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Virtual Reality Videos for Delivery of Extension Educational Materials on Manure and Mortality Management: A Pilot-Study

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Abstract: This study presents pilot evidence of virtual reality (VR) videos as an effective technique for delivering extension educational materials on manure and mortality management. Virtual reality is a distance learning technology for immersive and engaging learning scenarios. VR tours can offer immersive learning experiences in manure and mortality management technologies, eliminating the need for in-person farm visits, saving traveling time and money, and reducing exposure to farm-related hazards such as pathogens and unpleasant odors. During the initial phase of this project, 360° VR tours were created covering various aspects of manure management, including composting, anaerobic digestion, and preliminary wastewater treatment. These videos were disseminated to agricultural producers, extension specialists, and researchers through in-person and online extension events and the Texas Manure YouTube channel. The effectiveness of VR videos in delivering technical content was assessed using online surveys, measuring the audiences' awareness of manure and mortality management topics and VR video perceptions before and after viewing the VR videos. According to the statistical analysis, the increase in awareness after watching the videos was statistically significant, with a p-value of less than 0.0001. Statistical analysis also revealed that job classification and professional experience significantly impacted the change in awareness. Researchers, extension specialists/agents, and participants with less experience in manure and mortality management experienced a more substantial increase in awareness than agricultural producers and participants with more experience. Survey results indicated that most participants perceived the VR videos as an effective educational technique for conveying manure and mortality management information. They also found the VR videos interesting and expressed their willingness to learn more content through the VR platform. Additionally, participants were highly inclined to recommend the VR videos to their peers. Lastly, a statistically significant correlation was calculated between the increase in awareness and the effectiveness rating provided by the participant to the VR videos.

Keywords: extension; manure; mortality; management; virtual reality

1. Introduction

Virtual reality (VR) has been used in education for over 100 years [1]. However, this education technology continues to evolve, serving educators in various educational settings and knowledge domains [1–3]. VR technologies use computer-based equipment and software to simulate an object or environment three-dimensionally [1]. VR has demonstrated the potential to provide learners with experiences that would not be attained without this technology [4–6]. Even though VR's potential to improve user experience in gaming and entertainment is well-known, its potential for other sectors has been most recently documented and reported [7,8]. For example, VR has transformed

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communication, training, and education by providing immersive learning experiences that simulate a natural environment and daily life working scenarios for medical and first respondent personnel [9–12]. Virtual reality has been used more frequently in formal settings, that is, in traditional education programs, where students typically gather in a standard room to participate in lessons [13]. On the other hand, non-formal education approaches the content and instructional methodologies with a flexible perspective, considering learners' motivations and interests as a central element of the curricula and instruction [14], and several researchers and practitioners have highlighted VR's potential to reduce educational gaps, reach broader audiences, and address training needs in disadvantaged groups [3,15].

Extension Education is considered the most extensive non-formal education system, covering various content areas from agricultural production to family and consumer sciences. According to National Institute of Food and Agriculture (NIFA) [16], Extension programs offer informal education and learning experiences to a wide range of people across the country, including farmers, rural community residents and urban dwellers, with the primary focus of transferring research-based knowledge and educational insights directly to the public to create positive changes. Extension Education has slowly incorporated virtual reality in its technical assistance offerings. Therefore, innovation in information and communication technologies remains relevant for extension services [17].

With more than 100 years of history in the United States, extension services have provided technical assistance and non-formal education to farmers and communities in urban and rural settings. Texas has the largest Extension service in the country, serving all 254 counties across the state. According to official reports, the Texas Extension service (AgriLife) assists approximately 20.8 million direct teaching contacts [18]. Although face-to-face methods and site visits are recognized as the most effective means to exchange knowledge with farmers and other consumer groups [19,20], cost, logistics, and other funding and organizational structure issues continue to call for different methodologies to facilitate education and training [19,20].

Virtual reality has shown learning and teaching benefits in students participating in programs with agricultural themes, and it adds other elements and ideas to classroom settings and controlled environments [5]. Unfortunately, there are limited studies on using this technology or records of training programs in or using VR in programs offered by non-formal education programs designed and promoted by extension services [21–23]. The expected potential VR can have in Extension education is rooted in demonstrated improvements in service provision in mental health, customer service, communication, and medical training [24–26]. However, such evidence is still limited to relevant agricultural-related issues and must be gathered before using virtual reality technology on a larger scale to improve Extension service provision [23].

