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Engaging dairy farming stakeholders in developing the *Mooving Cows* digital tool for practicing appropriate cow handling

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ABSTRACT

Appropriate handling of dairy cows improves animal welfare and milk production and reduces the risk of injury to cows and people. However, safely interacting with cows requires training to understand their natural behavior. Our objective was to develop, in collaboration with Wisconsin dairy farming stakeholders, an innovative tool for dairy farm staff to practice appropriate cow handling. We created and evaluated a prototype of *Mooving Cows*, a digital touchscreen game in which players practice moving cows in simulated dairy farm environments. The learning objectives were to understand how human actions affect safety and cow behavior, stress, and productivity. We conducted focus groups with dairy farm staff (3 groups in Spanish, n = 16; 2 groups in English, n = 4) and 3 English focus groups with decision-makers (n = 10) such as farm owners and managers, bilingual consultants, and veterinarians. First, the focus group participants completed questionnaires about their experiences with and perceptions of cow handling and professional training and then they played the game prototype individually. On average, participants indicated they felt fairly comfortable using mobile applications (scale: 1 = very comfortable, 5 = very uncomfortable; farm staff: 1.9 ± 1.2, mean ± SD, range = 1 to 5; decision-makers: 1.8 ± 1.0, range = 1 to 4). After playing the game prototype, participants engaged in recorded, facilitated discussions about their qualitative impressions of the game. The research team reviewed the transcriptions to identify action items for improving the final version of the game, then conducted an inductive codebook thematic analysis to summarize themes relating to the participants' impressions of the game. We incorporated participants' feedback into version 1.0 of the game and compiled their ideas for future versions of the game. Overall, participants indicated the game was entertaining and would be useful for job training, particularly for new hires with little cow-handling experience. The results from the qualitative evaluation of the game prototype by dairy farming stakeholders suggest that the game could be a relevant way for farm staff, especially new hires, to remain current with national standards and expectations for continuing education.

Key words: animal handling, stockmanship, serious games, educational games, simulation

INTRODUCTION

Cattle are a prey species, and learning to interact with them appropriately and safely requires specialized training to understand how they perceive and react to their surroundings. On dairy farms, it is necessary for personnel to interact directly with cows to provide care as well as to harvest milk. However, human–cow interactions present several types of risks. First, close contact with cows can result in personnel injury (Dyk, 2008; Keller et al., 2017; Liebman et al., 2016), which can be severe and occasionally fatal (Watts and Meisel, 2011; Lindahl et al., 2013; Perez, 2019). Second, inappropriate actions toward cows can increase their fear and stress levels, impairing both animal welfare and milk yield (Breuer et al., 2000; Hemsworth et al., 2000). Third, inappropriate or rough handling of cows can result in negative public perception of dairy farming (Robbins et al., 2024). To safeguard the social sustainability of dairy farming, practices on farms must align with societal expectations

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The list of standard abbreviations for JDS is available at adsa.org/jds-abbreviations-25. Nonstandard abbreviations are available in the Notes.

for the humane treatment of animals (Weary and von Keyserlingk, 2017).

The US dairy industry recognizes the importance of appropriate cow-handling practices for personnel safety, animal welfare and productivity, and public acceptance of dairy farming. The industry's primary quality assurance program, Farmers Assuring Responsible Management (FARM) Animal Care, is implemented on more than 99% of US farms. This program publishes standards that dairy farms are expected to meet to maintain their ability to sell milk, accompanied by on-farm evaluations at least every 3 yr to verify they meet the standards. As of version 4 of the program (NMPF, 2020), an explicit expectation was established that all personnel on dairy farms who interact directly with cattle must show annual documentation of continuing education on stockmanship (i.e., appropriate animal handling). Before this national standard was established, the USDA reported that, as of 2014, only 55% of dairy farms provided training in cow handling (USDA, 2018).

Training or continuing education on cow handling is necessary for those who interact with cows. Safe and humane cow handling requires an understanding of natural cattle behavior and of how human actions affect the cows' behavioral and physiological responses. Without proper training, human handlers may use counterproductive, aversive techniques such as raising their voices or striking cows (Breuer et al., 2000; Hemsworth et al., 2000). People may also inadvertently cause cows to panic by approaching them too quickly or by entering the blind spot in their field of vision (Grandin, 2008). In contrast, working with cows' natural instincts to move away from humans when they reach a certain proximity (known as the flight zone, similar to a "personal bubble"), and allowing them to walk at their own pace, generates less fear and stress. When cows are kept calm, milk yield is greater (Breuer et al., 2000; Hemsworth et al., 2000) and the risk of injuries to both the cows and people is reduced. However, although these principles for handling cows are well established (Grandin, 2008; Kammel et al., 2019), dairy industry professionals report that negative handling practices are commonly used on dairy farms (Robbins et al., 2024). This suggests that, as in many other industries (Sookhai and Budworth, 2010), transfer of training remains a challenge.

In the US dairy industry, many popular and free training resources exist on appropriate cow handling, including videos and texts produced by university extension groups, the FARM program, and the pharmaceutical company Merck (i.e., DairyCare 365). However, with few exceptions (i.e., Hemsworth et al., 2002; Román-Muñiz et al., 2006), the training programs have not been tested empirically for their effectiveness in improving knowledge or skills. Furthermore, despite the abundance of free resources on this topic, Minnesota dairy farm owners cited a lack of resources as a barrier to implementing training on cow handling (Sorge et al., 2014), in addition to lack of time or language differences. This suggests that some dairy farm owners may be either unaware of or dissatisfied with current resource offerings. Indeed, in conversations with the lead investigator of the current project (JV) about their priorities for animal welfare, Wisconsin dairy farm owners made numerous requests for staff training on cow handling. Their expressed need highlighted an existing gap in training resources and opportunity to identify innovative solutions.

One limitation of resources such as videos or texts is that these are passive modalities, which on their own do not provide opportunities to apply concepts and practice skills. In contrast, active or interactive learning approaches (Chi and Wylie, 2014) are more engaging, provide learners with immediate feedback, and allow for learning by doing. Serious games, or those intended to produce learning outcomes and not only provide entertainment, are an example of a more active modality. Serious games have produced documented positive learning and skill-building outcomes in settings such as classrooms, health-behavior education, military, and professional training. Compared with conventional instructional approaches, meta-analyses have shown that serious games result in greater learning and retention (Sitzmann, 2011; Wouters et al., 2013; Clark et al., 2016). Games can give learners opportunities to navigate situations that would be challenging to mimic, even during in-person trainings, due to barriers of cost, time, or safety (Susi et al., 2007). For digital games in particular, the environments can include features to promote learning that cannot be easily achieved using other training modalities, such as immediate, responsive feedback, controlled opportunities to fail and learn from mistakes, built-in data collection on trainee decisions, and visual augmentation to help convey abstract concepts.

