important to heat processing for food safety?	37.0	91.3	50.7
Microbiology	Foodborne pathogens . . .	53.3	91.3	70.0
Transmission	The "fecal-oral" route describes . . .	88.0	95.7	70.0
Processing	Which of the following foods does not receive a heat treatment in processing?	83.7	82.6	70.7
Microbiology	Which of the following is not true of spores?	27.2	69.6	30.0
Processing and storage	Which of the following permits rapid growth of most foodborne bacteria?	70.7	60.9	75.0
Processing	Pasteurization is . . .	43.5	91.3	29.3
Post-gameplay				
Risk	Which of the following foods should be recalled?	80.4	100.0	86.4
Processing	Which of the following food processing practices is not appropriate when using a new ingredient in a product?	82.6	82.6	79.3
Processing	Which of the following food processing practices is not regulated in the United States?	72.8	65.2	70.7
Transmission and prevention	Which of the following statements is incorrect?	13.0	13.0	27.1
Microbiology	Which of the following is not a bacterium?	65.2	95.7	81.4
Processing	*Salmonella* bacteria are challenging to control and have even been found to survive in contaminated flour, chocolate, and peanut butter in spite of the fact that each of these foods is shelf stable due to . . .	59.8	60.9	21.4
Microbiology	A biofilm is a(n) . . .	84.8	87.0	67.9
Processing	Cold chain refers to . . .	78.3	91.3	54.3

Continued on next page.

TABLE 3. Students' performance on knowledge-based food safety questions before and after using *Potluck Panic!* [a] (cont.)

Topic	Question (multiple choice response)	Food for Thought (n = 93) correct responses (% subjects)	Food Science (n = 23) correct responses (% subjects)	Animal and Food Science Laboratory (n = 140) correct responses (% subjects)
Consumer practices	A recipe calls for a food to be cooked at a specific temperature for 30 min for safety. The cook has only 25 min to prepare the food. For safety of the finished food product, the consumer should avoid: . . .	54.4	52.8	46.4
Production	Which of the following is a best practice for food production?	82.6	69.6	67.9
Microbiology	Which of the following statements about *Staphylococcus aureus* is incorrect?	33.7	30.4	37.9
Consumer practices	Which of the following is not a consumer safe food handling responsibility?	77.2	82.6	72.1
		Correct responses (% questions)	Correct responses (% questions)	Correct responses (% questions)
Pre-gameplay		63.2 (±17.8)	81.9 (±14.1)	59.2 (±15.1)
Post-gameplay		68.57 (±17.3)	73.55 (±15.4)	60.0 (±20.9)
Pre- to post-gameplay change		5.34 (±24.6)	−8.33 (±16.7)	0.8 (±21.4)

[a]No significant change ($P < 0.05$) in correct responses to knowledge-based questions was identified for each class for all questions combined.

Correct response rate for knowledge-based questions *(Table 3)* varied by the course of enrollment, with pregameplay correct responses received by 59.2 to 63.2% of subjects in the 100-level courses and 81.9% of subjects in the 300-level course. Correct responses to knowledge-based questions varied considerably with greater accuracy on questions concerning consumer practices than questions related to microbiology or industry food safety strategies. Change in overall correct response was not significant within a course *(Table 3)*; however, greater overall improvement was observed for subjects in the 100-level courses who scored in the lower quartiles for pre-gameplay questions *(Fig. 4)*. Changes in correct number of responses to knowledge-based questions within a course were not associated with reported enjoyment of the game, ease of use, or time spent playing the game.

Secondary school educators

Seven survey respondents (25% response rate from 28 consenting players) taught family and consumer sciences, biology, food science, general science, engineering, Earth and space, and microbiology in secondary schools. Educator evaluation of *Potluck Panic!* was positive *(Table 4)*; over 70% enjoyed the game and would recommend it to a colleague as an educational classroom activity. Open-ended feedback included implementation concerns regarding difficulty of game format, undesirable repetition, and access to electronic devices.

DISCUSSION

Educational Web-based games and simulations have been developed for various scientific topics *(20)*, such as animal science *(3)*, biology *(12, 25)*, microbiology *(10, 18)*, forensic science *(15, 17)*, and neuroscience *(16, 19)*; however, formal studies on the impact for science education remain limited. This study evaluated a Web-based food safety game for impact on science learning *(20)*, including engagement, perception, conceptual understanding, and the recognized role of science and scientists for society.