Manure and mortality management is one of the most concerning issues for livestock producers, opening a growing opportunity for Extension services to support agricultural communities. However, time, cost of travel, and cross-contamination are prohibiting barriers when it comes to site visits for extension services. VR video could bypass these physical barriers by developing and applying appropriate, interactive information mechanisms whenever/wherever our farmers, ranchers, and other agriculture stakeholders need, as this immersive technology allows participants to observe and revisit the site remotely [5,6].

Manure and Mortality Management in Texas

Texas is a significant and leading contributor to the United States' animal agriculture, accounting for ~14% of cattle and calves, ~13% of cows, ~1.4% of hogs, ~5.6 % of chickens, and ~14% of sheep and lambs [27]. In Texas, the volume of manure from dairy cows alone (646,000 heads in 2022) almost equals human bodily waste from the whole state's population of 29 million [28,29]. Manure management plays a significant role in the sustainable water-food-energy nexus, as land-applied manure returns nutrients and organic matter to cropland, improving its productivity. Unfortunately, Current Texas manure systems have had limited growth in technology and efficiencies that improve environmental sustainability.

High levels of nutrients released by land-applied manure are among the leading causes of algal blooms, eutrophication, nitrate accumulation, soil salinity, and the formation of antibiotic-resistant bacteria [30,31]. Manure treatment, storage, and land application also contribute to ~9% of total greenhouse gas (GHG) emissions (mainly CH4 and N2O) from the Texas agriculture sector [32]. There is a great need to improve manure management to protect water, air, and soil quality and reduce greenhouse gas emissions [33].

Manure collection and treatment/separation systems are crucial on large livestock farms such as dairy and hog operations. Seventy-three percent of large dairy operations (> 500 cows) house cows in freestall barns [34]. Forty percent of the more extensive operations employed a wet manure management system (i.e., flushing systems) to clean the barn alleyways [35]. The flushing water is typically a recirculated low-solid stream from manure processing (such as liquid/solid separation using gravity or mechanical separation) with fresh water if needed. The manure separation process generates a nutrient-rich solid stream and a nutrient-reduced liquid stream. After liquid/solid separation, manure with high solids and significantly higher N and P contents may be hauled at a lower cost and stored by stockpiling [36,37]. It has been found that the separated liquid stream has lower pathogen levels and that disinfecting the manure solids is less chemically, energetically, and operationally intensive [38,39].

Composting manure solids can produce biofertilizers via microbial actions. It stabilizes volatile compounds in the manure and dramatically reduces odors and pathogens in manure [40,41]. Anaerobic digestion of manure liquid is suggested to resolve manure disposal, energy recovery, and greenhouse gas control [42,43]; these manure management practices can be readily integrated into livestock systems, but the awareness and knowledge for adopting these practices must be improved. It is clear that producers need demonstrations to intuitively show the technology options and their impact on various types of farm systems.

Proper farm manure and mortality management can contribute to agricultural communities' economic, social, and environmental sustainability [44–46]. In addition to addressing environmental issues related to manure and mortality disposal, such as eutrophication and groundwater pollution, manure and mortality management can increase farms' economic benefit by producing valuable products, including biogas and compost [44–46]. Economic stability and reduction in environmental pollution provided by manure and mortality management could also enhance the quality of life of agricultural communities. However, these practices are relatively new, and farmers lack adequate training and assistance [44,47,48].

This research project aimed to evaluate the effectiveness of VR videos for disseminating knowledge on manure and mortality management, based on the central hypothesis that 'Watching the VR videos causes a significant increase in the viewers' awareness of a given topic.' Through rigorous analysis of survey data collected from a diverse audience of farmers, extension specialists, and researchers, we propose VR videos as an effective and engaging educative format. The information gathered through this research will serve extension services working on manure and mortality management to communicate evidence-based information using VR technology.

2. Materials and Methods

A pilot study is “the first step of the entire research protocol and is often a smaller-sized study assisting in planning and modifying the main study [49]. This pilot study was conceptualized and implemented to gather baseline information to inform larger extension efforts. This study’s methodology consisted of five components: (1)video development, (2) video dissemination, (3) survey design and dissemination, (4) data collection, and (5) data analysis and reporting. A block diagram of the overall methodology is given in Figure 1.

