Delivering Food Safety Education to Middle School Students Using a Web-Based, Interactive, Multimedia, Computer Program


ABSTRACT: More than 76 million persons become ill from foodborne pathogens in the United States each year. To reduce these numbers, food safety education efforts need to be targeted at not only adults, but school children as well. The middle school grades are ideal for integrating food safety education into the curriculum while simultaneously contributing to national and state education standards in science, technology, and family and consumer sciences. For this project, a multimedia, self-paced online resource for delivering a food safety curriculum to middle school children was developed. Animated characters were used to deliver the lesson content. The application also included video segments, quiz feedback, and interactive games and activities. The effectiveness of the Web site was evaluated using validated cognitive and attitudinal assessment tools, and by comparing student cognitive gains to individual student learning styles. Participants were recruited from 6 middle schools in 5 states, totaling 217 students (20 sixth graders, 157 seventh graders, and 40 eighth graders). The results show that students had statistically significant modest gains in pretest to posttest knowledge and enjoyed using the Web site. The 6th grade students had significantly lower pretest to posttest improvement compared to 7th and 8th grade students, suggesting that this program may not be appropriate for this grade level. Furthermore, the results indicate that this Web-based computer application meets the needs of varying individual student learning styles.

Introduction

Foodborne illness is a serious public health concern. There are approximately 76 million illnesses, 325,000 hospitalizations, and 5,000 deaths in the United States each year due to foodborne pathogens (Mead and others 1999). Fortunately, foodborne illness can be prevented. Educational interventions beginning at an early age can play a significant role in this prevention strategy. The middle school years offer an ideal target group for food safety educational efforts. In fact, in 1998 the USDA and FDA reported that food safety education directed at school-age children should be a top priority (Koeppl and Robey 1998). Middle school students are at an age where they can begin to understand the science behind food safety concepts and apply the knowledge to real-life situations. In addition, many students at this age are beginning to prepare meals or snacks at home (Haapala and Probart 2004). Food safety education can be easily incorporated into existing middle school curricula in courses such as science, family and consumer science, and health. Yet, a study of 8th grade students revealed that they were lacking in food safety knowledge and practiced some risky food-handling behaviors (Haapala and Probart 2004).

One way to engage students in learning about food safety is through the use of computers and the Internet. Research indicates that middle school students are interested in using computers in school for educational purposes (Levin and others 2002). Already, more than 87% of adolescents use the Internet, and 88% of online teens believe that the Internet helps them to do better in school (Hitlin and Rainie 2005). Another benefit of Web-based computer programs is that any school with Internet access can use the program. Thus, schools with limited access to faculty with expertise in food safety can still incorporate food safety into their courses using Web-based resources.

Computer programs also have the potential advantage of meeting individual student learning styles. “Learning style” describes “the way in which each learner begins to concentrate on, process, and retain new and difficult information” (Dunn and Dunn 1993). Studies indicate that when a student’s learning style is matched to the instructional method, there is greater learning achievement (Wheeler 1983; Martini 1986; Dunn and Dunn 1993). For example, a student who is a visual learner would have greater learning achievement when instructional tools include texts with graphics and videos, instead of a lecture. The rapidly expanding capabilities of the Web may allow for the development of Web-based learning tools that meet the needs of varying learning styles.
The purpose of the present research study was to develop a Web-based food safety instructional application targeted at middle school students and to evaluate student cognitive gain and attitudes regarding use of the program. In addition, individual student learning styles were measured to determine if learning style influenced student performance and attitudes.

