Using a Mobile App to Teach Individuals with Intellectual Disabilities to Identify Potential Food Allergens

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The purpose of this study was to examine the effects of using augmented reality applications to identify potential food allergens. Seven individuals with intellectual disabilities participated. Participants were shown how to use a mobile device equipped with the Red Laser application to identify potential food allergens. Results indicated a functional relation. All participants readily identified possible food allergens using augmented reality and maintained the skill six weeks later. Conclusions are discussed in the context of using augmented reality applications to increase independent living skills for individuals with intellectual disabilities.

A healthy lifestyle consists of making informed food choices and developing sound eating and physical activity habits. While nutritional health is important for all people, it can be especially challenging for individuals with intellectual disabilities. People with intellectual disabilities must be aware of food allergens, their potential dangers, and how to manage those risks. They need to understand the potential effects of common allergens on individual health, on the health of a family member, or on potential employment. Current instructional technologies exist to facilitate the acquisition of such knowledge and skills.

Like all people, individuals with intellectual disabilities face challenges in following a healthy lifestyle. Approximately 1 in 20 people—including individuals with disabilities—suffer from a food allergy (American Dietetic Association, 2010). The American Dietetic Association has suggested specific nutritional concerns for individuals with intellectual and developmental disabilities, including metabolic disorders, poor feeding skills, and medication-nutrient interactions: "Those with special care needs are more likely to develop comorbid conditions, such as obesity or endocrine disorders that may require nutrition intervention. Poor health habits, limited access to services, and long-term use of multiple medications are considered serious health risk factors that can greatly impact the individual's life" (p. 296).

Draheim, Stanish, Williams, and McCubbin (2007) reported that individuals with intellectual and developmental disabilities also are at an increased risk for obesity and nutritional related issues such as hypertension (i.e., high blood pressure), hypertriglyceridemia (i.e., elevation of cholesterol and/or triglyceride levels), and hyperinsulinemia (i.e., high levels of insulin in the blood). Food allergens are a priority concern for people with intellectual disabilities. They can face both physiological and cognitive challenges relating to healthy living and nutritional decisions (Emerson, 2005; Heller, McCubbin, Drum, & Peterson, 2011).

People who have food allergies need to avoid foods that result in severe reactions. They need to learn how to read food labels, identify potential food allergens, and make appropriate choices to manage their food intake. Although individuals with intellectual disabilities experience challenges learning phonics, vocabulary, fluency, and comprehension skills (Coyne, Pisha, Dalton, Zeph, & Smith, 2012; Kellas, Ashcraft, & Johnson, 1973; Wong, 1978), evidence does support systematic prompting and time delay procedures (e.g., Browder, & Xin, 1998) and targeting critical sight words to improve literacy skills (e.g., Browder, Wakeman, Spooner, Ahligrm-Delzell, & Algozzine, 2006). One of the most important ways sight words can be used is to increase individuals with intellectual disabilities' ability to make choices. By targeting sight words on food labels and cooking recipes, these individuals can improve their reading and choice-making skills.

Technological advances have allowed many individuals with intellectual disabilities to gain access to information they otherwise may not have gotten. Parette (1991) suggests that the use of technology has benefitted these individuals educationally and socially. Computer-assisted instruction has been used successfully to teach them to learn sight words (Coleman-Martin, Heller, Cihak & Irvine, 2005), grammar (Mechling & Hunnicutt, 2011), math facts (Hammond, Hirt, & Hall, 2012), community (Hansen & Morgan, 2008), and vocational skills (Mechling & Ortega-Hurdon, 2007). However, research also has demonstrated that technology is often not fully utilized by individuals with intellectual disabilities (Happestad, 2007; Kling, Campbell & Wilcox, 2010; Tanis et al., 2012).

Mobile learning applications, or apps, are growing exponentially. Mobile learning, sometimes called M-Learning, is shifting from a learning environment that students enter and leave to a learning environment that follows students wherever they are (Ogata & Yano, 2004). Mobile devices with large selections of apps are one means of providing multiple areas of representation to support the independence and inclusion of individuals with intellectual disabilities (McMahon & Smith, 2012). Previous research noted that students with intellectual disabilities acquired and generalized a variety of community and vocational skills using hand held mobile devices (e.g., Cihak, Kessler, & Alberto, 2007, 2008; Davies, Stock, & Wehmeyer, 2002a, 2002b, 2004; Ferguson, Myles-Smith, & Hagiwara, 2005). Researchers (Cihak et al., 2007; 2008) recommended mobile devices as effective tools for empowering students with intellectual disabilities to live and work with greater independence. Currently, there are thousands of mobile apps that can be applied to solving problems and addressing educational needs. It is important for individuals with intellectual disabilities to understand and use mobile technologies as tools for independent living.