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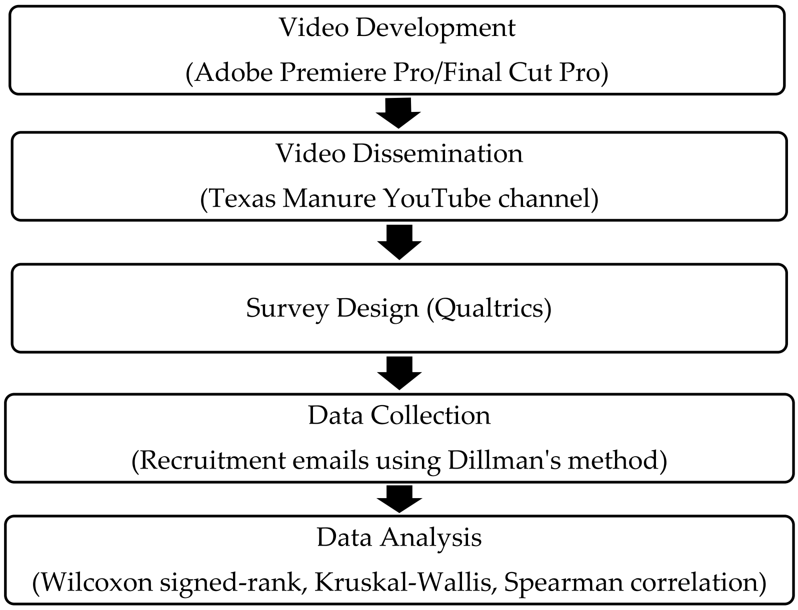

Figure 1. Flow diagram for research methodology employed in this study.

2.1. Development of 360⁰ VR video series

The Videos were recorded using the RICOH Theta 360° camera, capable of capturing the whole 360° range. Video recordings were done at multiple dairy farms and composting facilities in Texas, New York, Idaho, and Utah. *Adobe Premiere Pro CC* and *Final Cut Pro X* software were used to edit and produce the final videos. The videos' length was, on average, 1.5-2 minutes, following [50] recommendations on video length for more effective viewer engagement—however, some videos, including discussions with manure and mortality management professionals, resulted in longer recordings. Overall, five VR video series were created during this project, focusing on (1) VR farm tours, (2) composting, anaerobic digestion, (3) animal waste separation, and (4) disposal and (5) mixed farming, respectively. Videos were elaborated and reviewed by researchers and professionals with extensive experience in manure and waste management. Videos and their lengths per playlist are presented in Table 1.

Table 1. VR video series.

Playlist (videos)	***Location***	***Length (min)***
Farm Tours		
Idaho VR Farm Tour	Idaho	1:23
Southwest Regional Dairy Center	Texas	5:17
Composting		
Composting Horse Mortality	New York	1:32
Compost Pile Turning	New York	2:20
Leachate Pond Management at Cornell Compost Facility	New York	1:27
Poultry Mortality Composting	New York	1:53
How to Maintain a Compost Pile	Utah	4:56
Compost Pile Turning Idaho	Idaho	1:51
Compost Pile Making	New York	3:32
Anaerobic Digestion		
Supporting Units of a Digestor	Idaho	1:25
Overview of an Anaerobic Digestor	Idaho	1:41
Cornell Waste Management Facility Part 2 360SD - Overview of a Carcass Digester	New York	4:28

Animal Waste Separation and Disposal		
Cornell Waste Management Facility Part 1 360SD - Introduction to Rotoclave	New York	2:37
How to Dry Manure?	Idaho	0:33
Manure Management Operations in a Dairy Farm	Idaho	2:28
Supporting Units of a Centrifuge	Idaho	1:09
Mixed Farming		
Maintenance of a High Tunnel Greenhouse	Utah	4:45
How to Have Animals and Crops in the Same Farm	Utah	4:23

2.2. Video Dissemination

VR videos were disseminated and permanently made available through the Texas Manure YouTube channel. Several efforts, including emails, flyers, and face-to-face conversations, were used to increase stakeholders' awareness of these videos' availability. Additionally, video YouTube links were constantly shared on the Texas Manure Twitter account. For targeted participants (extension specialists/agents, academics/researchers), an email including the YouTube links was directly delivered to their institutional email accounts.