To address the aforementioned limitations, our objective was to develop a digital serious game, *Mooving Cows*, to offer dairy farm personnel opportunities to practice safe and appropriate interactions with cows. An additional benefit of a digital setting is that the use of live cattle would be replaced by simulated ones, consistent with the "3Rs" concept of reducing, replacing, and refining animal use (Russell and Burch, 1959). Indeed, digital simulations are becoming more widely used in veterinary medicine curricula to reduce or replace the use of real animals (Braid, 2022). To ensure its relevance to our end users, we created and refined the game with qualitative input from a range of Wisconsin dairy farming stakeholders. Existing serious games have demonstrated key principles that could be applied to *Mooving Cows*, such as learning how to reduce the risk of injuries from

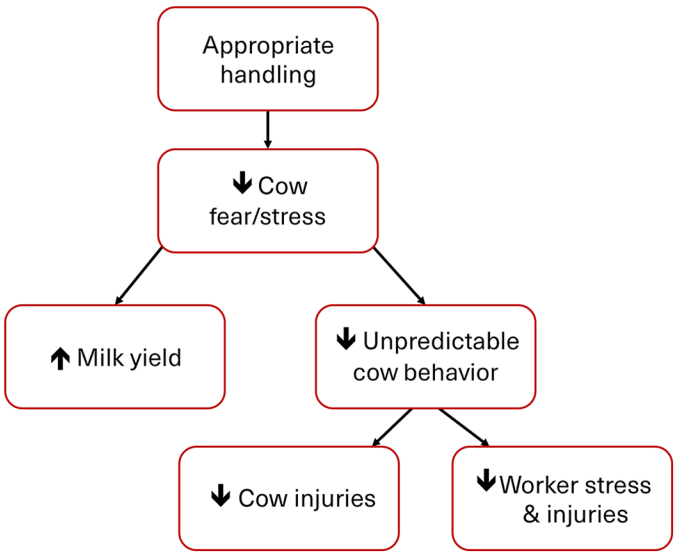

Figure 1. Learning objectives in the *Mooving Cows* game. By practicing cow-handling techniques in the simulated game environment, players will learn that appropriate handling reduces the cows' fear and stress levels, resulting in greater milk yield. When cows are less fearful or stressed, they are also less likely to have a fight-or-flight response, resulting in fewer unpredictable and dangerous behaviors, and thus improving the safety of the cows and the humans who work with them.

farm equipment (Mazur et al., 2014), practicing spatial and situational awareness in submarine or bicycling situations (Stone et al., 2009; Lehtonen et al., 2017a,b), and learning about farm animal welfare concepts (Hawkins et al., 2019). At the time of the project inception, there was no published application of serious games to animal handling. Therefore, our work represents the proof of concept for a digital serious game on this topic.

MATERIALS AND METHODS

Researcher Positionality

We include a researcher positionality or reflexivity statement, a standard reporting practice for qualitative research (O'Brien et al., 2014), to acknowledge how our backgrounds, perspectives, and relationships with the participants and the dairy industry may have influenced our interpretations. The lead investigator (JV) is a faculty member with research and extension-outreach duties in a department that maintains active relationships with dairy industry stakeholders in Wisconsin, a major dairy-producing state. JV works closely with stakeholders to conduct applied research on dairy cattle welfare and to translate findings to the industry through extension-outreach programming. NC is a dairy veterinarian with extensive experience and relationships with the global dairy industry. DL, RC, and OA are trained in qualitative and mixed-methods social science research approaches, and MB has expertise in quantitative social science methods. DL is a Spanish-fluent language professional with experience in the linguistic appropriateness and cultural relevancy of extension-outreach programming. OA is an expert in developing serious games through community stakeholder engagement; her previous work in this area (e.g., Abraham et al., 2020; Abraham and McCarthy, 2023) informed our approach in the current project. We value diversity in dairy farm practices and stakeholder perspectives. However, we also believe that best practices in animal care should be grounded in evidence from animal welfare science, and we thus predetermined the learning objectives within the *Mooving Cows* game and set constraints on the scope of the first version of the game. To evaluate the game prototype, we used a pragmatic research paradigm because we sought to solve a real-world problem: How to effectively improve cow-handling practices among dairy farm personnel.

Game Development

Scope of Learning Objectives and Content. Our objective in creating *Mooving Cows* was to demonstrate the proof of concept for a digital video game as a modality for people to learn and practice how to appropriately handle dairy cows. We decided to keep the scope relatively narrow, focusing on routine cow handling in the context of moving cows out of their living areas and loading them into the parlor to be milked.

In this single-player game, the player takes on the role of a handler on a dairy farm tasked with moving cows through routine farm environments, including a freestall pen in a barn (i.e., where the cows are housed for most of the day). The final version of the game also included an outdoor pasture paddock and the milking parlor. Players progress sequentially through levels in the game and must successfully complete a level before playing the next one. In each level, the objective is to move the cows to a target location. The player moves their character using a touchscreen, and the cows respond to the character's actions, particularly their relative location in the simulated environment.

The in-game learning objectives are shown in Figure 1. By playing the game, players will understand that, by using appropriate actions to handle cows, cows' fear and stress levels will be reduced. Less fear and stress results in both improved milk yield and more predictable cow behavior, reducing the risk of injuries to both cows and people.

Target Audience and Accessibility. Although the game has the potential to benefit many types of learners, we envisioned personnel on dairy farms as the primary target audience. Therefore, a top priority was accessibility to dairy farm personnel in the context of workplace training

and continuing education. An increasing segment of the US dairy workforce consists of immigrant laborers from Latin America (Maloney and Grusenmeyer, 2005; Adcock et al., 2015). In certain parts of Wisconsin, nearly three-quarters of dairy personnel are Spanish-speaking immigrants (Dyk, 2008). Therefore, creating a dual-language version of the game in Spanish and English was a top priority for ensuring that personnel could access and benefit from this workplace education tool.

Variability in literacy levels presented another noteworthy consideration for potential accessibility barriers within our primary target audience. Among some US farm worker populations, previous studies have reported limited English proficiency, relatively low levels of educational attainment, and variability in literacy skills in either Spanish or English (Arcury et al., 2010; Hagevoort et al., 2013). However, based on their professional roles, we assumed our target audience would have a reasonable amount of familiarity with typical US dairy farm environments and terminology. In these contexts, our goal in creating a culturally responsive and linguistically appropriate game meant we carefully considered how the amount of screen text, use of technical terms and concepts, speech register in the voiceover narration, and other factors would affect learner accessibility. We used these factors as discussion points when engaging with stakeholders in our iterative approach to the game's design, content, and playability.

Another aspect of accessibility was the type of device on which the game could be played. After initial consideration of virtual reality headsets, we determined that the hardware for this format was too specific and could have too great of a learning curve for some users. Instead, we focused on mobile touchscreen devices, such as tablets and smartphones. Within this context, we considered augmented reality, in which the device could show images or illustrations of cows overlayed on camera-captured real environments. Such a format could potentially allow the user to move their whole body, using the relative distance between them and the simulated cow to influence cow behavior, as with real cows. However, a major limitation would be that if the player was close to the simulated cow, only a small part of the cow's body would be visible on the screen. Therefore, we decided on a completely simulated game environment on a touchscreen device, with the player represented as a digital character within the game. Using touchscreen tablets as the medium for game play would be unlikely to present a barrier for dairy personnel because this format has been used effectively for safety training on dairy farms (Rodriguez et al., 2018). Finally, another accessibility consideration relating to the dairy farm workplace setting was that internet access on farms is variable. Therefore, it was a priority for the game to function as an offline application.

Game Prototype Evaluation. Wisconsin dairy farming stakeholders evaluated an "alpha" prototype of *Mooving Cows* in August 2022, and our research team compiled their feedback to refine the game into a "beta" prototype and then a "gold" release version. We sought to understand stakeholders' experiences of playing the alpha prototype. This included their comprehension of, and satisfaction with, the prototype's content, their perceptions of its usability and usefulness, and their suggestions to improve its relevance. The alpha prototype included language selection (text in English or Spanish), basic graphics, placeholder menus, rudimentary cow behavior, and limited in-game feedback to players. There were 2 levels with identical freestall pen layouts, containing 1 or 5 cows. This draft version of the game did not include final, polished graphics or animations. For example, the barn layout was incomplete and lacked "set dressing" (e.g., bedding or water troughs for the cows), there was only one coat pattern for all cows, and the limbs on the human character and cows did not move. This version of the game also lacked character choices and had no audio or tutorials. The research team deliberately chose to solicit feedback from stakeholders at this preliminary stage in the game-development process to allow for meaningful incorporation of their feedback into later iterations of the game. Additional details about the game-development timeline and design iteration process are provided in Supplemental Document S1 (see Notes).