Augmented reality is the combination of digital information over a live video display of the real world, while virtual reality is a fully artificial digital environment. Migram and Kishino (1994) described a mediated reality taxonomy of the interaction of the real world and digital information across the concepts of the physical world, blended reality, augmented reality, and virtual reality. Mediated reality has been applied to provide additional information for textbooks, museums, college campuses, and teacher preparation (Dieker, Hynes, Hughes, & Smith, 2008; Etxeberria, Asensio, Vicent, & Cuenca, 2012; Pence, 2011). Richard, Billaudeau, Richard, and Gaudin (2007) used augmented reality to teach matching skills using an intuitive interface for students with intellectual disabilities. Not only were the students successful, but they also demonstrated a very high level of engagement and required little training to achieve mastery. The intuitive nature of mediated reality was also recognized in a study that implemented a virtual reality kitchen safety training program for people with intellectual disabilities (Brooks, Rose, Attree, & Elliot-Square, 2002). The mediated reality training was found to be as effective as traditional on-site kitchen training. The blending of real world and digital supports is a promising area of technology that can be applied to meeting the needs of individuals with disabilities. One limitation of both of these studies, however, was the lack of mobility of the intervention.

Because the researchers identified the need to teach individuals with intellectual disabilities an effective way of determining if the ingredients of a meal were safe when preparing food for others with previously identified food allergies, the purpose of this study was to examine the effects of using a mobile device app with augmented reality features to identify potential food allergens. Specifically, the research questions were: (1) Will students with intellectual disabilities correctly identify potential food allergens in common food products using a mobile device app with access to nutritional information? (2) Will students correctly identify if the food item is safe for an individual with an identified food allergy? and (3) What is the social validity of using mobile apps to solve nutritional/food allergy problems?

Method

Participants

Seven individuals with intellectual disabilities attending a postsecondary education program at a southeastern university participated in this study. There were four males and three females. Participants ranged in age from 19 to 23 years. Participants were selected based on the following criteria: (a) diagnosis of an intellectual disability, (b) participation in a postsecondary education program, (c) no physical disability that would impede the performance of the skill, and (d) consent to participate in the study. Participants' full-scale IQ standard scores ranged from 48 to 70, and adaptive behaviors standard scores ranged from 30 to 82. Of the seven participants, Bridget had the only known allergy; she was lactose intolerant.

Table 1

Participant Characteristics

Student	Adaptive (SS[*])	IQ (SS[*])	Reading level (GE[†])
Allen	71[‡]	60[**]	Decoding 8.1[¶¶] Comprehension 5.1[¶¶]
Bridget	71[‡]	64[††]	Decoding 7.0[§§] Comprehension 8.3[§§]
Carl	75[‡]	65[‡‡]	Decoding 7.1[§§] Comprehension 7.2[§§]
Dawn	82[¶]	65[††]	Decoding 8.0[§§] Comprehension 7.4[§§]
Ellen	71[‡]	54[**]	Decoding 8.0[¶¶] Comprehension 4.3[¶¶]
Fred	72[‡]	62[††]	Decoding 8.0[§§] Comprehension 8.1[§§]
Gabe	69[§]	51[**]	Decoding 8.3[¶¶] Comprehension 5.0[¶¶]

[*] Standard Score
[†] Grade Equivalent
[‡] Vineland Adaptive Scales
[¶] Adaptive Behavior Evaluation Scale, Revised
[§] Adaptive Behavior Assessment System
[**] Wechsler Intelligence Scale for Children (WISC)
[††] Woodcock-Johnson III Tests of Cognitive Abilities (WJ III COG)
[‡‡] Stanford-Binet Intelligence Scales
[¶¶] Wechsler Individual Achievement Test Second Edition (WIAT-II)
[§§] Woodcock-Johnson III Tests of Achievement (WJ III)

Setting

Participants attended a postsecondary education program at a southeastern university for individuals with intellectual disabilities. Each participant was enrolled in traditional university courses for audit credit; recreational classes; a student work internship; and program specialty/core courses that included life skills, career development, and digital literacy. Each participant was included in traditional university courses and activities for a minimum of 80% of the week. All phases of this study occurred in the core digital literacy course. The digital literacy course occurred three times weekly for 55 minutes.