2.3. Survey Design

The Internal Review Board at Texas A&M University (IRB2022-0414) reviewed and approved this attitudinal and knowledge research. To evaluate users' VR experience, Qualtrics was used to disseminate a team-designed online survey containing questions about (1) awareness of participants before and after viewing the videos, (2) level of interest in virtual reality videos compared to conventional ones, (3) interest in potential learning opportunities using virtual reality technology, (4) efficiency of VR videos to inform perceived by users, and (5) probability of recommending VR videos to a colleague. Several researchers with expertise in agricultural production, waste management, and agricultural education and extension reviewed the survey. Following the literature for attitudes and knowledge studies[51–54], Likert-scale questions (5-point) were used in the online survey. Additionally, surveys included questions regarding participants’ job classification and professional experience to evaluate the study sample composition. No identifiable information was collected in the interviews. The Supplementary Materials section has a full version of the survey questionnaire.

2.4. Data Collection

Agricultural producers from several Texas dairy, poultry, swine, equine, and organic farms were randomly selected to participate in this study. Researchers confirmed that producers have accessed the VR videos. Extension specialists and professional researchers at Texas A&M University and Texas A&M AgriLife were purposefully selected based on their experience in agriculture and animal waste management. They were invited to watch the videos and participate in the study. A total of 277 agricultural producers, 145 extension specialists, and 73 researchers received an email invitation, including the link to complete the survey questionnaire. Participants received an electronic informed consent form detailing the study and the voluntary nature of their participation. Email reminders were sent following Dillman’s Tailored Desing Method [55], which has demonstrated effectiveness in increasing research participation [56,57]. The first reminder was sent one week after the initial contact, followed by two more reminders with one-week spacing between each, and a fourth and final reminder two weeks after the third reminder. The survey questionnaire remained open for one week after the last reminder.

Additionally, VR videos’ YouTube links and the survey questionnaire’s link were constantly shared on the Texas Manure Twitter account to enable any other interested and qualified participants to be part of the study. This study did not include incomplete surveys or those completed by individuals outside the target populations. Eighty-eight surveys were usable data for analysis and interpretation. Pilot studies research suggests a simple size of minimum of 30 participants. However,

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others have recommended lower sample sizes, stating that 12 participants are enough for a pilot study [49].

2.5. Data analysis

Data were analyzed using *JMP PRO16* and *Microsoft Excel 2016*. Since continuous approximation is not generally acceptable for individual Likert-type questions [57,58], data was treated as ordinal, and only non-parametric testing was conducted. *Wilcoxon signed-rank test* compared participants' awareness levels before and after watching the VR videos. *Pratt's modification for handling zero-difference* was used in the *Wilcoxon test* in response to the 16% response, showing no change in participants' awareness levels. The *Kruskal-Wallis test* determined how awareness levels varied across several demographic characteristics. Finally, Spearman correlations were used to determine the correlation between the change in awareness and their interest and impression of the videos.

3. Results

3.1. Participants Description

Most participants were researchers and/or academics (40%) with no professional experience in manure and mortality management (75%). Even though all videos were available permanently, participants could select one or more to watch. A total of 166 series were watched by all the participants, with an average of 1.89 per individual. The *VR Educational Video Series on Composting* reported more viewers (n = 43). Table 2 presents the participants' characteristics and engagement frequencies (number of participants who watched each video series).

Table 2. Participants Characteristics.

Demographic	*f*	*f%*
Job category		
Producer/Farm manger	11	12.5
Extension Specialist/Agent	25	28.5
Researcher/Academic	36	41
Industry/Consultant	16	18
Manure and mortality management experience		
No experience	66	75
< 2 years	6	6.8
2- 10 years	10	11.4
>10 years	6	6.8
Number of viewers/ video series		
VR Farm Tours Series	43	48.8
VR Educational Video Series on Composting	45	51
VR Educational Video Series on Anaerobic Digestion	33	37.5
VR Educational Video Series on Animal Waste Separation and Disposal	25	28.4
VR Educational Video Series on Mixed Farming	20	23

3.2. Participants' Learning Experiences

Even though some analyses were performed to understand participants' learning experience, an aggregated 82% of the participants reported an increase in awareness. A significant difference in awareness was reported before (*median* = 3) (Figure 2 (a)) and after (*median* = 4) (Figure 2 (b)) engaging with the VR videos. The *Wilcoxon signed-rank test* with *Pratt's modification* was conducted to determine if the increase in awareness after watching the videos was significant. Based on the calculations, μW was 6930.5, and σW was 620.2, resulting in a z-value of -11.17 and a corresponding p-value less than 0.0001. Simultaneously, our results also indicated a significant shift in participants' awareness

