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Enhancing Food Safety Training for Small-Scale Processors: An Interactive Digital GMP Educational Module

ABSTRACT

Small food processors often face challenges accessing adequate training, which can negatively impact consumer safety and limited compliance with regulations and audit success. Interactive tools such as virtual labs, games, and VR offer engaging ways to deliver food safety training, yet few studies have evaluated their effectiveness. This study examines an interactive module designed to provide accessible Good Manufacturing Practices (GMP) training for small processors. Using a retrospective pre- and post-survey, results showed statistically significant improvements in participants' perceived knowledge of food safety practices and strong engagement with the module.

INTRODUCTION

Since 2020, the value of small-scale food production has become increasingly evident. Researchers have created tools like the Local Food Impact Calculator, demonstrating the significant economic footprint of local and regional food projects *(24, 25)*. Moreover, a study on the resilience of local and regional food systems during COVID-19 revealed that small processors quickly reached capacity when larger facilities' outputs slowed, underscoring their adaptability and economic importance. To expand their market, many of these processors utilize shared-use processing facilities and commercial incubator kitchens *(2)*. These processors primarily produce value-added products using specialty crops, which are minimally processed. Despite the increasing value of small-scale food production, this sector faces challenges in complying with food safety regulations. Despite their enthusiasm, these processors often lack food safety training and have a limited understanding of regulations. Limited food safety experience usually hinders the establishment of a strong food safety culture, which can directly impact product safety and put consumers at risk of foodborne illness.

Public health agencies, academia, and Extension professionals have started to focus on food safety risks associated with the less commercialized side of the food industry and have identified small processors as a group that needs support *(3, 15, 24, 29)*. These regulations emphasize personal hygiene, facility design and construction,

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equipment maintenance, and effective sanitation and production controls, ensuring safe and high-quality food production *(27)*. Although the Food Safety Modernization Act (FSMA) provides some exemptions for small qualified facilities, all processors must adhere to GMP regulations *(9, 28)*. The preventive control for human foods rules (21 CFR 117.4) require that anyone involved in food manufacturing, processing, packing, and storage must have the training or experience to practice safe food handling and procedures. While formal standard training curricula are available nationwide for supervisory or management-level food producers and processors, this training does not cover all basic GMP topics necessary for regulatory compliance and is not mandatory for all food processors, which means it may not be accessed by all food processing team members. Despite the availability of training, studies have identified persistent gaps and content needs among small and very small processors *(2, 9, 31)*.

Production-level employees in the food processing industry have specific needs for specialized training. While many valuable resources have been developed for small and very small food processors *(4)*, there is a gap in resources designed to support processors in implementing current Good Manufacturing Practices (cGMPs) *(17)*. Small processors face significant barriers to obtaining proper food safety training, exacerbated by limited resources. These barriers include a lack of trust in food legislation and enforcement *(31)*, insufficient motivation due to a limited understanding of food safety regulations *(31)*, and financial constraints that limit their ability to send employees for training *(2, 9)*. Additionally, "time" and "cost" are significant obstacles to implementing training for production-level employees *(2)*. Small facilities often lack awareness of potential vulnerabilities due to an underdeveloped food safety culture among their workforce *(2)*.

Technology has fostered innovative ways to deliver tailored and engaging food safety content. Multimedia design, the basis for any digital online training (e.g., animations, games, virtual interactive labs/modules, or visual graphics like videos and infographics), has been used for many years to deliver information *(16)*. Multimedia learning can effectively teach a wide range of content, from simple skills, such as math expressions *(5)*, to complex health behavioral changes, such as correctly washing hands *(20)*. With a combination of media forms, such as colorful graphics, engaging animations, and interactive features, multimedia design makes the learning experience more engaging and appealing to learners while addressing procedures, concepts, facts, processes, and principles. Complementary to motivation aspects, studies have also highlighted the benefits of using graphics as part of multimedia, as they can aid the learning process *(7)*. As described by Clark & Lyons, graphics can help learners focus attention on specific content areas, activate prior knowledge (by connecting previous knowledge with new content) and minimize cognitive load (through examples that help with processing information). Graphics also help learners build mental models, support transfer of learning from conceptual to practical application, and provide motivation by delivering complex material in an interactive, lively way *(7)*.