Materials

During each phase, participants responded to eight scenario-based problems created by the first author and reviewed by the second author. Each scenario identified a person with a common food allergy and a specific food item. For example, "Travis is allergic to dairy. Can he eat the Blueberry muffin ? YES or NO." Each participant also was given real packaged food items that were purchased from a local grocery store chain and, each participant was provided with a list of common food allergens using industry terms, as they usually appear on food packaging. For example, the list included Gluten—wheat, maltodextrin, and malted barley flour—and Lactose—sour cream, margarine, and cheese. Using this list, each participant had the opportunity to search for ingredients and possible allergens as described in the scenario-based problems.

The app used in this study is an example of an augmented reality tool that falls closer to the reality side of the mixed reality continuum as described by Milgram and Kishino (1994). The app uses live video from the mobile device's camera to identify an object, which in this case is a barcode. The app displays an augmented view by including a red line across the screen that pulses from side to side. This provides the user with context-relevant information that indicates where to aim, focus, and scan each product. When the user moves the mobile device so the laser is across the barcode, the app reads the information and displays the product identified, menus for comparing prices, and in the case of food items, additional nutritional and food allergen information. The app uses color-coded words to provide visual cues of relevant nutrition ingredient information (Coyne et al., 2012).

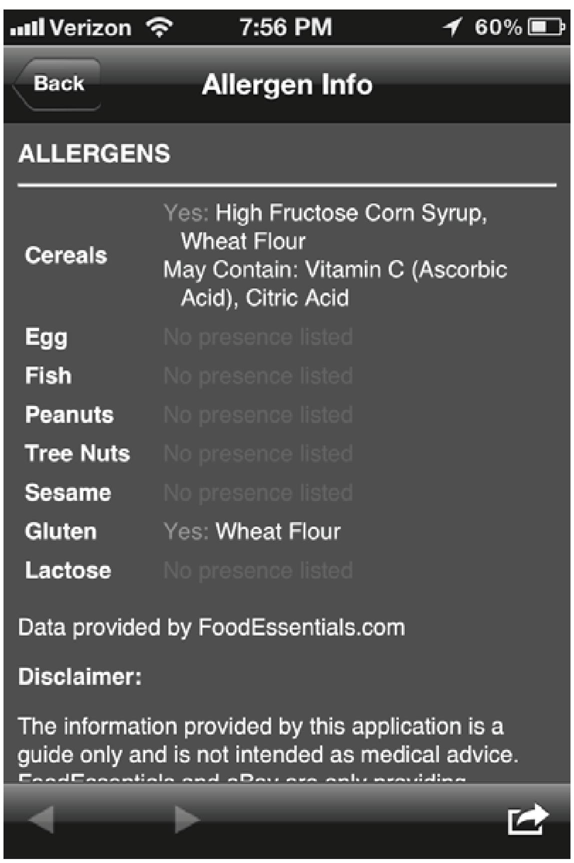
During intervention phases, each participant was provided with either an iPad or iPhone device equipped with the Red Laser app. When using the Red Laser app, the participants looked through the camera lens to view the food item and scan the barcode to activate the app. The Red Laser app displayed all possible food allergens corresponding to the specific food item. Figure 1 illustrates what participants viewed when scanning the product barcode with the Red Laser app.

Variables and Data Collection

The independent variable was the use of the Red Laser app to identify potential food allergens. The dependent variable was defined as a correct response on a questionnaire presenting food allergen scenario-based questions. Permanent product data collection procedures were used to record the number of scenario-based problems solved correctly per session. Each session was made up of an assessment that included eight scenario-based problems. The problems were distributed randomly across participants, and no participant responded to the same problem twice. If the participant answered the problem correctly, it was recorded as a correct response. If the participant did not answer the problem correctly or did not respond, it was recorded as an incorrect response. The number of correct responses per session was graphed for each participant.

Figure 1

Red Laser app. "YES" response displayed for Gluten and Cereals.



Procedures

Ten school days prior to the baseline phase, all participants attended a 55-minute lesson on the importance of eating healthy foods, and common food allergies. The class was taught by a certified dietetic technician. The dietetic technician distributed a list of common food allergies using industry terms and modeled how to review product ingredients and identify possible food allergens.

Baseline. During baseline, each participant received a list of common food allergens, real packaged food items, and an eight-item scenario-based problem assessment. Participants were assessed at the beginning of each class session. Participants were instructed to circle either "yes" or "no" in response to each question. All problems were read aloud to the participants. No additional feedback or prompts were provided. Baseline phase continued for a minimum of three sessions, until data were considered stable or a descending trend was evident.