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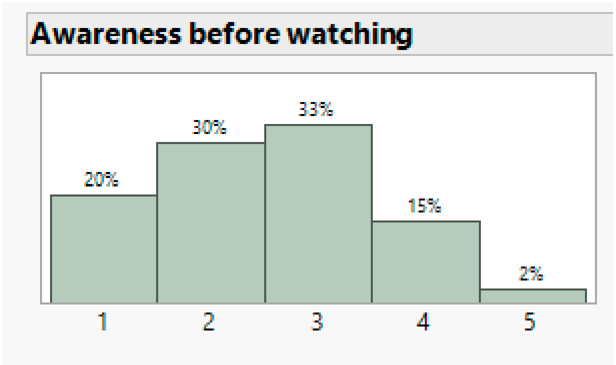
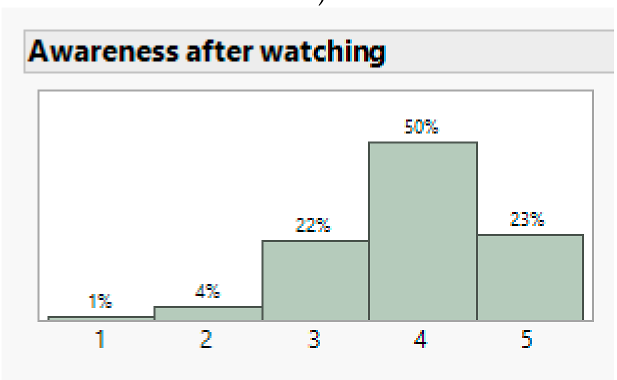
distribution. A 45% decrease in participants with low awareness was reported after watching the videos (Figure 2).

The *Kruskal-Wallis test* revealed that job classification and manure and mortality management experience had a statistically significant impact on the change of awareness ($p < .005$). Job classification demonstrated a higher influence on awareness change, with an *H* statistic of 34.2 ($p < .001$). Based on average ranks and medians, we observed that extension specialists/agents and researchers experienced a greater awareness change than producers/managers and others. Professional experience demonstrated being highly significant in the level of awareness, with an *H* statistic of 17.27 and a *p*-value of 0.0006. Video topics did not significantly impact the change in awareness ($p = 0.8425$).



a)



b)

Figure 2. Participants shift on awareness level a) before and b) after watching the VR videos about manure and mortality management. 1 means no awareness at all, and 5 means very high awareness.

3.3. VR Videos' Effectiveness and Potential

Most participants perceived VR videos to be effective (43%) or very effective (29%) in informing the public about manure and mortality management (Figure 3). A similar trend was followed by participants' perceived levels of interest in the VR video series over conventional videos, with 36% and 31% reporting being interested and very interested, respectively (Figure 4). Participants' interest in learning more content through VR videos recorded the higher percentage of participants (36%) as interested, followed by 28% feeling very interested in learning more (Figure 5). Finally, most participants (43%) reported that they would likely recommend the VR video series on manure and mortality management to their peers (Figure 6).

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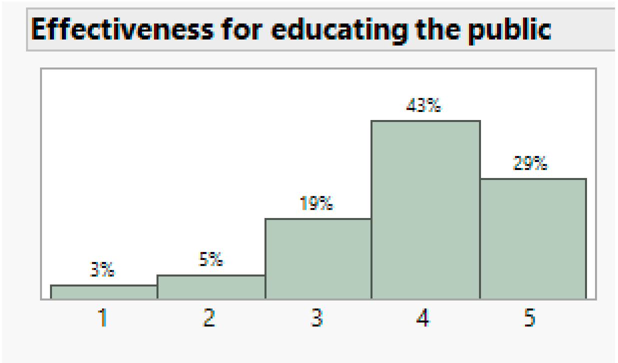

Figure 3. Participants' perceptions about VR videos' effectiveness in educating the public about manure and mortality management. One (1)means not effective at all, and five (5) means very effective.