Materials and Methods

Computer application and curriculum

The curriculum for this Web-based food safety program was based primarily on an existing, validated, middle school food safety curriculum developed by faculty from the Univ. of Vermont Extension and Univ. of Connecticut Cooperative Extension (Hirsch and others 2002). This curriculum, entitled Food, Flies, and Fungus, is based on experiential learning methodology and targeted at grades 5 to 8. Although it was originally implemented in a 4-H club format, it was also intended for use in the classroom. It was pilot tested with 4-H leaders and members in 1998 and revised in 2000. Four units were selected from this curriculum for inclusion in the Web-based program. These units were Explore the Microworld, which describes the differences between bacteria, mold, parasites, viruses, and yeast and conditions necessary for their growth; Challenge of the Microorganism, which explains the differences between beneficial, spoilage, and pathogenic microorganisms, the 2 types of foodborne illness, the factors required for a foodborne illness to occur, and the populations at the greatest risk of illness; Microbes are Everywhere, which addresses the importance of cleaning and sanitizing; and A Cookbook of Consumer Food Safety and Preparation, which provides guidelines for preparing risky foods such as eggs, ground beef, and leftovers. Additional topics in the Web-based program were derived from various Farm to Fork curricula (Food and Drug Administration and Natl. Science Teachers Assn. 2001a, 2001b; California Foundation for Agriculture in the Classroom and Alliance for Food and Farming 2004). In this adaptation of the Farm to Fork curriculum, students learned how food is processed by following how a hamburger is made, from the farm to the backyard BBQ, emphasizing the methods used to prevent contamination and growth of microorganisms at the farm, during transportation, in the processing plant, at the supermarket, and finally in the home. The Food Safety Website also included other various activities and videos on topics such as hand washing, bacterial growth, and the 4 C’s of food safety (Food and Drug Administration and Natl. Science Teachers Assn. 2001).

A screenshot of the Web application homepage is shown in Figure 1. The application uses animations, videos, activities, games, and quizzes to convey the various food safety topics. The program was developed primarily with Adobe Flash software (San Jose, Calif., U.S.A.). In addition, Adobe Cold Fusion was used for database connectivity, and Flicks Authentix software (Las Vegas, Nev., U.S.A.) was used for login security and tracking student use of the program.

The central design theme for the program was a college campus (Figure 1). Navigating the program was done with a virtual Personal Digital Assistant (PDA), which would show up every time the student logged onto the site. The PDA would keep track of lessons completed and where the students had left off when they last exited the program. Each lesson was delivered by an animated character (professor), or avatar, that served as the pedagogical agent.

Figure 2 shows an example of a typical lesson in the program. The professor moves around and interacts with the graphics on the screen. Students were able to rewind, fast-forward, and pause the lesson, which enabled them to learn at a pace appropriate for their needs. Interactive games and activities reinforced material from the lessons, and students could test their knowledge by taking short quizzes after completing each module. Students had to correctly answer at least 6 out of the 10 quiz questions to move to the next module. The program was designed to be completed sequentially, which ensured that all students viewed material in the same order, but students could also go to earlier lessons, quizzes, or activities to review material. A demo version of the program can be found at http://www.nfs.uvm.edu/ootledemo.

Figure 1—The Web site’s homepage is designed to look like a campus. Students navigated the site by using the PDA, pictured on the left side of the screen shot.
The assessment tools

Based on the course content described previously, learning objectives were identified that the students were expected to meet. A Table of Specifications was then constructed in which the amount of time a student would be expected to spend on each learning objective was estimated.

Cognitive and attitude assessment instruments were developed to measure student knowledge about food safety and their attitudes regarding the use of the food safety computer program, and the use of computers in general. Development of the cognitive assessment tool was based on the table of specifications. Each question in the assessment was written to specifically address a learning objective in the same cognitive domain of Bloom's Taxonomy (Bloom and others 1956), and the estimated amount of learning time spent on the objective was reflected in the number of questions on the assessment for that objective. In order to develop a tool with content validity, the assessment was given to a panel of 7 experts, which included professionals in the field of food safety and professionals with expertise in educational methods and assessments. In addition, feedback was obtained from 3 middle school students. The suggestions and feedback from these groups were considered and, where appropriate, incorporated into the final version of the assessment instrument. A copy of the cognitive assessment tool can be downloaded at http://nfs.uvm.edu/ootledemo/post-test.pdf.

The attitude questionnaire also was validated by the panel of experts. It consisted of 9 questions based on a 5-point Likert scale (from 1 = “strongly disagree” to 5 = “strongly agree”). Four of the questions focused on student perceptions of the learning experience while using the Web program, and 5 questions focused on design aspects of the program (ease of use, fun to use, usefulness of the animations). An additional 3 questions queried students on which features they most liked and where they most often accessed the program (home, school, library, computer room, other). For data analysis, the responses to the 4 “learning” questions and the 5 “design” questions were separately averaged for each student to obtain a single learning and a single design score. A copy of the attitude assessment tool can be downloaded at http://nfs.uvm.edu/ootledemo/attitude_assessment.pdf.