Red Laser App. Similar to baseline, each participant received a list of common food allergens, real packaged food items, and an eight-item scenario-based problem assessment. In addition, each participant received either an iPad or iPhone equipped with the Red Laser app. Participants also took part in a 55-minute lesson regarding how to use the Red Laser app to identify possible food allergens in real packaged food items. The investigator (first author) implemented the Model-Lead-Test procedures (Adams & Englemann, 1996). The investigator modeled how to turn on the iPad or iPhone device, select the app, use the camera lens to scan the item's barcode, and identify the potential food allergens in the product. The investigator also specifically stated that all the possible food allergens corresponding to the specific food item were color coded in red, while gesturing toward the identified food allergens related to the product. The investigator then led each participant as they used the Red Laser app to scan the package barcodes and identify the food allergens in the product. When a participant was observed operating the device incorrectly or did not identify the correct food allergens, the investigator implemented a system of least prompts. A four-second delay occurred between each prompt level. The least-to-most prompt hierarchy consisted of the following levels: (a) verbal prompt (e.g., "[Name] do you see the barcode", (b) gesture plus verbal explanation (e.g., pointing to the barcode and saying "[Name] scan the barcode"), and (c) physical assistance plus verbal explanation (e.g., investigator and participant holding the iPad or iPhone together, guiding the device to scan the product's barcode, and saying "[Name] scan the barcode"). Participants continued to practice using the app to scan food items and identify potential food allergens for the remainder of the class session. An example of the scan view of the app is shown in Figure 2.

Figure 2

Red Laser app Augmented Reality view.

At the beginning of the next class session, the investigator then tested each participant. Each participant was given an iPad or iPhone device and the eight-item scenario-based problem assessment. Only one assessment was given per class session. The investigator did not provide additional feedback or prompts. Participants were given the assessment until they reached criteria of answering all problems correctly for three consecutive sessions.

No Red Laser App. After participants reached criteria, participants were given the assessment without the use of iPad and iPhone equipped with the Red Laser app. Similar to the baseline phase, each participant received a list of common food allergens, real packaged food items, and an assessment. No additional feedback or prompts were provided. The intervention withdrawal phase continued for a minimum of three sessions and until mean levels approached baseline levels or trended in the opposite direction of intervention.

Reimplementation of Red Laser App. Similar to the initial intervention phase, each participant was given either an iPad or iPhone equipped with the Red Laser app, real packaged food items, and an eight-item scenario-based problem assessment at the beginning of each class session. The investigator did not provide additional feedback or prompts. Participants were given the assessment until they reached criteria of answering all problems correctly for three consecutive sessions.

Maintenance. Six weeks after reaching criteria during the reimplementation phase, each participant was reassessed to examine the long-term effects of using the app to identify potential food allergens. Each participant was given an iPad or iPhone equipped with the Red Laser app, real packaged food items, and an eight-item scenario-based problem assessment. The investigator did not provide additional feedback or prompts.

Design

An ABAB design (Gast, 2010) was used to examine the relationship between the Red Laser app and each participant's ability to correctly identify potential allergens in specific food items. During baseline and withdrawal phases, participants used a list of common food allergens and industry terms to solve eight problem-based scenarios. During the intervention phases participants were taught how to use the Red Laser app to identify common food allergens.

Reliability

The investigator and a graduate assistant independently and simultaneously collected interobserver reliability and procedural reliability data. Interobserver reliability data were collected during a minimum of 60% of baseline, intervention, and maintenance sessions for each participant. Observers independently and simultaneously recorded the number of problems solved correctly on each participant's assessment. Interobserver agreement was calculated by dividing the number of agreements of participant responses by the number of agreements plus disagreements and multiplying by 100. Interobserver reliability was 100% for each participant's assessment during all phases.

Procedural reliability data also were collected during a minimum of 60% intervention and maintenance sessions for each participant. The investigator was required to provide participants with the necessary materials (i.e., iPad with the Red Laser app, food items, assessment), read problems aloud, and provide a system of prompts. The procedural agreement level was calculated by dividing the number of observed investigator's behaviors by the number of planned investigator's behaviors and multiplying by 100. The mean procedural reliability was 95% for Allen and 100% for all other participants. The majority of disagreements occurred as a result of not waiting a full four seconds before introducing the next level of prompt.

Social Validity

Following the conclusion of the reimplementation phase, each participant was asked to complete a six-item Likert survey created by the authors to assess their opinions and acceptability of using the iPad or iPhone with Red Laser to identify potential food allergens.