Participant Recruitment and Ethical Review. The University of Wisconsin (**UW**)–Madison Education and Social/Behavioral Science Institutional Review Board (IRB) reviewed the procedures and designated the activities as program evaluation (i.e., nonresearch; submission ID: 2022–0795). All written instruments were translated to Spanish by a native Spanish-speaking staff member at the University of Wisconsin Survey Center (**UWSC**) and reviewed by DL for accuracy, consistency, and appropriateness.

First, we recruited a pilot group of professional trainers among the staff of the Research Animal Resources and Compliance (**RARC**) group at UW–Madison. These trainers provide support to researchers at UW–Madison, including training personnel on appropriate handling of research animals such as dairy cattle. Four trainers who frequently work with dairy cattle were recruited to participate in a pilot session. The purpose of the pilot session was to verify the timing of the evaluation procedure, to refine the focus group questions if needed, and to informally gather feedback from the RARC trainers. The focus group discussions from this session were recorded but not transcribed. The trainers received light refreshments but no monetary compensation.

Subsequently, we recruited dairy farming stakeholders with a variety of professional roles using purposive

Table 1. Breakdown of groups of Wisconsin dairy industry participants who evaluated the prototype of the *Mooving Cows* game

Participant category	Location	Number	Language	Role represented
Decision-makers				
	UW–Madison	2	English	1 farm owner, 1 veterinarian
		3	English	2 farm owners, 1 bilingual consultant
		5	English	3 farm owners, 2 bilingual consultants
Dairy farm staff				
	Farm A	2	English	Cow-handling staff
		6	Spanish	Cow-handling staff
	Farm B	2	English	Cow-handling staff supervisors (1 bilingual)
		5	Spanish	Cow-handling staff
		5	Spanish	Cow-handling staff

sampling. All participants received light refreshments and a $200 cash incentive for participating in the game evaluation session. These participants were divided into 2 main categories (details in Table 1).

The first category was people (n = 20) employed on 2 Wisconsin dairy farms in cow-handling roles, hereafter referred to as farm staff. The 2 farms were selected because the owners had previously engaged in conversations with us about cow-handling practices and their expectations for their staff, and both farms were known to have both Spanish- and English-speaking staff who routinely handled cows. To recruit participants, the facilitators (English: RC, Spanish: DL) and the lead investigator (JV) visited both farms to introduce the project team, describe the purpose of evaluating the game prototype, answer questions, and obtain signups. The project team left both English and Spanish information sheets and signup sheets for the prospective participants at both farms. For the focus group sessions, the participants were grouped by primary language (English: total n = 4; Spanish: total n = 16); one group of supervisors was scheduled for a session separately from their direct reports. These sessions were held in conference rooms or break rooms at the participants' worksites. On farm A, 2 concurrent sessions (one in each language) were held during work shifts as part of a monthly time dedicated to training and continuing education. On farm B, the 3 sessions were held outside of working hours, immediately before or after work shifts.

The second category was those (n = 10) in other relevant professional roles in the Wisconsin dairy industry, hereafter referred to as decision-makers. These participants were recruited by direct email through our professional network, including the owners of the 2 aforementioned farms. The recruitment list included those who make or influence decisions about cow handling and training on dairy farms, such as dairy farm owners, professional bilingual (Spanish-English) dairy consultants or staff trainers, and bovine veterinary practitioners. Three focus group sessions, conducted in English, were held during regular business hours in a conference room in the Animal Sciences Building on the UW–Madison campus.

Procedures. For all groups, the following methods were used. The facilitators were present throughout all steps. To ensure participants felt comfortable sharing their honest opinions, JV did not attend the game evaluation sessions. Each evaluation session was completed in approximately 2 h.

First, the facilitators gave the participants an overview of the session's activities and purpose using a PowerPoint slideshow (Supplemental Document S2; see Notes). Second, participants were given individual mobile tablets (Samsung Galaxy Tab S8; Samsung Electronics Co.) to complete a questionnaire using the Qualtrics XM offline application. The questionnaire collected demographic information and asked about the respondents' experiences with and perceptions of cow handling and training on this topic. The questionnaires for the farm staff versus the decision-maker groups differed slightly (Supplemental Document S3; see Notes), with the former focusing on the participants' own experiences and the latter also asking about the respondents' perceptions and observations of dairy farm staff. In addition, the former was offered in both English and Spanish, whereas the latter was only in English. For on-farm participants with limited literacy or familiarity with survey software, the facilitators offered to read the questions and response choices aloud to the group; participants responded individually on the provided touchscreen tablets.

Third, the facilitators delivered a tutorial on how to control the game character's movement and speed using the PowerPoint slideshow. Fourth, participants individually played the alpha prototype game at their own pace on the mobile tablets. Screen recordings were captured for a subset of n = 14 of the farm participants (4 English, 10 Spanish) and the n = 10 decision-maker participants. Based on recordings rounded to the nearest minute, the average gameplay duration was 26.4 ± 6.7 min (range: 15–37 min). As needed, the facilitators provided technical support with the mobile tablets. However, they did

not help participants solve problems within the game because we deliberately sought feedback on sticking points during gameplay.

Finally, during the second half of the 2-h sessions, participants engaged in a facilitated focus group discussion, which was led by one facilitator in the appropriate language, using a semistructured interview guide (Supplemental Document S4; see Notes). In both versions of the guide, participants were asked to elaborate on their experience with the game prototype, including what they thought the objectives of the game were, problems they encountered and how they overcame them, the relevance of the cow-moving scenarios, how they interpreted in-game feedback, how useful they thought a more complete version of the game would be, and general suggestions to improve the game. The guide also included questions about the participants' impressions of concept art for character choices and dairy farm environments, shown on PowerPoint slides (Supplemental Document S2). The guide for farm staff also asked about the participants' own experiences and practices when moving cows in real life, whereas the guide for decision-makers asked about their observations of and expectations for dairy farm workers' actions; the responses were used to inform which types of cow-handling actions to include as options in the full version of the game. Two of the decision-maker focus groups included bilingual consultants (Table 1); in those sessions, those participants shared insights on potential issues with learner accessibility and provided input on the accuracy and appropriateness of the game's Spanish-language content. The focus group discussions were audio-recorded using 2 voice recorders (ICD-UX570 Digital Voice Recorder; Sony) placed on the table. At the start of each discussion, the facilitators explicitly reminded the participants that they were not involved in the design of the game content and that they sought honest feedback, even if negative, to improve the relevance and usefulness of the game. Based on the length of the recordings, rounded to the nearest minute, the discussions lasted 59.5 ± 6.1 min (range: 52–67 min).

Analysis. Descriptive quantitative statistics were calculated to summarize the participants' demographics and their experiences with or perceptions of cow handling and training on this topic. Survey responses were summarized separately for the farm staff (initial n = 20; final n = 19 due to a technical issue with Qualtrics XM) and decision-makers (n = 10); these groups were not compared directly to each other using inferential statistics because the study was not designed for this purpose. All decision-makers responded to all questions, and none selected "unsure" in response to any questions. The numbers of farm staff who responded to each question are indicated if fewer than 19 responded.