Potluck Panic! contextualizes food safety in a familiar life scenario and requires players to identify and solve problems. This approach is rooted in constructivism educational theory, supports learning through audiovisual and interactive

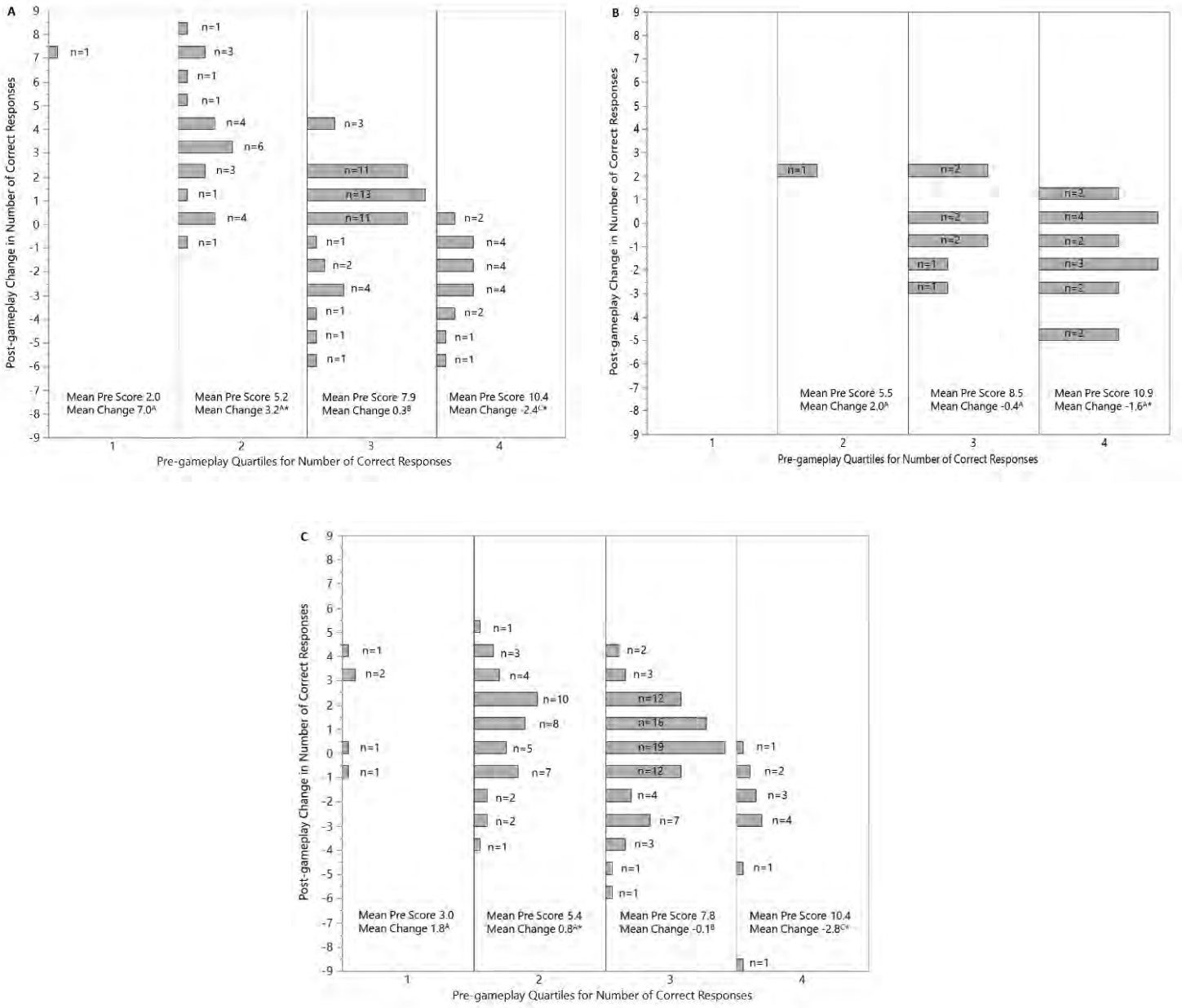

Figure 4. Change in number of student subjects' correct responses to 12 knowledge-based questions after gameplay (y axis) as grouped by student subjects' pre-gameplay quartile of correct responses (x axis). Students grouped in quartile 1 = 1 to 3 correct questions on the pretest; quartile 2 = 4 to 6 correct pretest responses; quartile 3 = 7 to 9 correct pretest responses; quartile 4 = 10 to 12 correct pretest responses. The y axis indicates the change in the number of questions answered correctly post-gameplay as compared with pre-gameplay with increased number of correct responsed indicated by values > 0, no change = 0, and decreased number of correct responses indicated by values < 0. Bars indicate the number of students in each quartile and the change in number of questions answered correctly from pre- to post-gameplay. Students enrolled in courses (A) Food for Thought (n = 92); (B) Food Science (n = 23); and (C) Animal and Food Science Laboratory (n = 140). Significant difference ($P < 0.05$), as measured by t-test, in change in mean scores among quartiles for each class are indicated by different letter superscripts. Significant change in mean scores within a quartile for each class are indicated with an asterisk.