One of the stated objectives of this research study was to assess the influence of learning styles on learning achievement when using the food safety Web application. A search of the literature found very few learning style assessments that were appropriate for younger students. Since the students in this study were located in different parts of the United States, it was important to use a tool that could be administered online and easily scored. The Dunn, Dunn, and Price Learning Styles Inventory (Human eSources Ltd. 2005) was determined to be the best fit for this study, since it was validated for middle school students, it was available online, results were quickly tabulated, and it only took about 20 min to complete. The inventory is based on the Dunn and Dunn Model of Learning-Style Preference and has been validated through meta-analysis of 36 studies (Dunn and others 1995). The learning styles inventory (LSI) evaluates 18 different learning preference elements that relate to environmental, emotional, sociological, and physiological preferences. The LSI was administered online and was completed under the supervision of the teacher. Students were presented with 100 separate statements. Examples of these statements include:

- I study best when it is quiet,
- I like to study by myself,
- The things I remember best are the things I hear,
- It’s hard for me to sit in one place for a long time (Dunn and Dunn 1993).

The student responded to each statement by indicating the extent to which he/she agreed or disagreed with the statement. An individual report was generated for each student that indicated his/her score on each of the elements and elaborated on ways the student or teacher could support greater learning achievement in the classroom. For each preference, a scale of 20 to 80 is used. Students with a score between 20 and 40 are considered to have a low preference for that particular element. Students with a score between 60 and 80 are considered to have a high preference for that element. Students with a score between 40 and 60 typically do not require the...
specific element to learn and therefore do not have a preference.

Recruitment of participants

An advantage of having a Web-based learning program is that it allows for recruitment of a large number of participants (middle school students) from a broad geographical spectrum. To accomplish this, an informational e-mail was sent to the Natl. Family and Consumer Science Teacher listserv, which targeted teachers and state directors in the United States. A total of 150 schools expressed interest in the research study. The list was narrowed by following up with teachers who taught 6th, 7th, or 8th grade in schools that had broadband Internet access, had computers with headphones or speakers for every student, were willing to administer the assessment tools and learning styles inventory, were willing to devote 8 to 12 h of classroom time to the computer application, and would use all parts of the curriculum. The schools also needed to be able to use the program between October 2006 and January 2007. Seven schools met these selection criteria and were included in the study.

Implementation

This research study was approved by the Univ. of Vermont Institutional Review Board’s Committee on Human Research in the Behavioral Sciences. Prior to starting the program, an informational letter was provided to teachers that could be sent home to parents and guardians. Teachers were provided with written instructions on how to access the Web site and on how to administer the LSI online. They could view each of their students’ LSI reports and a summary report for their entire class. Teachers used individually assigned registration codes to access the program the first time and then chose a personal username and password for all future logins. Students began by completing the LSI and the cognitive pretest. Upon completion of the pretest, they were given access to the computer program. All data collected were coded by registration number and username to maintain individual confidentiality. The data were then stored on a secure server at the Univ. of Vermont.

At the 1st login, after completing the pretest, every user watched a brief orientation/overview of the Web application, led by the animated professor avatar. The users were shown how to access lessons, quizzes, games, activities, and resources in the library. Students then could continue to the 1st food safety lesson. When the entire class completed the lessons and activities, the cognitive posttest and attitude assessment instruments were administered. Classes used the program for an average of 19 d. Teachers were given the option of when to start using the program, how the modules would be integrated into their teaching schedule, and how long they would give the student to complete the unit. It was important to remain flexible so teachers would be willing to spend valuable class time using the Web-based program. Teachers reported that they did not supplement the program with other food safety material.

Data collection and statistical analysis

The server recorded how many times each student logged onto the site, as well as how many times each student completed a lesson, quiz, game, activity, or visited the library. Paired t-tests were used to compare pretest and posttest scores for each student (learning achievement). Bonferroni’s pair-wise comparison was used to compare scores between schools. One-way analysis of variance (ANOVA) was used to assess the influence of learning style preference on learning achievement. Pearson’s correlation and regression analysis were used to study the relationship between learning achievement and program usage. Statistical analyses were performed using SPSS (version 12.0 for Windows, SPSS Inc., Chicago, Ill., U.S.A.) and Minitab (Release 14.20, Minitab Inc., State College, Pa., U.S.A.), statistical software programs.