Virtual interactive modules have gained much popularity in recent years due to the increased demand for remote learning prompted by the COVID-19 pandemic *(10, 11)*, lower cost of development (for example, compared to an educational game), and outreach capabilities – reaching a much larger population than conventional on-site educational activities *(22)*. Researchers have recognized the value of virtual labs in science education for supporting the acquisition of conceptual knowledge *(19)*, preparing learners for real-life scientific investigation *(13)*, replicating expensive labs and materials *(21)*, and providing a safe environment for learners to explore *(13)*. Furthermore, virtual modules help institutions save significant resources and make learning affordable and accessible to many people, providing an interactive and effective learning experience that can be sustainable and updated for many years *(22)*. Regarding the use of interactive digital modules for food safety education, research has shown that active learning in e-learning environments such as digital modules for food personnel training improves participants' understanding of food safety concepts and leads to better implementation of Good Manufacturing Practices at food processing facilities *(14, 18, 30)*. Training design is important to the transfer of training into the job context and the maintenance of learned behavior over time *(1)*.

This study evaluates the impact of iTIPS (Interactive Tools to Improve the Practice of Food Safety), an educational learning module designed in 2021–2022 and released in 2023. This interactive educational technology module shares an innovative approach to providing Good Manufacturing Practices (GMP) training for processors, focusing on a self-paced mode and engaging experience through digital media. The module is freely available at itipsfoodsafety.com. Utilizing graphical and multimedia strategies, the iTIPS project aimed to enhance engagement and improve GMP training by addressing topics identified by small production facilities. The iTIPS Food Safety training addresses the need for these topics, even though other trainings exist, because it uses a strategy of appealing graphics and interactivity to increase engagement. Many food safety trainings include minimal interactivity. User-testing of iTIPS suggested that users found the graphical, interactive style of training to be more engaging. The iTIPS interactive modules are not intended to provide certification, but rather to offer a free and accessible educational experience that prepares users to pursue certification and understand the importance of food safety training. The module is designed as a 30-minute experience that conveys essential food safety concepts while sparking interest in more in-depth training tailored to individual or facility needs.

TABLE 1. Summary of learning objectives related to food safety GMP topics within each facility space

Office/Breakroom	Food Processing	Warehouse	Facilities & Grounds
After using the iTIPS food safety module, users will have increased understanding of Good Manufacturing Practices related to:			
• Personal protective equipment • Hygiene protocols • Handwashing • Standard Operating Procedures (SOP) • Sick policy and how it relates to food safety • Record-keeping	• Proper cleaning and sanitizing • Manufacturing operations (oven temperature; thermometers) • SOP for manufacturing	• Food product storage • Storage of chemicals • Hazards during distribution • SOP for receiving ingredients and supplies • Food storage and distribution, including related SOPs	• Sanitary conditions • Potable water and drainage • Facility inspection • Outside ground maintenance protocol to keep spaces clean and to reduce pests

MATERIALS AND METHODS

In this study, we investigate users' learning outcomes from the interactive module by measuring whether they gained confidence in food safety practices for each of the four rooms of the facility: *Breakroom, Food Processing, Warehouse & Distribution,* and *Facilities & Grounds.* The research utilizes formative and summative data to assess the effectiveness of the module's design. Formative data helped inform the decision-making processes of the instructional designers, with input from user needs assessments, advisory board meetings, and user testing. Summative data was collected via a retrospective pre-post survey, allowing for the evaluation of participants' enjoyment levels and their perceptions of knowledge gained from the module. After approximately 15–20 minutes of using the interactive module, participants completed the survey via Qualtrics. By employing a mixed-methods approach that incorporates both qualitative and quantitative data, the study assesses the learning outcomes of the educational module based on self-reported confidence and evaluates the impact of the iTIPS Food Safety module. Formative data is presented in a simplified manner, as the focus of this study is on discussing the summative data related to participants' perceived knowledge after using the module. It is important to note that this research was not designed to measure knowledge gain directly, but rather participants' perception of their own knowledge.

Formative research

iTIPS Food Safety is an educational learning module designed in 2021–2022 and released in 2023. Researchers conducted formative research during the module's iterative design and development phases, allowing developers to identify the product audience's learning needs and refine the interactive user experience.