Results

Overall, the participants solved a mean number of three problems correctly during baseline. When the Red Laser app was implemented, the participants mean number of problems solved correctly increased to 7.7. On average, participants required 4.4 sessions to reach criteria. When the Red Laser app was withdrawn, the mean number of problems solved correctly decreased to 3.0. However, the participants solved all problems correctly when the Red Laser app was reimplemented. In addition, all participants maintained 100% accuracy six weeks later. Figures 3 and 4 display each participant's number of problems solved correctly across all phases.

During baseline, Allen's mean number of problems correct was 2.0. When using the Red Laser app, his mean problems solved correctly increased to 7.8. He reached criteria after six sessions with 83% nonoverlapping data demonstrating an immediate change. Allen's number of problems correct decreased to a mean of 3.0 when the intervention was withdrawn. When the Red Laser app was reimplemented, he solved all problems correctly and continued to maintain 100% accuracy six weeks later.

Bridget's mean number of problems solved correctly was 5.7 during baseline. When using the Red Laser app, her mean number of problems solved correctly increased to 7.8. She reached criteria after five sessions with 100% nonoverlapping data demonstrating an immediate change. Bridget only solved one of 24 problems correctly when the Red Laser app was withdrawn. However, when the intervention was reimplemented, Bridget solved all problems correctly. In addition, she maintained 100% accuracy six weeks later.

Carl's mean number of problems solved correctly was 5.3 during baseline. When using the Red Laser app, he solved all problems correctly and reached criteria after three sessions. Nonoverlapping data were 100%, which demonstrated an immediate change. When the intervention was withdrawn, Carl's number of problems solved correctly decreased to a mean of 4.3. However, he solved all problems correctly when the Red Laser app was reimplemented. In addition, he maintained 100% accuracy six weeks later.

During baseline, Dawn's mean number of problems solved correctly was 3.3. She solved all problems correctly when using the Red Laser app and reached criteria after three sessions. Dawn demonstrated an immediate change with with100% nonoverlapping data. When the intervention was withdrawn, Dawn's mean number of problems solved correctly decreased. She correctly solved a mean of 2.3 problems. When the Red Laser app was reimplemented she

Figure 3

Allen, Bridget, Carl, and Dawn's number of problems solved correctly with and without the use of the mobile app.