Results and Discussion

Recruiting participants

Approximately 300 students from 7 schools and 5 states were initially recruited for the study. One school was dropped from statistical analysis since the teacher reported that a last-minute scheduling conflict prevented nearly all of her students from taking the posttest and the students who took the posttest did not take it seriously. Furthermore, 71 students were eliminated from analysis because either they did not complete a posttest or they did not complete the LSI. The remaining 217 students (20 sixth graders, 157 seventh graders, and 40 eighth graders) were used for statistical analysis. The breakdown of the participating schools were as follows: 1 class from Michigan (MI), 2 classes from 1 school in New York (NY1/NY2), 2 classes from 1 school in Rhode Island (RI1/RI2), 2 classes from each of 2 schools in Tennessee (T1/T2, TN1/TN2) and 1 class from Vermont (VT).

A convenience sample was the best approach for this project since it helped to guarantee that participating teachers were committed to the project and its goals. But, because it was a convenience sample, the study did have limitations since it excluded teachers and schools that did not have adequate resources to fully implement the program. The teachers who participated in the study may have already been familiar with computers and felt comfortable using them in their classroom. Teachers who were not comfortable using computers may have excluded themselves from the study, even though their students might have been ready and willing to use technology in the classroom.

Learning achievement

In order to be confident that learning achievement was an accurate measurement of student knowledge, it was necessary to ensure that the assessment tool for measuring knowledge was both valid and reliable. When constructing the cognitive assessment tools (pre- and posttest), content validity was addressed by carefully constructing multiple choice questions based on the table of specifications and by considering, and where appropriate incorporating, feedback from the panel of experts. An item analysis of the test was also performed. Item analysis focuses on analyzing questions based on a difficulty index and discrimination index (Erikson and Wentling 1976). The difficulty index is the percentage of students who responded correctly to a particular question and identifies questions that may be too easy or too difficult (Erikson and Wentling 1976). In this study, the cognitive test contained 30 multiple-choice questions and 1 question was eliminated because more than 94% of students answered the question correctly. The discrimination index provides a measure of how well a question discriminates between high and low scorers on a test. If students in the low scoring group answer a question correctly more times than students in the high scoring group, it indicates that the question is poorly constructed, unclear, or contained poor distracters and the question should be eliminated. Based on the discrimination index score that was calculated for each question, none of the questions in the cognitive assessment instrument needed to be eliminated.

The reliability of the cognitive test was determined by the split-halves method and applying the Spearman–Brown formula (Erikson and Wentling 1976). The split-halves method involves
correlating the number of correct responses to odd-numbered questions for each student with the number of correctly answered even-numbered questions. The posttest cognitive evaluation instrument had an excellent reliability score of 0.81.

The results for the pre- and posttest assessments are shown in Table 1. When all 217 students were analyzed together, the students scored 52.4% ± 15.5 (mean ± standard deviation) on the pretest and 63.7% ± 17.7 on the posttest. This difference of 11.3% was statistically significant (P < 0.001) but much smaller than expected. One-way ANOVA analysis of the student pretest scores, posttest scores, and change in score for each of the grade levels indicated that there was no significant difference in pretest scores across the 3 grade levels. There was also no significant difference in posttest scores between the 3 grade levels (P > 0.07). However, the 7th and 8th grade students had significant improvement in scores from pretest to posttest. In addition, the 6th grade students’ change in score was significantly lower than the 7th and 8th grade students. These data suggest that this computer program may not be appropriate for the younger grade level. However, even accounting for the poor pretest to posttest score change in the 6th graders, the overall improvement in scores for the 7th and 8th graders was still low. This may be partly due to the relatively high pretest scores. The students on average already knew more than 50% of the material before using the program. In addition, the research design and limitations of this study may have contributed to the modest improvement in pre- to posttest scores. The mean number of individual student visits to the Web site was only 8 (with a range of 3 to 15). Clearly, students did not use the site as frequently as intended. Perhaps this was due to the teacher’s expectations of the students to finish the lessons and complete the research assessment instruments. If teachers were given more individual control over how to implement the Web site (rather than feel restricted by the research requirements of the study investigators), it may have encouraged students to explore and revisit the site more often and foster class discussions.