The design process began with a two-day collaborative summit, where developers (programmer, artist, instructional designer) and content experts (a food safety extension specialist) met to discuss the project goals and immerse themselves in the topic. Using methods based on the transformational design process *(6)*, the team articulated the audience's intended educational change, defined activities to lead to that change, and designed media to engage the audience, as a strategy to shape and articulate better the problem statement. To inform design decisions, prior to the meeting, the team performed literature reviews and a needs assessment with an advisory board (industry and small facilities managers) to better understand the content and audience needs. Data from the advisory board identified the need for a training that was brief – workers lack time for long training; included less technical content – many workers do not have advanced degrees or may not be aware of technical food safety vocabulary; applied hands-on interaction – workers need to have a level of interaction rather than passively receiving information; and provided the material in both English and Spanish – many workers in small facilities have Spanish as their first language. The team also identified that employers and supervisors often fail to explain the rationale behind their actions to workers, leading employees to mimic these behaviors without grasping the underlying principles of "why". The team outlined the content for the module and identified specific learning objectives for participants *(Table 1)*. In seeking transformational change, the project articulated that after using the interactive module, learners would gain specific GMP food safety knowledge



Figure 1. Content curation for each room of the interactive facility module. (Left) Image of the interactive main page that presents each food facility space. (Right) A summary of key GMP topics is discussed within each facility area.

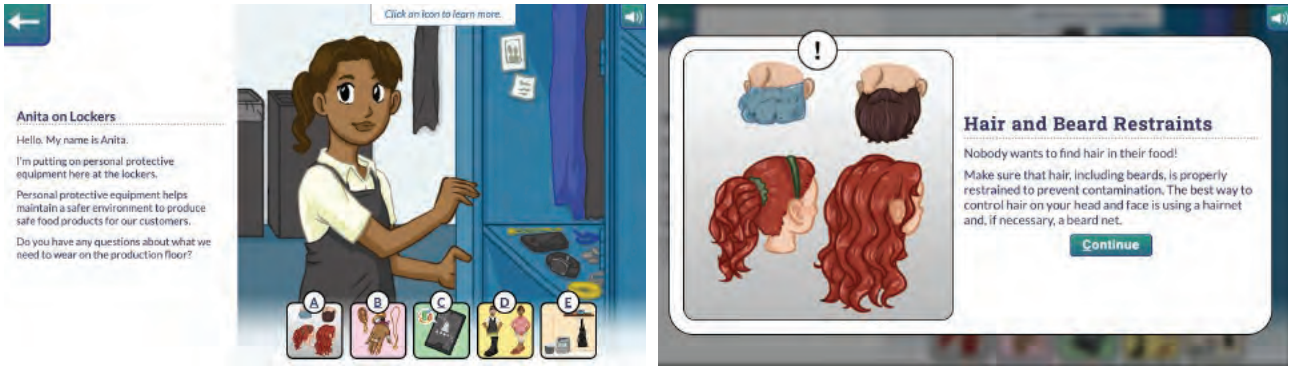


Figure 2. Locker content with Anita in the Breakroom area. (Left) Examples of some interactive content presented within the iTIPS training. (Right)

(content listed in *Table 1*) and be informed about why food safety is essential. Additionally, the interactive module aimed to spark their interest in seeking more information on food safety training.

During production, the team used prototypes and wireframes for several user testing sessions with the project's intended audience. Through observations and qualitative feedback (interviews, focus groups), the team was able to collect information regarding content information and identify ways to improve user experience with the tools. Examples of changes made in response to user testing included functionality, such as adding the ability to use a back button within each content area; terminology, such as defining "defect action level considerations"; and specificity, such as adding details about water temperature in the handwashing scene. Content adjustments included changing the materials of certain items and adding traceability to the documentation example. User testing also led to the team adding information on drainage treatments, avoiding depicting wet floor hazards without a warning sign, and specifying the importance of specific guidelines for specific facilities (for example, around jewelry wearing). The team also interacted with the advisory board on key development points to get their feedback on the tools being created.

In summary, iTIPS Food Safety aims to help workers understand the reasons behind food safety practices through visual and accessible content. The module provides examples of best practices for different areas of a food facility (see *Figures 1 and 2*), incorporating interactive graphics to explore various situations, barriers, and the behavioral aspects of workers in small facilities. The module is designed as a 30-minute experience that conveys essential food safety concepts while sparking interest in more in-depth training tailored to individual or facility needs. In the interactive module, players explore four different rooms of a facility, click to interact with characters, learn information from each character (text plus graphic visuals about the food safety content), and take a quiz about this information.