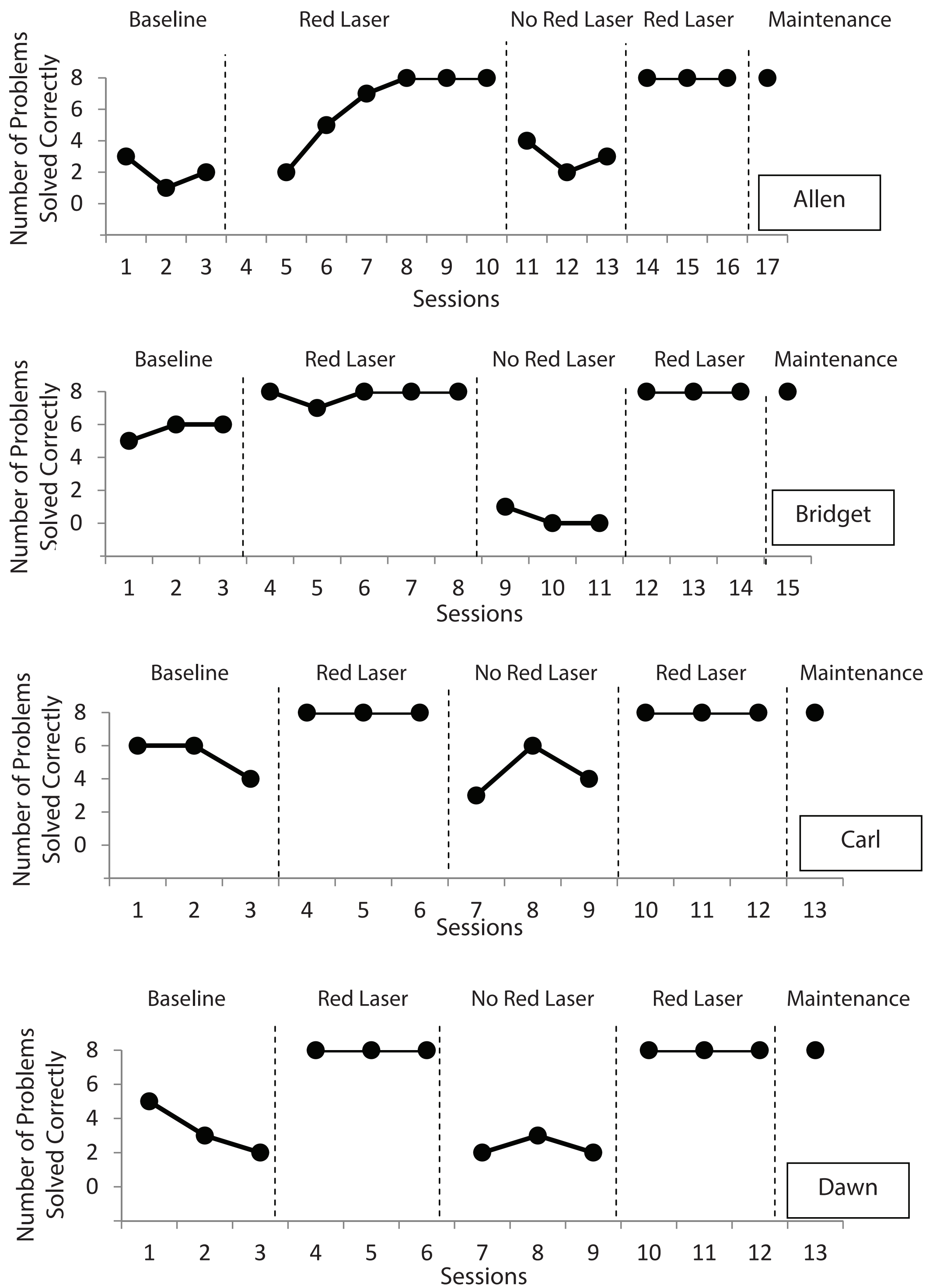
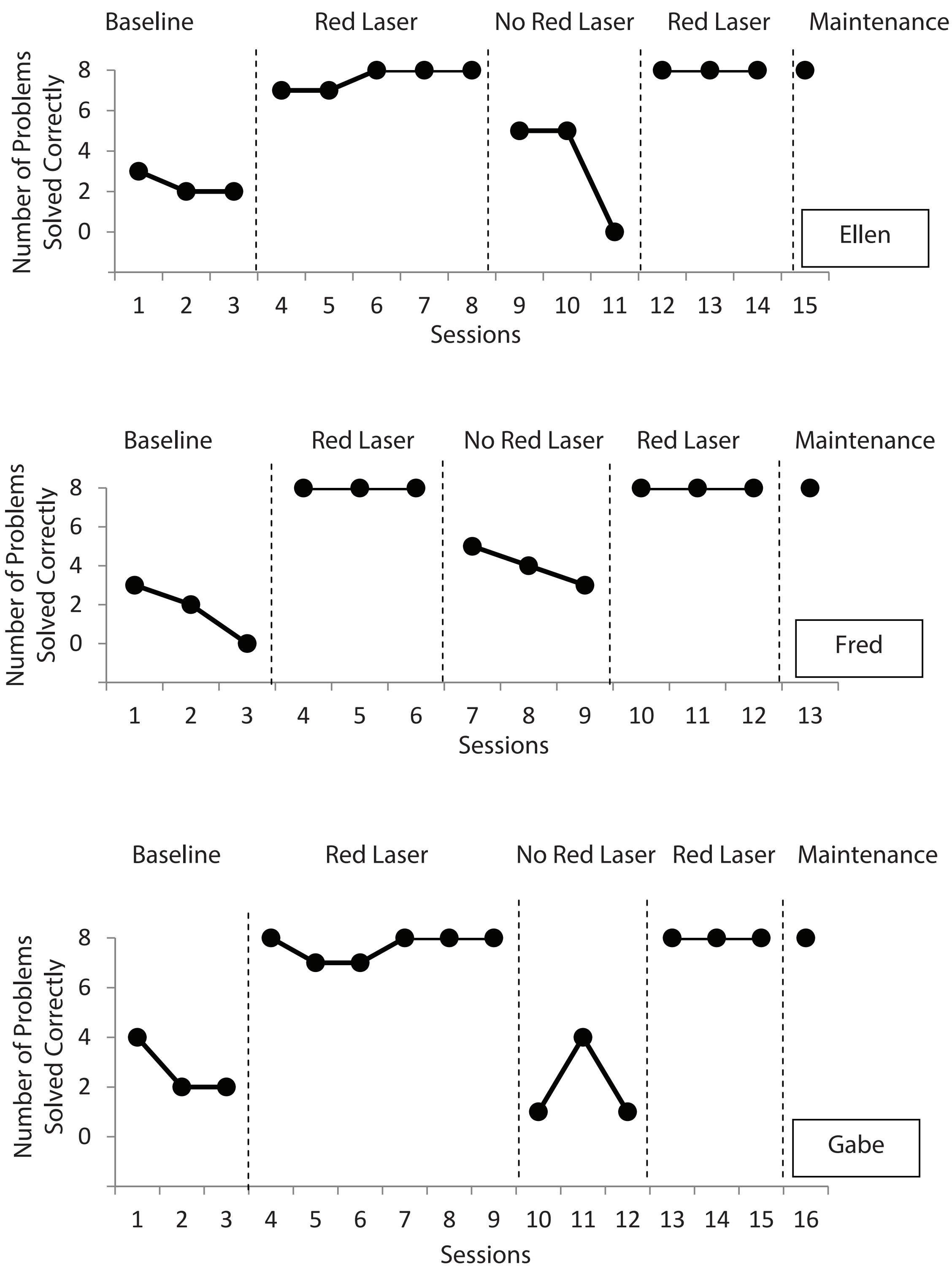