### Attitudes

Student and teacher attitudes regarding use of the food safety program were also examined. The responses from the Likert scale statements on the student attitude survey were converted to numerical values. Attitude assessment statements were grouped into either “learning with computers” or “design of program” categories, then scores were averaged within each grouping. In general, students had positive attitudes about using the computer application (Figure 3). They liked the flexibility that the computer program provided and they thought that the Web site was fun and easy to use. Most students used the program in their classroom, computer room, or library. The features that students enjoyed the most were the videos, games, and activities. Students felt that a lack of time was the biggest factor that prevented them from more fully utilizing all aspects of the computer application. An informal survey of the 8 participating teachers revealed that teachers liked using the program, felt that it fit into their existing course, and that it helped them to meet their food safety educational objectives.

### Differences between classes

The influence that different teachers might have on the learning achievement of students in their class was also examined. There was no significant difference in pretest scores between classes, but there were significant differences in learning achievement (change in score from pre- to posttest) between classes. In fact, 1 class (T2) actually had a mean learning achievement of –0.86% (data not shown). This lower posttest mean score was probably not a result of T2’s unfamiliarity with the program since the teacher in this class had already used the program with one of her other classes (T1). However, the teacher reported that her T2 students were 6th graders, that the material seemed too difficult, and there were some students requiring special assistance in her class. The computer application was designed for middle school students, which may include 6th grade, but might be more suitable for 7th, 8th, or 9th graders. Interestingly, 1 teacher who used the program but was not part of the study reported that the program worked very well for her special needs students in high school since the program is self-paced and engaging.

Student attitudes also differed between classes. For each student, the attitude score for each of 4 questions about “learning with computers” was averaged. The average score for each class was then calculated. Most classes had a positive attitude about learning with the program (data not shown). Students in the MI class had a significantly less positive mean attitude score (P < 0.05) regarding “use of the program” than the other classes. They expressed neutral feelings about learning with the program. Interestingly, MI students used the program over the longest time span, approximately 2 mo. However, MI students did not visit the Web site more frequently than the classes who used the program for a shorter time. It is possible that visiting the site once a week led to the MI students’ less frequent use of the Web program. Interestingly, MI students used the program more frequently than the other classes over a shorter period of time.

### Learning achievement and usage of the program

Since the study focused on the use of computers for educational purposes, a regression analysis was used to compare how the use of various components of the Web site correlated with learning achievement. Table 2 shows the

### Table 1—Cognitive assessment scores for the pre- and posttest.

<table>
<thead>
<tr>
<th>Grade level</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Change in score</th>
</tr>
</thead>
<tbody>
<tr>
<td>6th graders (6, 7)</td>
<td>56.0 ± 15.6</td>
<td>56.0 ± 20.12</td>
<td>0.0 ± 8.67</td>
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<tr>
<td>7th graders (7)</td>
<td>52.2 ± 15.19</td>
<td>65.2 ± 16.44</td>
<td>13.0 ± 11.90</td>
</tr>
<tr>
<td>8th graders (8)</td>
<td>49.8 ± 16.83</td>
<td>60.1 ± 20.35</td>
<td>10.3 ± 17.08</td>
</tr>
<tr>
<td>Combined (6, 7, and 8)</td>
<td>52.4 ± 15.51</td>
<td>63.7 ± 17.70</td>
<td>11.3 ± 13.19</td>
</tr>
</tbody>
</table>

### Table 2—Regression analysis results for learning achievement versus Web site usage.

<table>
<thead>
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<th>Table 2—Regression analysis results for learning achievement versus Web site usage.</th>
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<tbody>
<tr>
<td><strong>Measurements of Web site usage</strong></td>
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<tr>
<td>(n = 217 students)</td>
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<tr>
<td>Completion of tasks</td>
</tr>
<tr>
<td>Total usage of Web site</td>
</tr>
<tr>
<td>Lessons completed</td>
</tr>
<tr>
<td>Quizzes completed</td>
</tr>
<tr>
<td>Visits</td>
</tr>
<tr>
<td>Games completed</td>
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<tr>
<td>Activities completed</td>
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</table>