As part of the design team's commitment to designing for people from diverse backgrounds and with varying accessibility needs, the instructional designers considered inclusive design issues during planning of the module in

2021, and throughout the entire development. To meet accessibility needs, the team incorporated keyboard control functionality, allowing users with motor impairments to interact with the module more easily. Although this functionality is important for users, web standards are unclear in how they apply to game-like interactions, which means that it often is not incorporated into interactive digital modules. The design team also chose to use clear and straightforward language for content delivery, ensuring that users with limited reading skills or cognitive needs could access the information. Furthermore, the module was developed in English and Spanish, allowing more learners to access the content in their native language. All characters represented in the module were intentionally designed to reflect the diversity of individuals working in small facilities and incubator kitchens, including characters with mobility assistance, hair coverings, and a variety of appearances, creating a richer experience for users.

Summative research

To assess the impact of the module on participants' perception of knowledge gained (specific to identified learning objectives for each of the four rooms), participants were presented with retrospective pre/post matrix surveys *(12)* that asked them to rate their level of perceived knowledge gained in each area before and after completing the room's activities. The study team defined these areas, and activities for each module were designed to impact each learning outcome. The survey also asked participants for feedback about the modules, including what was effective, what could be improved, future use and plans to share the game, and their roles and responsibilities at their current position.

Data collection

Participants were recruited through existing food processing events involving small-scale processors and shared-use kitchen facilities within the Northeast and the North Central regions of the United States. Recruitment was conducted as an add-on activity to existing events, such as Sanitation training sessions, Preventive Controls for Human Food classes, and other agricultural events. Researchers sought participants who worked with food products, food safety, inspections, maintenance, or supervision of food facilities. After using the iTIPS interactive module, participants were prompted to complete the retrospective pre- and post-survey. Surveys were administered via Qualtrics. The New Mexico State University Institutional Review Board (IRB) approved the study (IRB protocol number #2305058490).

Data analysis

For the numeric pre- and post-questions, levels of perceived knowledge gained were measured on a Likert scale with options including *None, A Little, Some,* and *A Lot*. To assess changes in perceived knowledge before and after each module was completed, each room was given a total before and after score, with each perceived knowledge level coded as 1, 2, 3, and 4, respectively. For each room, a dependent *t*-test was administered to compare the average perceived knowledge before and after the room activities for four dependent *t*-tests. Descriptive statistics are provided for all other numeric responses. For open-ended questions, data were analyzed using thematic and inductive coding techniques *(23, 26)*. Responses were reviewed and categorized into researcher-generated codes or short descriptions. These codes were then collapsed into themes, which are shared in the Results section.

Validity and reliability

Survey validity was established by mapping the questions to the course objectives, and content experts reviewed the questions before they were finalized for the final version. To adjust for a Type I error, an a priori alpha of .05 was adjusted and divided by four (for the number of dependent *t*-tests) for a utilized alpha of .0125. The validity of the open-ended questions was ensured by capturing the direct responses of participants *(26)*. Where applicable, quotes are presented in the results section to demonstrate credibility.

RESULTS

Only participants who completed at least one pre/post matrix were included in the data analysis, resulting in 105 individuals. The survey included questions about demographics and reflective perception knowledge for each of the module rooms' content. Note that not all 105 participants answered every reflective question for the module rooms, mainly because, as part of the module experience, participants could choose which of the four module rooms they wanted to interact with. For the reflective pre/post, all *t*-tests were significant ($p < .001$), and across all tests, Participants reported significantly increased perceived knowledge following module completion. Effect size, indicated by Cohen's d, shows that these differences range from medium, indicated by the Breakroom coefficient of .54, to large for the other rooms at .80 and over *(8)*. This suggests the modules effectively increase participants' perception of food safety and other constructs associated with the office/breakout rooms. *Table 2* provides a summary of the analyses.

Demographics

A closed-ended question asked participants to identify their years of experience in the food industry. Of the 103 participants who responded, the most frequent (n=28) selected option was for more than 10 years of experience. *Table 3* reports the frequencies of participants' responses.

An additional demographic question allowed participants to write in the state where they were located, with most

TABLE 2. Perceived knowledge gain of participants before and after each room

Room	N	Time	Mean	Std. Deviation	*t*	p	Cohen's d
Breakroom	76	Before	20.99	3.50	-4.699	< .001*	.54
		After	23.13	2.42			
Food processing	68	Before	13.79	2.61	-6.595	< .001*	.80
		After	15.54	0.97			
Warehouse and distribution	58	Before	19.81	4.83	-6.250	< .001*	.82
		After	22.79	2.06			
Facilities and grounds	58	Before	13.02	3.37	-6.975	< .001*	.92
		After	15.17	1.68			

**significance* p <.001

TABLE 3. Number of years in food industry and location by state – frequencies of survey participant responses

Number of years in food industry	n
Less than one	24
1 to 2	18
3 to 5	20
6 to 10	13
More than 10	28
Total	103

respondents *(64)* reporting they were from Iowa. Many respondents reported being in Massachusetts *(10)* and New Mexico *(9)*, with other states (Illinois, Indiana, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Texas, Pennsylvania) having 1–3 respondents.