Figure 4

Ellen, Fred, and Gabe's number of problems solved correctly with and without the use of the mobile app.



solved all problems correctly and continued to maintain 100% accuracy six weeks later.

Ellen's mean number of problems solved correctly was 2.3 during baseline. When using the Red Laser app her mean number of problems solved correctly increased to 7.6. She reached criteria after five sessions with 100% nonoverlapping data demonstrating an immediate change. Ellen's mean number of correct responses decreased when the Red Laser app was withdrawn. She correctly solved a mean of 3.3 problems. However, when the Red Laser app was reimplemented, she solved all problems correctly. She also maintained 100% accuracy six weeks later.

During baseline Fred's mean number of problems solved correctly was 1.7. When using the Red Laser app he solved 100% of the problems correctly. He reached criteria after three sessions, with 100% nonoverlapping data demonstrating an immediate change. When the intervention was withdrawn, the number of problems he solved correctly decreased to a mean of 4.0 problems. However, when the intervention was reimplemented, he solved all problems correctly. In addition, Fred maintained 100% accuracy six weeks later.

During baseline, Gabe's mean number of problems correct was 2.7. When using the Red Laser app, his mean number of problems solved correctly increased to 7.7. He reached criteria after six sessions, with 100% nonoverlapping data demonstrating an immediate change. When the Red Laser app was withdrawn, Gabe's number of problems solved correctly decreased to a 2.0. However, he solved all problems correctly when the Red Laser app was reimplemented. Gabe also maintained 100% accuracy six weeks later.

Social Validity

Following the study, each participant completed a six-item social acceptability questionnaire about food allergies and using the app and device to identify potential food allergens. All participants either agreed or strongly agreed that it was important to learn about potential food allergens in order to make appropriate choices. All participants also agreed or strongly agreed (a) that using the app and device helped them read and identify food allergens, (b) it was easy to use, and (c) that they preferred the app to matching the allergen word list to the food labels.

Discussion and Implications

The purpose of this study was to examine the effects of using an augmented reality app, Red Laser, to teach individuals with intellectual disabilities to identify potential food allergens. When participants were provided with an iPad or iPhone equipped with the Red Laser app, participants successfully identified potential food allergens associated with real food items. A functional relation was established since experimental control occurred by demonstration of data variation patterns in at least three different series at three different points in time between

Table 2

Results of Social Validity Survey

Questions	Allen	Bridget	Carl	Dawn	Ellen	Fred	Gabe
I understand how food allergies affect people.	5	5	3	5	3	5	5
I enjoyed learning about food allergies.	5	5	2	3	4	4	2
I remember the most common food allergies.	5	5	2	5	1	3	5
I can find the ingredient list on a food item.	5	5	3	5	4	3	4
I liked reading the food labels without the iPad.	4	5	3	5	3	3	5
The iPad easy to use.	5	5	3	5	5	5	5
Which option did you like better?	iPad	iPad	iPad	iPad	iPad	iPad	iPad

Note. Responses to Likert scale of 1 strongly disagree to 5 strongly agree.

correctly identifying food allergens and the introduction of the augmented reality app (Horner, Carr, Halle, McGee, Odom, & Wolery, 2005).