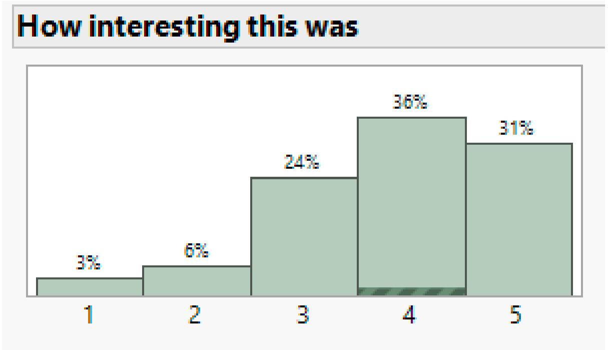

Figure 4. Participants' interest level in VR videos about manure and mortality management. One (1) means not interesting at all, and five (5) means very interesting.

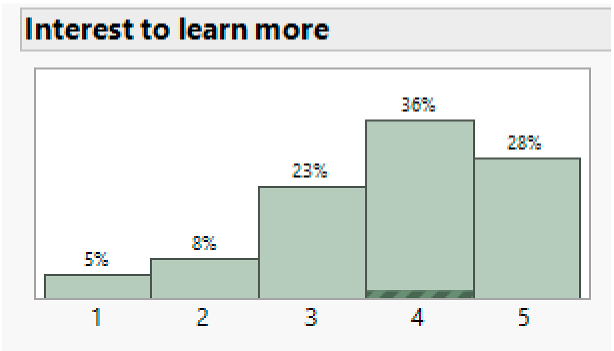

Figure 5. Participants' interest level in learning more content using VR videos. One (1) means not interested at all, and 5 (5) means very interested.

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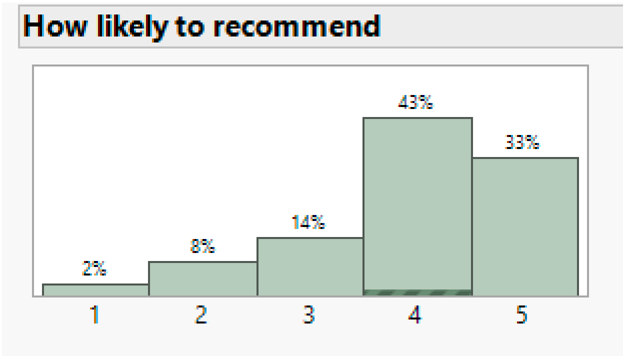

Figure 6. Participants' likelihood of recommending manure and mortality management VR videos to their peers. One (1) means not likely at all, and five (5) means highly likely to recommend.

To understand more about the VR influences' effectiveness and potential, the *Kruskal-Wallis test* was implemented to understand how participants' job classification and manure and mortality management experience influence their perceptions of the four parameters presented in Figures 1-5. Results demonstrated that participants' perceptions' of VR video series to educate the public about manure and mortality management are influenced by their job classification and experience in manure and mortality management. Participants' interest in VR video series over conventional videos, interest in more VR video series, and likelihood to recommend VR video series to their peers are not influenced by their job classification and experience with manure and mortality management (Table 2).

Spearman correlation tests were performed to evaluate the association between the participants' change in awareness, interest level, and overall impression of the VR video series in manure and mortality management. All *Spearman correlation tests* were evaluated with an a priori-stated 95% confidence level. Participants increased awareness (change) had a moderate correlation factor of 0.37 with the effectiveness rating and a corresponding p-value less than 0.0001. Participants' interest in learning more content, interest level in VR video, and likelihood to recommend VR video series had correlation factors lower than 0.25 with the increase (change) in awareness, meaning a weak or negligible correlation.

In comparison, the four interest and impression parameters had stronger correlation factors with one another. The effectiveness in informing the public rating given by the participants had a strong correlation with how interesting they found the videos ($rs = 0.65$) and the likelihood of recommending the videos to others ($rs = 0.54$) and had a moderate correlation with the interest to learn more content trough VR video series. Interestingly, they found the videos strongly correlated to the interest to learn more content through this platform and how likely they were to recommend them to others. Spearman correlation factors and corresponding p-values for each pair of variables are given in Table 3.

Table 3. Spearman correlation coefficients among dependent variables.