The focus group recordings for all dairy stakeholder sessions (but not the pilot session with the RARC staff) were transcribed verbatim by third-party professionals (Premium Business Services, Madison, WI), who also translated the Spanish transcriptions to English. The accuracy and fidelity of the translations were cross-checked by a native Spanish-speaking staff member of the UWSC. The transcripts of the focus groups conducted in Spanish were analyzed using the English translations.

During game development, a formal thematic analysis of the transcripts was infeasible because of time constraints due to the production timeline of the game determined by Filament Games. Instead, we reviewed the transcripts and synthesized the stakeholder feedback into a spreadsheet in Microsoft Excel. Three tabs were created, for (1) actionable feedback to incorporate into the beta prototype of the game, (2) ideas for additional scenarios to incorporate into future versions of the game, and (3) select notes and reflections on participants' experiences playing the game prototype. Inspired by the latter reflections, we conducted a descriptive, iterative codebook thematic analysis (Vaismoradi et al., 2013; Ritter et al., 2023) after version 1.0 of the game was completed. This analysis was inductive, with the themes identified from reading the transcripts; however, we particularly focused on passages in which participants discussed their impressions of the game's usefulness, relevance, or enjoyableness, rather than details about the game content. The coding was performed using NVivo software (release 1.4.1; QSR International). All transcripts were reviewed multiple times, and the identified parent- and child-level codes were revised to classify themes and subthemes. The codebook, including definitions and example quotes, is presented in Supplemental Document S5 (see Notes).

RESULTS AND DISUSSION

Participant Characteristics

The descriptive quantitative survey results are reported in Table 2. This information provides context about our participants and their diversity of perspectives on cow handling and training on this topic.

Demographics, Experiences with, and Perceptions of Training

The average age in the farm staff focus groups was 31.1 yr old (range: 18–60 yr old). To our knowledge, no comprehensive demographic survey of Wisconsin or US dairy farm staff has been published. However, a multistate evaluation of a safety training program with more than 1,400 dairy farm staff reported a similar mean age of 34.4 years (range: 18–79 years old; Rodriguez et

Table 2. Demographic data and perceptions of cow handling and training on the topic among Wisconsin participants who evaluated the prototype of the *Mooving Cows* game[1]

Variable	Dairy farm staff[2]	Decision-maker[3]
Age (yr)	31.1 ± 10.6 (18 to 60)	44.9 ± 8.7 (31 to 60)
Years on the current farm	3.8 ± 6.6 (0 to 26)	—
Previous experience with dairy cows (yr)	6.0 ± 8.4 (0 to 20)	—
Years of experience in the dairy industry	—	26.1 ± 9.2 (12 to 45)
Frequency of handling cows[4]	—	4.4 ± 0.7 (3 to 5, sometimes to very frequently)
Job role(s)[5]	Milking cows (16, 84%) Moving cows to/from parlor (14, 74%) Other[6] (8, 42%) Selected multiple (14, 74%)	Farm (co)-owner (6, 60%) Trainer (5, 50%) Farm manager/supervisor (3, 30%) Consultant (non-nutritionist; 3, 30%) Veterinarian (1, 10%) Selected multiple (6, 60%)
Comfort with using mobile apps[4]	1.9 ± 1.2 (1 to 5, very comfortable to very uncomfortable)	1.8 ± 1.0 (1 to 4, very comfortable to fairly uncomfortable)
Perceived comfort of farm staff using mobile apps[4]	—	2.8 ± 1.0 (1 to 4, very comfortable to fairly uncomfortable)
Who first taught you cow handling? (farm staff[5]) or Who is best suited to teaching cow handling? (decision-makers)	Experienced colleague (13, 68%) Manager/supervisor (12, 63%) Off-farm trainer (7, 37%) Selected multiple (10, 53%) No one, learned on own (2, 11%)	Experienced colleague (1, 10%) Manager/supervisor (5, 50%) Off-farm trainer (2, 20%) Other ("all of the above;" 2, 20%)
How did you first receive information on cow handling? (farm staff[5]) or What format do you use or recommend? (decision-makers[5])	Practiced moving real cows (15, 83%) Listened to someone explain (10, 56%) Watched videos (5, 28%) Role-played (3, 17%) Read materials (3, 17%) Selected multiple (9, 47%)	Practice moving real cows (9, 90%) Listen to someone explain (9, 90%) Watch videos (7, 70%) Role-play (7, 70%) Read materials (6, 6%) Selected multiple (9, 90%)
Safety when working with cows[4,7]	3.8 ± 1.3 (1 to 5, very unsafe to very safe; n = 18)	3.3 ± 0.9 (2 to 4, fairly unsafe to fairly safe)
Frustration when moving cows[4,7]	2.5 ± 1.3 (1 to 5, almost never to almost always; n = 17)	3.2 ± 0.6 (2 to 4, not very often to fairly often)
Ease of moving cows[4,7]	3.3 ± 0.9 (2 to 5, fairly hard to very easy; n = 16)	3.3 ± 0.8 (2 to 4, fairly hard to fairy easy)
Skill at moving cows[4]	1.8 ± 0.7 (1 to 3, very good to neither good nor bad)	—
Enjoyment when working with cows[4]	4.1 ± 1.1 (1 to 5, not at all to very enjoyable; n = 18)	—
How much handling affects cows' stress[8]	3.2 ± 1.0 (1 to 4, not at all to a great deal; n = 17 plus one selected "unsure")	4.0 ± 0 (a great deal)
How much handling affects milk production[8]	3.7 ± 0.6 (2 to 4, not very much to a great deal; n = 15)	3.7 ± 0.5 (3 to 4, somewhat to a great deal)

[1]For continuous and ordinal variables, the mean ± SD is given with the range in parentheses. For categorical variables, the number and percentage of responses are given in parentheses.

[2]Responses from n = 19 dairy farm staff members who work with adult dairy cows. Unless otherwise specified, all 19 respondents answered each question.

[3]Responses from n = 10 dairy industry professionals with decision-making roles on cow handling and personnel training. All respondents in this subgroup answered each question.

[4]Five-point Likert-scale response.

[5]Totals add up to >100% because participants could select multiple choices.

[6]Those who selected "other" indicated these roles: cleaning cattle pens, helping to breed cows using artificial insemination, assisting with calving, moving dry cows and heifers and scraping manure from pens, sorting dry cows and performing health checks, moving youngstock and fresh cows, trimming hooves and managing sick cows and dry cows, and caring for calves and feeding cattle.

[7]Farm staff rated their self-perception, whereas decision-makers rated their perception of farm staff in general.

[8]Four-point Likert-scale response with an additional option to indicate "unsure."

al., 2018). Sixteen participants (10 on one farm, 6 on the other) indicated Spanish as their preferred language, whereas 4 participants (2 per farm) indicated English. The proportion of participants in our study who primarily spoke Spanish (75% on one farm, 83% on the other) was similar to older Wisconsin data reporting that in certain parts of the state, nearly three-quarters of dairy farm personnel are immigrant laborers, primarily from Spanish-speaking countries (Dyk, 2008). This was unsurprising, because we deliberately recruited participants from farms that we knew had a mix of hired staff who spoke Spanish or English. In the aforementioned large-scale evaluation of dairy-staff training (Rodriguez et al., 2018), approximately 13% of participants reported English as their native language, whereas more than 60% indicated Spanish, and 22% spoke K'iche' (an indigenous language in Guatemala); however, that sample did not include Wisconsin.