The results demonstrated that there was an immediate improvement in making the correct choice relating to specific foods and possible allergens using the Red Laser app. The user interface design, which includes the augmented view of the product, supported participant scanning, reading, and selecting the relevant information with very little training. Several participants achieved mastery immediately. When errors were made during intervention, the investigator observed that participants often had correctly identified whether the food had an allergen or not, but struggled with how to answer some questions. For instance, in the question "Damon is allergic to gluten. Can he eat the cookie?" A participant correctly used the app and identified that the product had an allergen for Damon; however, they circled "yes," indicating that a food allergen was present, rather than "no." The researchers were aware of this challenge of processing the question but believed it was an important feature because the participants would have to use the same decision-making process during employment or independent living situations. Therefore, future research needs to examine the type of questions asked, as well as the language used in order to ensure appropriate decision-making skills when managing specific diets. The design of the user interface (Shneiderman & Plaisant, 2010) probably assisted participants in making the correct choice. One of those user interface features is the text labeling and color coding of common allergens that included red colored text for identified allergens. Interventions such as this can help people with intellectual disabilities make decisions about their environment and life.

Mobile learning tools such as the one used in this study have advantages over stationary computer-based tools. Unlike using a desktop computer, mobile learning emphasizes not learning in one location but creating a learning environment that moves with the learner (Ogata & Yano, 2004). The skills developed by the students using these mobile devices persist wherever they have the device and need to use it. An emphasis on mobile learning is an important feature for the education and empowerment of students with intellectual disabilities. Mobile device apps such as the Red Laser app often are dedicated tools designed to simply complete a task. This simplicity also supports the ability of students with disabilities to correctly choose the correct tool for a task. The simplicity and successful choice making supported in mobile learning makes learning, decision making, independent living, and employment related tasks less complicated for people with intellectual disabilities.

This study supports previous research that mobile devices support learning (Cihak et al., 2008; Ferguson et al., 2005). Mobile devices such as iPads and iPhones are part of the evolution of computer-assisted instruction and hand held computer devices, both of which have established benefits for students with intellectual disabilities. As new mobile devices bring additional capabilities to the market and the apps available on those devices continue to increase, new research will be needed to establishing the benefits of this technology.

The flexibility and familiarity of mobile devices makes using them to support individuals with intellectual disabilities a practical, cost-efficient, and effective intervention. This study provides some evidence that mobile apps can be used to support literacy and choice-making skills. Mobile apps are part of the evolving concept of literacy that emphasizes both reading and the application of reading skills in a variety of methods, including using technology. Twenty-first century literacy is evolving as society's expectations for individuals continue to grow to incorporate new technologies and skills.

According to the National Council of Teachers of English (NCTE), being literate now has the implication of both being able to comprehend information from a text and use technology to effectively achieve goals (NCTE, 2008). One of the implications of this study is that the augmented reality Red Laser app was more effective for learning the task and the participants found it more socially acceptable. Using commercially available devices to address literacy and choice-making skills for individuals with intellectual disabilities has advantages for these individuals in that the assistive technologies are more inclusive. Using popular devices that have large libraries of available apps allows teachers and others to customize mobile devices to meet specific needs.

Teachers implementing this or other mobile learning app solutions need to address several considerations when using these tools to address the needs of their students with disabilities. One possible approach would be to evaluate apps through traditional assistive technology assessment frameworks such as the Human Activity Assistive Technology framework (Cook, Polgar, & Hussey, 2008). Another, possibly faster and easier, method of evaluating mobile learning apps on devices such as the iPad would be to examine them in terms of the Universal Design for Learning guidelines (CAST, 2011). With the tremendous number of apps available a quick tool for investigating apps is necessary to identify potential useful and life-changing uses of technology. Design features such as the user interface and display options impact the ability of a student with a disability to understand and persist in using a mobile device app. Using the Universal Design guidelines, educators could evaluate apps based on an established research framework. For example, a teacher could determine if an app provides alternatives to text or if it allows multiple means of action and expression. Examining commercial apps in terms of their Universal Design features is an area of research that needs to be developed.

The results of this study require replication, and they should be interpreted with caution. As with all single-subject design studies, a small sample size was used. Future research needs to include a larger sample size and the research population should be extended to include other disabilities. Also, the app used required access to the Internet to retrieve nutrition and allergen information on the products, so this study could not have been implemented effectively in a location without Internet access. Future investigation needs to examine prerequisite skills needed to operate and use mobile devices successfully. Additional studies need to examine areas where mobile device apps using augmented reality features can support the independent living needs of individuals with intellectual disabilities. Using mobile devices to support such individuals through the blending of the physical world and digital information can include future research in navigation, employment, and independent living tasks. Additional research should explore methods of providing systematic supports for individuals with intellectual disabilities using more complex combinations of the physical world and digital information and augmented reality tools. Despite its limitations, the results of this study do support the use of mobile devices to improve the identification of potential food allergens and making appropriate choices for people with intellectual disabilities.

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