Finally, a last demographic question captured participants' primary responsibilities in their current role, with most (n=56) reporting *Food Safety*. A frequency table of all responses is provided in *Table 4*. Note that this question allowed participants to select multiple options.

Perception of knowledge on food safety content

Open-ended responses corroborated the findings from the survey analysis, indicating that participants acquired knowledge as a result of completing the various rooms. Some respondents simply stated that they had nothing to add. However, many participants identified what they had learned in the multiple modules and reported how valuable it was to learn interactively. The following captures participants' learning experiences in each room, as reflected in open-ended responses when prompted for overall feedback.

Of the locations in the digital module, the Breakroom received the highest pre and post-survey responses (n=76), mostly positive or neutral, with 48 offering additional feedback. Respondents reported learning about cleaning protocols and record-keeping. In the Food Processing room, 68 participants completed the pre- and post-surveys, with 45 offering additional feedback, reporting

TABLE 4. Primary responsibilities in current role – frequencies of survey participant responses

Role	n
Food production	30
Food safety	56
Inspection	21
Maintenance	12
Supervisor or management	43

TABLE 5. Sharing the interactive module with others – frequencies of survey participant responses

Audience	n
My coworkers	39
My employees	11
My supervisor	10
Others	15
Total	75

that they learned about record-keeping, hazards, and cleaning. Participants also noted that the interactive was easy to follow. In the Warehouse and Distribution room, 58 participants completed the pre and post-surveys, with nearly all of these offering additional feedback, noting that they learned about storing and positioning equipment and allergens. One participant wrote, "The amount of inches from floor and inches away from wall in storing product was helpful." Participants also took the opportunity to provide suggestions, including a request for more information regarding allergens and chemicals.

In total, 58 participants completed the pre- and post-surveys for Facilities and Grounds, with 38 offering additional feedback, reporting that they had learned about cleaning, pesticides, and the six-inch rule (this rule specifies how high food should be stored off the floor to prevent contamination). One participant said, "I think talking about the water and drainage was super helpful. I work in a commercial kitchen daily, but this is a topic that seems to [be] skipped over regularly enough that in all the training I've done we haven't ever covered it." This response suggests the Facilities and Grounds module was impactful in emphasizing information that has not been emphasized in other training sessions.

Experience with the interactive module

Sharing the module

In assessing the overall experience with the module, survey questions asked participants to report if and how they would share the modules with others. Of the 105 participants who responded, 58 participants indicated they would share the module with others. *Table 5* shows that most participants *(39)* planned to share the interactive module with their co-workers, based on a closed-ended question where they could select all applicable options. Regarding the best way to share the modules, the most frequent response was through email *(39)*, followed by QR Code *(15)*, flyers to display at the workplace *(15)*, and pdf hard copies *(15)*. Those who indicated they would not share the module did not provide reasons why not.

Using what was learned

When asked how participants planned to use what they learned in the interactive modules, 84 participants responded. Most participants answered they would share with others, including colleagues and vendors, as demonstrated in the following response: "Have myself, fellow coworkers and new hires use the module as training and refreshers." Another salient theme was that participants

would take what they learned and apply it in a job-specific context. One participant reported that the modules provided valuable insight into what needs to be shared in their teaching kitchen: "We just finished renovation on our school's teaching kitchen. It's a very new thing to have for us, and I am slowly learning what policies and procedures we need to implement to keep things safe. I knew about small things, like labeling anything that was in the fridge, keeping the trash low, but there is a lot of the administrative/inspection side that I don't know. This gave me a lot of direction on what items I need to implement and what questions to ask to learn more." These findings suggest the impact of the learning modules beyond the participants who completed them; that is, there are lasting impacts as participants plan to return to their jobs in food safety and share new knowledge with others.