Farm staff most commonly reported that an experienced colleague or their supervisor or manager first

taught them to move dairy cows. This aligned with more than half of the decision-makers indicating a supervisor or manager was best suited to teaching dairy farm staff how to move dairy cows. Similarly, in a mailed survey of 106 Minnesota dairy farm owners, two-thirds of respondents indicated that the farm owner was the person who primarily trained staff, whereas the other third reported that a manager or another employee trained the majority of staff (Sorge et al., 2014). The staff reported that when they first learned to move dairy cows, it was typically by practicing moving real cows and listening to someone explain how to do so. These formats closely aligned with those the decision-makers indicated they used or recommended for staff training. These descriptive results suggest that most participants see benefits with more than one teaching format. However, more research is needed to further probe the perceptions of the decision-makers and farm staff to evaluate the pros and cons of each format, including new modalities such as the *Mooving Cows* game.

On average, the decision-makers indicated they felt fairly comfortable with using applications on smartphones or tablets. When asked what they believed about "most dairy farm staff," the decision-makers rated them as slightly less comfortable with using mobile devices. However, the farm staff in our sample rated themselves as feeling fairly comfortable with using applications, which was nearly identical to how the decision-makers rated themselves. The discrepancy between these groups' assessments of farm staff comfort level may suggest that when selecting training formats, decision-makers should ask farm staff directly about their suitability instead of making assumptions. However, future research comparing farm staff self-assessments with those of their direct supervisors would be beneficial to more directly measure potential discrepancies and explore the underlying mechanisms. In a previous multistate study evaluating a safety training program delivered on mobile tablets, more than 90% of dairy farm staff reported that it was easy to use the mobile device (Rodriguez et al., 2018). These results suggest that, even if some participants may face a learning curve with using the devices, delivering training programs to dairy farm staff using mobile devices is a promising method.

Experiences with and Perceptions of Cow Handling

On dairy farms, injuries sustained while working with cattle are common, and in some cases can be severe or even fatal (Watts and Meisel, 2011; Lindahl et al., 2013; Liebman et al., 2016). Although the farm staff in our study indicated they felt fairly safe when working with dairy cows (Table 2), the decision-makers reported a more middling perception of how safe "most dairy farm staff" were. Previous studies have reported that, although farm owners or managers may view the handling of large animals as risky, farm staff may not perceive the interactions to be as dangerous (reviewed by Lindahl et al., 2013).

We also asked how much the farm staff enjoyed working with dairy cows and how often they got frustrated when trying to move cows because human handlers' attitudes and stress levels can affect their behaviors toward cows and the cows' reactions, resulting in a feedback loop (Breuer et al., 2000; Hemsworth et al., 2002; Lindahl et al., 2013). Although the decision-makers in our study rated "most dairy farm staff" as sometimes getting frustrated when trying to move cows, the farm staff participants indicated they felt frustrated less often, although with great individual variability. Furthermore, the farm staff reported they found it fairly enjoyable to work with dairy cows and that they were fairly good at it. However, they did not necessarily think it was easy to move cows. The decision-makers corroborated this assessment with the average belief that it was neither hard nor easy for most farm staff to move cows.

In future research, it would be interesting to probe participants' perceptions of the relationships between the ease of a task and their efficacy at performing it, as well as to compare their self-rated efficacy at handling cattle to evaluations by their supervisors and to impartial observations by researchers. Furthermore, future research could evaluate farm staff's perceived support from their supervisors and their farm's overall organization, because previous studies in other industries have identified relationships among self-efficacy, perceived organizational or supervisor support, transfer of training (i.e., applying what is learned to the job), positive work engagement, and job satisfaction (Sookhai and Budworth, 2010; Caesens and Stinglhamber, 2014).

Related to the aforementioned feedback loop, as well as to the learning objectives within the game (Figure 1), we asked participants to assess how much handling affects both cows' stress levels and milk production. Descriptive differences were apparent, both between the 2 questions as well as when comparing the subgroups of respondents. All participants with decision-making roles (e.g., dairy farm owners, trainers) indicated they thought handling affects cow stress a great deal, whereas the responses from dairy farm staff spanned the entire scale between not at all to a great deal, with the average response reflecting that handling somewhat affects cow stress. However, for the other question about how much handling affects milk production, the means between these 2 respondent groups were identical, with agreement that handling has a great deal of influence on cows' milk yield. These differences are interesting and somewhat unexpected because the biological mechanism by which

handling affects milk production is mediated through the cows' stress response. It is well established that when cows are handled aversively, they can experience a fear response, including a physiological cascade of stress hormones. These stress hormones disrupt the release of oxytocin, which is needed to promote milk ejection, resulting in residual milk left in the udder and reducing milk yield (reviewed by Wellnitz and Bruckmaier, 2001; and Bruckmaier, 2005). Therefore, from a biological perspective, handling has an indirect and lesser influence on milk production than on cow stress.

Previous studies have documented correlations between rough handling, cows' fear and stress responses, and reduced milk yield (Breuer et al., 2000; Hemsworth et al., 2000). When a handler who previously handled cows roughly was present at milking, the milk yield was 11% lower than when no handler was visible, due to greater residual milk left in the udder (Rushen et al., 1998). Similarly, after farm staff completed a training program targeting their attitudes and behaviors toward cows, milk yield on those farms was 5% to 10% greater than on the other farms (Hemsworth et al., 2002). Although these effects on milk yield are statistically and economically significant, they do not necessarily reflect a substantial biological magnitude.

It is possible that both groups of respondents overestimated the effect of handling on milk yield or that some farm staff lack awareness of the effect of handling on cows' stress. This could potentially highlight the importance of including the learning objective in the game about the effects of handling practices on cows' stress. In hindsight, our approach of asking "how much" handling affects cow stress and productivity could be interpreted to mean either biological significance or subjective importance. Based on the lack of variability among the decision-makers in their responses to both questions, the respondents likely interpreted the questions as inquiring about subjective importance. In the future, this type of question could be rephrased to distinguish between perceived importance versus biological effect size.

Participants' Reflections on Playing the Game Prototype

We identified 3 main themes when analyzing the focus group transcripts to characterize the participants' experiences playing the game: the potential for different audiences to learn from the game, the relationship between playing it and handling real cows, and its entertainment value.

Potential for Using the Game to Teach Various Audiences. A major theme reflected the potential for the game to be used for teaching various types of audiences about cow-handling practices. Most of the comments focused on dairy farm settings, which was the context in which we presented the purpose of soliciting the participants' input. The consensus among participants was that the game would benefit those with little or no previous cow-handling experience. Many participants suggested that playing the game could be a helpful part of new-hire onboarding and training. "Igual te ayuda evitar muchos riesgos porque, por ejemplo, cuando llegué aquí, no sabía nada de vacas. . . Pienso si me hubiesen puesto a jugar. . . una semana ese videojuego, ya tendría como más noción. Y ya no sería tanto riesgo de, ah, pues, mueve esta vaca, o así, pues. Yo ya sabría un poquito más decir, ah, pues, me paro aquí o aquí o así. . . Entonces, sí, es muy útil" (Farm focus group #4, participant #3). English translation: "It also helps you to avoid risks because, for example, when I arrived here, I didn't know anything about cows. . . . I think if they would have made me play. . . that videogame for a week, I would already have more of an idea. And there wouldn't be so much risk of, ah, well, this cow moves, or like that, I guess. I would already know a bit more to say, ah, well, I stand here or here, or like that. . . . So, yes, it's very useful."