*Completion of tasks was measured by tracking how far the student progressed through the computer program’s required lesson and activities.  
1 The sum of the number of times the student completed a lesson, quiz, game, activity, and used the library.
regression analysis for the different measurements of usage versus learning achievement. The completion of tasks significantly and positively correlated with learning achievement ($r^2 = 0.065, P < 0.001$). The completion of tasks is an indicator of how much of the program the student completed. In addition, total usage (the sum of all of the times the lessons, quizzes, activities, games, and library were viewed) significantly and positively correlated with learning achievement ($r^2 = 0.035, P < 0.005$). The use of the lessons ($r^2 = 0.030, P < 0.009$) and quizzes ($r^2 = 0.0497, P < 0.001$) also significantly and positively correlated with learning achievement. The lessons addressed the majority of the learning objectives, so it is not surprising that learning achievement correlated with the number of times lessons were viewed. The quizzes provided feedback to students to help them focus on food safety concepts that needed further review. As mentioned previously, the mean number of login visits to the site was only 8, with a range of 3 to 15. Nevertheless, visits also significantly correlated with learning achievement ($r^2 = 0.0357, P < 0.005$). Despite the statistical significance of some of these correlations, the $r^2$ values are relatively weak, likely due to the small mean learning achievement scores for the students (Figure 3). Interestingly, the use of the games and activities did not significantly correlate with learning achievement. One possible explanation for this may be that the topics covered in the games and activities did not reflect a large proportion of the learning objectives for the course, and therefore were not highly represented in the cognitive assessment.

The results are similar to what other researchers have reported (McNulty and others 2000; Davies and Graff 2005). Davies and Graff (2005) studied online, asynchronous interaction (primarily discussion board usage) of undergraduates in a business degree course for 12 mo. The students who used the discussion boards the most performed better than students who did not interact online as much. McNulty and others (2000) studied how medical students interacted with a Web-based computer program for learning about the human body. They found that the use of the computer program and the length of time spent with an application correlated with learning achievement. These observations make sense intuitively since spending more time with the material should enhance retention and storage of information. Although the direction of the relationship is unknown, designing programs that are able to hold the student’s attention may increase the amount of knowledge that students gain from using computers.

The total usage of the site also positively correlated with the students’ attitudes about learning with computers ($r^2 = 0.0180, P < 0.05$). The correlation is small and causality cannot be determined, but it is possible that designing a computer program that students enjoy using may increase how often students use it. By increasing the use of the computer program, learning achievement may also increase, so it is important to design a Web-based program that is appealing to the target audience in order to maximize learning.

**Influence of learning style**

A major objective of this study was to investigate the influence of learning style on learning achievement with the food safety computer program. Learning style was assessed using the Dunn, Dunn, and Price Learning Styles Inventory (Human eSources Ltd. 2005). As mentioned in the Methods section, students either have a high preference, low preference, or no preference for a particular learning element. Nine elements from the 18 in the LSI were selected based on what were most relevant to the use of a computer program. The 9 selected were motivation (M), persistence (P), responsibility (R), structure (S), alone versus peer (AP), auditory (A), visual (V), tactile (T), and kinesthetic (K) (Dunn and Dunn 1979). M describes how much a student enjoys learning, P describes a

![Figure 3](image-url)  
**Figure 3**—Mean attitude assessment scores for questions evaluating learning with computers and design of our program ($n = 217$). Bar values are mean ± SD. The attitude assessment was administered when the class was finished using the Web site. It was based on a 5-point Likert scale from strongly disagree (1) to strongly agree (5). Students were presented with a series of statements that were grouped into 2 categories, “learning with computers” and “design of program.”

![Figure 4](image-url)  
**Figure 4**—The number of students who were determined to have a low, high, or no learning preference for each element. Learning styles were assessed using the Dunn, Dunn, and Price Learning Styles Inventory (LSI). Students with a low preference for the element scored between 20 and 40 on the LSI. Students with a high preference scored between 60 and 80. Students with no preference scored between 40 and 60. Elements include emotional measures (M = motivation, P = persistence, R = responsibility, S = structure), sociological measure (AP = alone/peer), and perceptual measures (A = auditory, V = visual, T = tactile, K = kinesthetic).
student’s desire to complete tasks, R describes a student’s desire to conform, and S describes how much a student likes to be told what to do. AP, a sociological preference, describes if a student prefers to work with others or by him/herself. A, V, T, and K, describe how well a student learns by listening, reading or viewing, touching, or doing, respectively. M, P, R, and S are classified as emotional preferences, and A, V, T, and K are classified as perceptual preferences. Figure 4 shows the number of students in each category. For most individual elements, the majority of students did not have a preference, indicated by a score of between 40 and 60. More students have a high preference for tactile learning compared to other perceptual types, and prefer to learn with peers rather than by themselves.