elements *(18)*, and provides repetition, increasing challenge, feedback, and support for self-guided learning. Students reported overall enjoyment of the game, being engaged in the subject matter, and being inspired to learn more. Perceptions shifted in the importance of science for society, as indicated by increased recognition for scientific study to support food safety, connection-to-self as indicated by the decreased trust in families' food handling, and recognition of science

TABLE 4. Educator[a] evaluation of *Potluck Panic!*

Statement	Strongly agree (%)	Somewhat agree (%)	Neither agree nor disagree (%)	Somewhat disagree (%)	Strongly disagree (%)
I enjoyed playing *Potluck Panic!*	57.1	28.6	0.0	0.0	14.3
Potluck Panic! play format was easy to understand.	42.9	14.3	0.0	28.6	14.3
Potluck Panic! is a valuable tool to illustrate the complexity of the food supply.	71.4	14.3	0.0	14.3	0.0
Potluck Panic! is a valuable tool to illustrate scientist career opportunities in food production.	42.9	28.6	14.3	0.0	14.3
Potluck Panic! would be a good classroom activity.	57.1	28.6	0.0	14.3	0.0
Potluck Panic! would be a good homework activity.	28.6	14.3	42.9	14.3	0.0
I would recommend *Potluck Panic!* to a colleague.	57.1	28.6	0.0	0.0	14.3

[a]$n = 7$.

careers as indicated by the increased perception that food safety experts are employed in commercial food production. Students with the least experience in the subject matter also had significant gains in conceptual understanding. Although the game is not intended to replace traditional instruction, these data indicate it was an effective educational tool. The findings mirror limited reports on the sufficiency of one-time Web-based game use to improve conceptual understanding independent of traditional instruction *(18, 19)*.

Potluck Panic! presented a multitude of food safety strategies across commodities, and knowledge-based questions evaluated player ability to recognize facts, apply facts to a situation, and connect concepts across situations. The higher overall performance on *Potluck Panic!* knowledge-based questions among students in the 300-level course was expected due to prior instruction in commercial processing safety strategies. Although longer gameplay may have provided more exposure to food safety strategies, length of gameplay time for student subjects was not correlated to performance on knowledge-based questions.

Positive outcomes with novice college-aged students support application of *Potluck Panic!* for secondary science education to introduce career opportunities and support education content standards for health *(7)* and science *(21)*. This is supported by educators who noted cross-curricular potential of *Potluck Panic!* to engage students, reinforce concepts of disease control, and encourage students to think about careers and food. Web-based games have been used to introduce careers and teach students about topics not routinely covered in formal education but which support education content standards *(15–17)*. With the educational benefits observed independent of traditional instruction and its accessibility, *Potluck Panic!* may also have application for self-guided learning in informal learning settings.

Potluck Panic! was developed for longevity with recognition that scientific discoveries would continue after game development. Effort was made to illustrate the vulnerability of all foods to contamination without conveying either a false sense of security or suspicion for food categories but rather to convey scientific principles of strategies to prevent foodborne illness across food systems. There were limitations regarding what could be embedded in *Potluck Panic!* including assessment; thus, evaluation relied on pre-and postgameplay surveys similar to previous studies *(16, 18)*. More complex issues, such as degree of risk, were incorporated into Ask-a-Scientist or feedback features due to challenges in coding such concepts into the game. One user noted that the scoring system may fall somewhat short of conveying the seriousness of foodborne illness, as there is no game "penalty" in the form of virtual illnesses, hospitalizations, or deaths consequent of serving even one food with an unmitigated risk, even as other foods are served safely.

Some players reported frustration in the limited directions for gameplay and the chance factor associated with card access. Both of these features, however, are accepted characteristics of digital games for entertainment. One user acknowledged the card rotation differentiated *Potluck Panic!* as a game rather than a matching quiz.

CONCLUSIONS

The interactive Web-based game situated in narrative and problem-based learning was effective for engaging players and enhancing interest to learn more about food safety and the food science major. The game also raised awareness of

the role of science and scientists for providing safe food and improved conceptual understanding for players least acquainted with the topic prior to gameplay. Potential applications include introducing food safety and related careers and exercising content knowledge learned through traditional instruction.

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