However, opinions were mixed on whether the game could be a stand-alone tool or should instead be used to complement other modes for learning concepts or practicing skills. Multiple participants suggested that inexperienced handlers would first need exposure to basic concepts, such as the flight zone, using more traditional videos before playing the game. These ideas complemented the quantitative survey results, in which farm staff reported they initially learned how to handle cows using multiple modalities, and decision-makers used or recommended multiple training formats.

"Before they play, they should, if they never had experience, they should learn about cow behavior first. Where to stand to move a cow to a certain place, how the cow behaves. How we behave, that invites how the cow behaves. Otherwise, they wouldn't know what to do in the game. They need that first" (decision-maker focus group #2, participant #2).

However, as we noted in the overview slideshow for participants (Supplemental Document S2), the game prototype did not yet include tutorials. In the final version of the game, built-in tutorials explained concepts such as the flight zone as part of the game's story line. We speculate that, when evaluating the finished version of the game, concerns about needing prior exposure to these concepts may be alleviated. Indeed, other participants believed the game's animations could have advantages over traditional videos for illustrating these concepts: "This is a good chance for you to really explain. . . in a visual way. . . the flight zone. Because when you watch the [company name] videos, which are the best in the industry, they try to explain the flight zones in a drone flying over the cow,

and they are making these circles. . . . But I think the new audience that we have coming to work in every culture in this country, it's going to be better if you explain using these animations, these characters. I think it's very cool that you're using the characters" (decision-maker focus group #1, participant #5).

Some participants believed the game could supplement but not replace practice with real cows: "I see this as a tool, right, a tool for practice. But this, for sure, can't replace somebody, like the whole package. Like the video, then taking them to the parlor, that this is another tool that could be used to practice, to learn from each other, to have fun" (decision-maker focus group #1, participant #4).

This finding was unsurprising, and indeed, practicing with real cows is likely beneficial due to the inherent physical and spatial nature of cow handling. Nonetheless, compared with videos or other passive sources of information, the game may provide a more interactive introduction to best practices, principles, and spatial concepts. Indeed, digital serious games have been used to teach spatial and situational awareness in other contexts, such as bicycling (Lehtonen et al., 2017a,b) and naval submarine safety (Stone et al., 2009). Furthermore, the simulated environment in *Mooving Cows* is safe for both cows and people. Some participants referenced the low-risk nature of the simulation as an advantage: "So, kind of walking through all the possible scenarios and how we want them to handle it without actually having the repercussions on the farm." (Decision-maker focus group #1, participant #1). "And sometimes going out in the barn when you're very new and being interactive can be tricky. So this is an in-between step" (decision-maker focus group #2, participant #3).

For handlers already experienced with cow handling, participants' opinions were mixed on how useful the game would be for them to learn new things or practice their skills. Some participants believed the game could indeed benefit experienced handlers, who they thought still could use reminders or practice. "Yo creo que es útil tanto para el que tiene mucha experiencia como para el que no tiene" (farm focus group #4, participant #3). English translation: "I believe it's as useful for someone who has a lot of experience as it is for someone who doesn't."

Interestingly, multiple participants, in both the on-farm and decision-maker focus groups, described knowledge transmission among personnel on farms. They suggested that the game could improve the quality of the knowledge transferred among colleagues, including experienced handlers. "In my opinion, everybody [can benefit]. Because you see managers and owners doing the same mistakes that the workers, they do. And then the workers, they learn from them, right? So, I think in my experience, both [new and experienced handlers], everybody" (decision-maker focus group #1, participant #5).

In contrast, some participants did not believe those with extensive cow-handling experience would benefit from playing the game. "I don't know if somebody that really knew what they were doing would want to play it. They would, like me, I would play it and [be] like, yeah, I know all this" (farm focus group #2, participant #2).

One participant clarified that, although many experienced handlers would not benefit from the game, perhaps those with poor habits could learn something: "I really don't think it's beneficial for somebody that works with cows all the time or has lots of experience. . . . Maybe just somebody with bad habits" (farm focus group #2, participant #1). However, their colleague disagreed and felt that poor habits needed in-person correction: "If they got bad habits, it's something you got to teach them out in the barn. You know what I mean?" (farm focus group #2, participant #2).

Nonetheless, even for experienced handlers, US industrywide expectations have been established for annual continuing education on stockmanship (NMPF, 2020). Some participants referenced these national industry expectations and suggested playing the game could be a new way to fulfill these requirements: "We're required to do this training every year, and I get the same thing year after year after year, and it gets boring, right?" (decision-maker focus group #2, participant #1).

Indeed, although the level progression of the game is standardized, within a level, players can make choices resulting in different experiences than other players or between play sessions. This allows for the possibility of variety and continued stimulation and challenges, even when replaying the game.

Several participants mentioned that, apart from job training on farms, children, including their own families, could enjoy or benefit from the game. Some brought up schools or classroom settings: "I think it would be great for, you know, farms and schools, especially with kids. I think it would be great" (farm focus group #3, participant #1).

Although our initial primary audience was dairy farm personnel, in future work we intend to evaluate the game's potential applicability with learners in classroom settings such as undergraduate introductory animal science courses or students in primary or secondary schools.

Interestingly, one participant mentioned, more than once, that the game could benefit the dairy industry as a promotional tool with the public. Although such people would be unlikely to have a need to acquire cow-handling skills, they could learn more generally about dairy farming by interacting with the game: "I work for a private company, and we are always [looking] for interactive ideas to have in the booth. And at trade shows, there are also people that are not related to the dairy industry. So, as a way to promote this tool and as a way to also pro-

mote the industry and what we do . . . these things can be used in companies and booths with tablets or big screens. And people, they can come and play" (decision-maker focus group #1, participant #5).

We had designed the game's learning objectives to convey certain principles about cow-handling practices and their consequences. The idea that the game could more broadly showcase dairy farming practices to the public is intriguing. In a recent survey on public perception of cow-handling practices, our group found that a greater proportion of laypeople, compared with professionals working in the US dairy industry, perceived aversive handling practices to be common on US farms (Robbins et al., 2024). This perception may arise from exposure to negative news reports of instances of animal abuse (Robbins et al., 2016; Rice et al., 2020). Although the US industry expectation for dairy farm personnel to complete annual continuing education on stockmanship is publicly accessible, most laypeople are likely unaware of this requirement. Future research could potentially explore public perception of dairy farming practices in light of such industrywide initiatives to encourage on-farm continuing education of personnel, including by highlighting the use of high-tech tools such as *Mooving Cows* to help fulfill those expectations.

Comparing and Contrasting In-Game Versus Real-Life Behavior. Some participants explicitly compared their experiences playing the game to their experiences of handling cows in real life. Some participants believed that players' in-game choices could be interpreted to reflect their real-life cow-handling behaviors. Some decision-makers expressed an interest in using scores from the game to evaluate how farm staff would perform with real cow handling: "And that will affect the score, right? And you will have a way to measure how the workers or the people that [are] being trained, how they are reacting, right? If they are reacting like that in a game, then chances are they will react like that in a real-life situation" (decision-maker focus group #1, participant #5).

In contrast, other participants explained that they deliberately made choices within the game which did not reflect what they would do with real cows. They indicated the game provided an opportunity to explore and learn what could happen: "Like for me, in this case, I knew it was a game, and I just wanted to see what the game would do. . . . Like there's the option to hit the cow. I clicked it because I wanted to see what it would do. But obviously, I know it's not right, but I wanted to get myself stressed out and the cow stressed out, and I wanted to see what the game was going to do, right?" (farm focus group #3, participant #2).