In 1979, Dunn and Dunn reported that 20% to 30% of school age children have a singular high preference for auditory and about 40% have a singular high preference for visual. In general, very few students in the present study had a singular perceptual preference (for example, 1 high preference for auditory). Only 8.8% of the students had a singular preference for auditory and 8.8% had a singular preference for visual (data not shown). Almost 36% of the students preferred to learn in two or more perceptual ways. For instance, they had a high preference score for both auditory and visual, or any other combination of A, V, T, and K. Nineteen percent indicated no perceptual preference, so they did not have a high preference score for A, V, T, or K. Students’ learning preferences may have changed since 1979 for a number of reasons including the increased use of TVs, video games, and computers. Students may be able to learn in a variety of ways due to the increased use of various media, which might explain why the majority of students either prefer to learn in multiple ways, or have no preference for a particular perceptual way.

ANOVA was used to assess the influence of learning styles on learning achievement. Students with no preference are typically not included in learning style studies, so only average learning achievement scores between high preference and low preference learners were compared. The results are presented in Figure 5. There was no significant difference in learning achievement between students with low preferences and students with high preferences for each element. But, the improvement from pretest to posttest was small, so it might be difficult to detect differences between high and low preference learners. Martini (1986) reported similar learning achievement results when she studied students with high preference for auditory, visual, or tactile learning and their use of a computer application to learn about science. Students with low preferences were not included in her study. All students in Martini’s study, regardless of preference, had significant increases in knowledge when using the computer application. Interestingly, Dunn and Dunn (1979) believed that students with high preferences for motivation, persistence, responsibility, structure, working alone, or those who are visually oriented would respond best to programmed learning, such as computer programs. But, computer programs have become more complex and sophisticated since the 1980s, which may explain why individual learning styles did not influence learning with the multimedia computer program used in this study.

One limitation in the present study is the small change in scores between the pre- and posttest. The cognitive scores only increased by 11%, or an average of about 3 out of 29 questions. The small mean change in scores may have hindered the ability to detect an influence of learning styles on learning achievement. One explanation for the small change in achievement scores may be the difference between the intended use of the program and the actual use. Although the Web application was designed for students to review and repeat lessons, quizzes, and visits to the library, it was observed that many students only completed the minimum required tasks. Students would also repeat quizzes until they achieved a passing score of 60%, instead of going back to review the previous lesson before retaking the quiz. Completing the bare minimum seems to be a common observation for studies involving computers in education (Beasley and Smyth 2004). One possible way of overcoming this barrier may involve developing an instructional atmosphere based on gaming principles or a reward system. Students may be more motivated to complete tasks and activities multiple times if they are rewarded with points for completing tasks and if their names would appear on a scoreboard for all users on the Web site. In addition, the program could be modified in such a way that students are required to review the lesson before retaking the quiz. It would also be of interest to explore the relationship between age/grade and learning achievement. Nearly three-quarters of the students in the present study were 7th graders (72.5%). Perhaps this program is more appropriate for an older audience, such as 8th and 9th graders.

A few changes to the program and how it was implemented might also improve learning achievement and increase the change in score between the pre and posttest. One of the activities that students encountered early in the program was difficult for many students. The Web program includes a matching game called Microbe Match that required students to match common pathogens, foods associated with the pathogens, and important facts about the pathogens. Some teachers expressed the concern that Microbe Match was too difficult and quickly discouraged some students. Making the activity easier might keep students engaged in learning and prevent frustration. Also, although the lessons were very visual and accompanied by audio, they might have been too long for the short attention span of younger students. Breaking the lessons into smaller segments might improve the retention of information. Tactile students prefer to learn by writing, so providing either an online...
Conclusions

Food safety is an important topic that should be included in the middle school curriculum. A Web-based, interactive, multimedia program was developed that was successful in helping middle school students to learn about food safety. Teachers were excited about using the program and their students enjoyed using the Web site. In addition, learning styles did not influence the ability of students to learn about food safety with this Web-based program. This study illustrates that when a computer-assisted learning program is carefully designed and constructed, it has the potential to meet the needs of all students, regardless of learning style.

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References


California Foundation for Agriculture in the Classroom and Alliance for Food and Farming. 2004. Food safety from farm to fork. Sacramento, Calif.: California Dept. of Food and Agriculture and the USDA.


Wheeler R. 1983. An investigation of the degree of academic achievement evidenced when second grade, learning disabled students’ perceptual preferences are matched and mismatched with complementary sensory approaches to beginning reading instruction [Thesis]. St. John’s Univ. 146 p.