DISCUSSION

Users' learning outcomes from the interactive module indicate increased confidence in food safety practices across all four facility rooms based on the perceived knowledge gained (ranging from medium for Office/Breakroom topics to large for topics covered in Food Processing, Warehouse, and Facilities & Grounds). Themes of open-ended responses showed participants enjoyed their experience with the tool and intended to share their knowledge about the learning topics with others. Open-ended responses also suggested that the module sparked interest in more in-depth training tailored to individual or facility needs. Participants reported positive responses to the module level of interactivity. The module gives learners the agency to select a facility room to explore and click to talk with characters to learn the content. This level of interactivity aligns with active learning strategies, where learners are not passively receiving information but taking action and interacting with systems *(14, 18, 30)*. Also, this interaction is amplified by multimedia environment affordances such as appealing graphics (friendly characters) and interactivity with the digital interface *(7)*.

In the module, characters are diversely represented, with a majority being Hispanic (the main demographic for this project); in addition to visual representation, characters have Hispanic names such as "Fátima," "Anita," and "Alonso," which facilitates learners' connection with the character and consequently with the content, as they see themselves represented.

The highly visual multimedia environment also supported learning with concrete examples of the best practices and common mistakes. Even though participants had the agency to navigate the digital facility room in any order, most followed a linear interaction, starting with the Office/Breakroom (the first one listed in the interface) and then moving along.

Previous research has identified training awareness and content knowledge as significant challenges in food safety training *(9)*. This aligns with the historical struggles smaller food processors face adjusting to food safety regulations and buyer mandates *(9)*. The qualitative data gathered in this study supports these findings. Participants noted that while familiar with some aspects of the content, they lacked knowledge about specific administrative components, such as inspections, policies, and procedures. Additionally, they noted that particular topics, such as water and drainage management and product storage information, were not covered in previous regular training. Participants expressed that the training module prompted them to consider areas they needed to learn more about and encouraged them to ask questions about important topics.

Of the 105 participants who responded, 58 indicated they would share the interactive module. This suggests that they perceive the content and module experience as relevant. Most participants answered that they would share with others, including colleagues and vendors. Because the module is freely available online, anyone can easily share and access it.

As a limitation, this research was not designed to measure knowledge gain directly. It also had demographic limitations. The sample was heavily represented in the state of Iowa, and it could be expanded to better capture other states' food safety training needs around the U.S. Demographic information about ethnicity, race, and culture were not collected as part of the survey, in order not to impose upon participants with personal inquiries. Potential limitations also include the level of work experience of participants. Researchers sought participants who worked with food products, food safety, inspections, maintenance, or supervision of food facilities. Although some participants were in the first year of this work, most were highly experienced. This suggests that the module may help workers increase their food safety knowledge, even when progressing in their careers. However, the findings may not be applicable to individuals who are new to the field and starting with no prior knowledge. Future research could explore whether users also increased their understanding of the reasons behind food safety practices.

CONCLUSIONS

Innovative approaches to food safety training are essential to bridge the gap between theory and practice and ensure safer food for all. This study introduces one such alternative: the iTIPS Food Safety module. The project examined the effectiveness of a multimedia tool designed to teach users about Good Manufacturing Practices (GMP) through digital online training. The findings of this study supported the idea that effective online digital tools can meet an increased demand for remote learning and help reach more people with outreach efforts. By enhancing engagement and improving GMP training for workers at small production facilities, the iTIPS Food Safety tool (which has been accessed 2,764 times in its first year) can impact food safety around the U.S. This

study contributes to the field by providing data from one of the first evaluations of interactive GMP training specifically designed for small processors.

Online training courses focused on food safety can effectively meet the needs of smaller food processors. Training delivery like iTIPS provides foundational knowledge that can be combined with in-person training for more complex topics. Designed to be highly visual and interactive, these modules aim to spark interest in training among employers. The interactive content covers essential topics and guides learners toward more in-depth training sessions that are currently under development, which are currently under development and scheduled for release in August 2025. The interactive modules can also be used alongside hands-on practices and in-person training. This approach can help address challenges, such as the time and cost associated with training in small facilities and the lack of interest and motivation for food safety training.

Participants' intention to share the interactive modules with others, such as coworkers and new hires, and to apply the knowledge in their jobs, suggested that the impact of the learning modules will be transferred beyond just the individuals who are initially reached with outreach programs. This is promising for the implications and significance of this program in providing inexpensive, easily extensible improvements to food safety culture in small-scale production environments.

The iTIPS team also continues to distribute the modules via Cooperative Extension and professional networks and through online curricular portals and social media, as well as through promotional handouts such as stickers and bookmarks pointing to the website that hosts the modules. Long-term continuation of distribution relies on established methods which have proven success with past digital educational products on food safety (more than 100 million views since 2011 of past products created by the New Mexico State University production studio).

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