Indeed, the opportunities to explore and to learn by failure are features of serious games (Susi et al., 2007). Because players' in-game behavior may not reflect their real-life intentions or practices, we ultimately decided not to include scores on the certificate of completion in the final game. We wanted to avoid the potential for farm managers or owners to penalize staff who completed the game, but with lower scores than others, if they used the game as an opportunity to learn from less-than-ideal behaviors.

With participants in each focus group playing the game independently but in the same room together, they could determine when others finished playing, as well as discuss their scores on the individual levels afterward. Several participants mentioned an element of competition, either to finish faster, score higher, or both: "I think that's the cool part of the game, is people are going to be competitive. And they can't really compete in the barn for how quickly they can move cows out of the pen. But the game—and the reality is, if you win the game by doing more right behaviors with your character than wrong behaviors, then it's going to drive home the message" (decision-maker focus group #3, participant #2).

Despite the feeling of competition described by some participants, many of them mentioned that while playing the game, they had to be patient because of the dynamics between the character's movement and the cows' responses. For example, "it's building a level of patience. . . that's needed to deal with animals" (farm focus group #1, participant #3). Many participants used the terms "calm" or "quiet" in reflecting on how they interacted with the game: "When I was playing this, I was thinking, man, these guys will really learn—a beginner—that you can be quiet and the cow will move. So, getting used to the, you know, the calmness, I think it was good" (decision-maker focus group #1, participant #5).]

In designing the learning objectives for the game, we intended for players to internalize the importance of calm or quiet handling for minimizing cow stress. However, we had not anticipated the physical feedback players described, such as their actual voices having no impact on the cows in the game, which reinforced the concept of quiet cow handling. The same participant elaborated: "When I'm training people, you know, one of the things that is really hard to change in their minds is the voice, right? They are used so much to [kissing noise] and yell and scream and stuff. And then when we teach them about flight zone, and then they are supposed to use the flight zone in order for the cow to move in their favor, it's really hard to change that behavior, you know, the noise. So, when I was playing the game using my finger, it forced me to think about that I can move cows being quiet" (decision-maker focus group #1, participant #5). This was an interesting unanticipated benefit of the game interface. This phenomenon could be worth probing more explicitly in future evaluations of the finished game.

Figure 2. English menu for selecting avatars in version 1.0 of the *Mooving Cows* game. The artwork for the characters, including clothing, was intended to represent a variety of personnel with adult cow-handling roles on Wisconsin dairy farms.

Figure 3. The pasture paddock, 1 of 3 dairy farm environments in version 1.0 of the *Mooving Cows* game. In the 4 game levels (of 8 total levels) in which the paddock appears, the player's objective is to move the cows through the open gate on the lower right. This screenshot is from an early level in the game, in which visual augmentation around each cow depicts the flight zone (yellow circle), blind spot (red wedge), and point of balance (white lines), abstract concepts that are used to convey how cows respond to and move away from humans. In addition to influencing the cows' movement and responses based on the distance between them and the player's character, players could select actions, shown in the menu on the right side (i.e., speak softly, wave arms, or yell; English version shown). In this screenshot, a player's action has resulted in an increase in cow stress, depicted with the red icons above the cow and in the cumulative cow stress meter (upper left); the character's frustration (meter on the upper right) has also increased as a result of this interaction. Causing excessive cow stress can result in a player failing a level; players must repeat levels until they pass to progress to the next level.

Enjoyableness of the Game. In addition to its educational potential, many participants commented on the game's entertainment value: "A mí me entretuvo. El juego es interesante. Que si hubiera tenido otro nivel, yo le sigo al siguiente nivel" (farm focus group #4, participant #4). English translation: "It entertained me. The game is interesting. If there had been another level, I would go on to the next level." Participants used terms such as "fun" or "entertaining" (or in Spanish, "entretenido") to describe their experience of playing the game prototype. One participant commented that "ayuda de desestresarnos también." English translation: "It helps to destress, too" (farm focus group #4, participant #3).

Some participants indicated they would be willing to play the game again in the future, or they inquired whether and when it would be available. These comments suggest that if people found the game enjoyable and were interested in playing it more than once, it could potentially be an engaging way to fulfill mandatory professional training requirements. Indeed, one participant commented, "I don't think it's a bad idea to have fun when they are doing these trainings" (decision-maker focus group #1, participant #4).

Summary of the Final Game

In Supplemental Document S6 (see Notes), we describe examples of participants' suggestions that we considered to be actionable feedback and explain how these were incorporated into the beta prototype and the final game. This feedback included ideas about the dairy farm environments depicted in the game, the movement and behavior of both the virtual cows and the human character, and the instructions and feedback presented in the game. The completed version 1.0 of *Mooving Cows* included language selection (English or Spanish), character selection (6 options; Figure 2), action menus (Figure 3), finalized graphics, audio (music, voiceover narration, and sound effects), tutorials (e.g., Figure 4), finalized cow behavior, 8 gameplay levels, in-level immediate feedback (e.g., Figure 3), end-of-level visual feedback summaries (Figure 5), and a certificate of completion.

Avatars

The purpose of providing avatar options was to improve players' self-visualization and identification with their in-game character (Libby et al., 2007; Baranowski et al., 2013). Originally, we had envisioned allowing players to customize the features of their avatars, such as the color and style of head and facial hair, skin tone, and clothing and footwear. However, due to budget constraints, we instead decided to create 6 preset character options. The artwork was intended to represent a range of farm personnel with adult cow-handling roles on Wisconsin dairy farms, based on our professional experience and observations, rather than to capture the full diversity of the Wisconsin or US population.

Figure 4. The milking parlor, 1 of 3 dairy farm environments in version 1.0 of the *Mooving Cows* game. In the 2 game levels (of 8 total levels) in which the parlor appears, the player's objective is to load the cows single-file into one side of the parlor so they can be milked. The artwork depicts a double-8 parallel parlor configuration (i.e., capacity to milk 16 cows, 8 on each side). This screenshot is of the beginning of the first milking parlor level, with visual augmentation around the first cow to remind players of concepts learned in earlier levels. Tutorial text, with accompanying voiceover narration, introduces the new environment (Spanish shown; the English text read: "Welcome to the milking parlor. Let's move the cows into the milking stalls.") The baseline levels for the meters showing cumulative cow stress (upper left) and character frustration (upper right) start at the minimum.

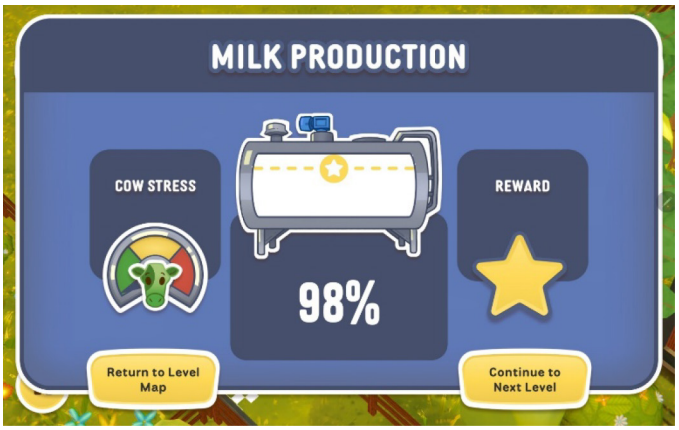

Figure 5. Example of the summary feedback (English version) shown at the end of each of the 8 levels in version 1.0 of the *Mooving Cows* game. Cumulative cow stress is shown on the meter at the left, followed by an animation of milk filling up in the bulk tank in the center. The percentage of milk production relative to a hypothetical maximum is indicated. When cow stress is greater, less milk is produced, illustrating one of the central learning objectives of the game. Causing excessive cow stress can result in a player failing a level, and players must repeat levels until they pass to progress to the next level. If the milk production exceeds the dashed line, the player earns a reward, depicted by a star on the right, but this is not required to move on to the next level. Level scores are not reported on the final certificate of completion, which can be used to document continuing education.

Level Progression

In version 1.0 of the game, players progress through 8 levels: 4 in the pasture paddock (Figure 3), 2 in the milking parlor (Figure 4), and 2 in the freestall pen (Figure 6). In each level, the objective is to move all of the cows to the target location. In the pasture paddock and the freestall pen, the target is for the cows to exit through the open gate. In the milking parlor, where only single-file cow movement is possible, the target is to load the cows into the milking stalls on one side of the parlor. Players must pass the levels sequentially. After successfully completing the game, players earn a certificate of completion, which is saved as a local JPEG image file on the mobile device and can be used as documentation of continuing education.

Tutorials and Feedback

Tutorials within the game provide players with some guidance, concurrently presented in text (Figure 4) and voiceover narration, on how to move the character, as well as on best practices for handling dairy cows. To better equip players to handle real-world situations, the game includes simulated challenges such as peer pressure and unpredictable or dangerous cow behavior. Within each level, 2 visual meters in the upper corners represent the levels of overall cow stress and character frustration (Figure 3). When the player's actions cause a change in cow stress, animations appear above the affected cow or cows (Figure 3), and the cow stress meter indicates the cumulative change, depending on how many cows were affected. Depending on the interaction between the character and the cows, additional pop-up screens provide immediate feedback, both in text and with voiceover narration.

At the end of each level, an animated summary (Figure 5) of overall cow stress levels is shown, followed by an illustrated bulk milk storage tank with an animation of milk filling up, compared with a hypothetical maximum level of milk production. When the cows are more stressed, less milk fills the tank, illustrating one of the overall learning objectives. If the level of milk production is at least 80% of the maximum, the player earns a star as an additional reward; however, a star is not required to pass the level. The internal calculation of whether a player passes a level and whether they earn a star depends on the level of overall cow stress that results from their actions, with internal point values assigned to specific actions. The direction of the effect of each action on cow stress was based on the established literature on human-animal interactions and dairy cattle welfare (e.g., Pajor et al., 2000, 2003). For example, actions such as yelling, tapping the cows' legs, or slapping the cow would increase cow stress, whereas speaking softly or gently patting the cow would reduce their stress.

Figure 6. The cows' home pen, 1 of 3 dairy farm environments in version 1.0 of the *Mooving Cows* game. In the 2 game levels (of 8 total levels) in which the pen appears, the player's objective is to move the cows out of the pen through the open gate at the lower right. The artwork depicts grooved concrete flooring, 16 deep-sand-bedded freestalls for the cows to rest in, headlocks at the feed bunk with feed and salt blocks, 2 mechanical rotating cow grooming brushes, and 2 water troughs (not visible here). The action menu (labeled in Spanish here) on the right shows options to speak softly, wave arms, yell, or extend the character's reach (an option in this environment, which was not available in the milking parlor). In this screenshot, the meters for cumulative cow stress (upper left) and character frustration (upper right) show minimal levels.

Limitations and Future Directions

One limitation of our participant recruitment approach is that we focused on specific Wisconsin dairy farms and industry professionals with whom some members of the research team had existing connections. First, this resulted in some constraints when forming focus groups, such that one decision-maker session and 2 farm staff sessions (all conducted in English) comprised pairs rather than groups. Compared with individual interviews, focus groups can promote a range and depth of responses, as participants can stimulate unanticipated contributions from one another and elaborate on group responses (Morgan and Krueger, 1993). Therefore, it is possible that the pairs had reduced exchange of ideas than what could have been achieved with larger groups. Second, social desirability biases could potentially have limited the breadth of responses and skewed them toward more positive feedback on the game. We took some steps to attempt to directly reduce the bias (Larson, 2019) by using interviewers who were previously unknown to the participants, emphasizing the usefulness of any negative feedback they provided, and reassuring participants their responses would be anonymized. Participants provided many comments on the game's limitations and ideas for its improvement. Nonetheless, it is possible that some participants avoided sharing the full extent of their negative perceptions.

A caveat when interpreting our findings is that we focused on a sample of Spanish- and English-speaking professionals in the Wisconsin dairy industry. We chose these participants to reflect a segment of our target audience for UW–Madison Extension resources, such as *Mooving Cows*. Future work could explore the views of those in other geographical regions of the United States or who speak other languages used on US dairy farms, such as K'iche'. In addition, although some of the decision-makers in our sample, such as the trainers, consultants, and veterinarian worked across facility types, the farm owners and staff were limited to freestall dairy farms that milk cows in double parlors. Other milking systems, such as rotary parlors or automatic milking systems (AMS/robots), or housing types such as bedded packs, drylots, tiestalls/stanchions, or pasture-based, were not represented among the farm staff and owners because most of these environments are not depicted in version 1.0 of the game. The farm staff in our sample reported that they generally enjoyed working with cows, believed they were fairly good at moving them, and felt fairly safe. In the future, the relevance of the game could potentially be broadened by including perspectives from a wider range of participants, including those who feel less skilled or safe when working with cows.

Mooving Cows represents a proof of concept for a digital serious game on animal handling. The scope of the first version of the game was limited to routine movement of cows in the context of milking. Participants in our study found the game prototype promising for new hires but expressed mixed opinions on its potential usefulness for those with more extensive cow-handling experience. In Supplemental Document S7 (see Notes), we report participants' ideas that did not fit within our scope constraints for the initial version of *Mooving Cows*. Those ideas could potentially be incorporated into future expansions of the game or in developing other dairy farming simulations or games. To address the industry's annual continuing education needs, creating an advanced version of the game with a variety of more complex scenarios may be beneficial. This would increase the level of challenge for experienced handlers and could reduce repetition and potential boredom.

Finally, to more fully evaluate the game's feasibility and usefulness for on-farm continuing education, further research is needed to quantify how long it takes end users to complete the full game, as well as to assess whether it results in improved knowledge. Indeed, our team subsequently conducted an evaluation of knowledge change after a new set of farm staff participants played version 1.0 of *Mooving Cows*; these results will be reported separately. We incorporated further feedback to improve the game and released version 1.1 as a free mobile app in 2024; download information can

be found at https://www.MoovingCows.org. Future research could investigate how playing the game could improve not only knowledge of best practices, but also users' skills when handling real cows.

CONCLUSIONS

Mooving Cows is the first application of digital serious games to animal handling. We engaged with Wisconsin dairy farming stakeholders in a range of professional roles to ensure the game's relevance to our target audience of dairy farm personnel. With their input, we iteratively improved the content of the game, as well as collected ideas for future versions of *Mooving Cows* and other applications for job-relevant digital farm simulations. There was consensus among participants that the game would be a useful on-farm training tool, particularly during onboarding for new hires with little cattle experience. However, they disagreed on its potential usefulness for those with more extensive cow-handling experience. Nonetheless, in the US dairy industry, annual continuing education on animal handling is required. Participants found the game enjoyable and entertaining, suggesting it could be a novel and relevant way to fulfill the industrywide annual expectation for continuing education.

NOTES

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Nonstandard abbreviations used: RARC = Research Animals Resources and Compliance; UW = University of Wisconsin; UWSC = UW Survey Center.

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