	Effectiveness level	Interest level	Desire to learn more	Likelihood to recommend
Change in Awareness	0.37 ($p < 0.0001$)	0.18 ($p = 0.0222$)	0.07 ($p = 0.3617$)	0.24 ($p = 0.0017$)
Effectiveness level		0.65 ($p < 0.0001$)	0.44 ($p < 0.0001$)	0.54 ($p < 0.0001$)
Interest level			0.63 ($p < 0.0001$)	0.69 ($p < 0.0001$)
Desire to learn more				0.76 ($p < 0.0001$)

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4. Discussion

As the problems of agricultural production are modified and complex due to the interaction of multiple socio-environmental factors [58–60], agricultural extension services are fundamental in developing human capacities in rural communities, ensuring production to meet the growing demand for food, energy, and fiber [61–63]. To serve more efficiently and inclusively, agricultural extensionists continue experimenting and researching new instruction forms that reach a broader audience [64]. Virtual reality is an educational innovation that has been used frequently and successfully in agricultural science education in formal training settings, where it has been shown to positively impact the development of critical and creative thinking in learners [5,65]. However, the use of VR in non-formal education programs such as those offered by extension services in the United States has been investigated and reported in the literature much less frequently.

Although preliminary, this pilot study's results offer exciting perspectives to inform future extension initiatives using VR technologies. Even though the VR video series included in this study was solely on manure and mortality management, this educational innovation has shown its flexibility to demonstrate real-world experiences through electronic devices in other areas of agriculture and other disciplines [66–68]. The changes in the participants' awareness levels before and after watching the videos prove this technology's capacity and potential to deliver agricultural technical information. Participants with prior experience with the video content demonstrated less change in their level of consciousness. This result is not surprising because it is presumed that, due to their prior knowledge, VR videos have less potential to contribute new information [69].

The effectiveness of the VR videos perceived by the participants was mostly high. The latter is significant, considering that several studies have shown that perceived efficiency will determine the adoption of an agricultural innovation [70–72]. Similarly, our results highlighted the perception of high interest in the content and the desire of the participants to continue learning through VR videos. Finally, the vast majority affirms that the probability that they recommend these materials to their peers is high, which could potentially benefit the adoption of VR technologies among farmers due to the widely demonstrated trust that agricultural producers have in their peers [73,74].

Although this study contributes to bridging a gap in the literature on the use of VR as a non-formal instruction tool, it opened other research questions based on our findings and the limitations of this study. For example, the low response rate of agricultural producers only reflects the difficulty in attracting agricultural producers to agricultural extension programs. Therefore, research must continue building trust and commitment relationships with the farming communities we serve. Similarly, the levels of participation of each group in this study suggest that virtual reality is less attractive for agricultural producers than for researchers and extension specialists, which could be explained by a self-perception of not having the skills to carry out program activities. To bring farmers closer to these educational innovations, it must be ensured that the farmer is prepared to embark on a positive training process that allows him to increase his knowledge [75,76]. A hybrid approach incorporating the VR videos with hands-on training could familiarize the farmers with these distant learning approaches. The extension agents or implementers using this innovation are responsible for ensuring equal access and use among the participants, anticipating and avoiding negative experiences that frustrate and cause farmers to drop out.

More research on VR technologies' power in forming non-formal agriculture is still required. First, expand to other domains of knowledge, such as climate adaptation, food safety, and occupational health, to name a few that could easily be replicated using this study and others in formal education settings on those same topics. Also, it is necessary to investigate these technologies' potential in other geographic contexts. Although the United States is the leading country in using VR technologies in agricultural science education, other countries have similar or even more pressing agricultural training needs but do not have the infrastructure, financial, and human resources to implement these innovations [77–79].

5. Conclusions

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This study provides farmers with research-based information and practical insights into real-world manure management and mortality through 360° virtual reality videos. The results bridge the gap in the literature by quantitatively assessing the opinion of Extension producers and educators on the use of virtual reality in Extension. The findings offer important implications for Extension educators in positioning VR as a promising potential tool for engaging growers and disseminating results.

VR video series on multiple topics related to manure management and mortality were created and disseminated to a diverse audience of farmers, extensionists, and researchers. The results showed an increase in the median in the mode of attention after watching the videos, and the Wilcoxon signed rank test revealed that the change in comprehension was statistically significant. This suggests that VR videos can effectively deliver manure and mortality management educational materials.

Further statistical analysis using the Kruskal-Wallis test showed that job classification and professional experience significantly impacted consciousness shifts. As expected, researchers, specialists/extension agents, and participants with less experience in manure management and mortality had more significant cognitive change than farmers and more experienced participants.

The results of the study showed that the majority of the audience considered these VR videos as an effective approach to educating the public about manure management and mortality; they found the virtual reality videos interesting, and they expressed willingness to learn more content through videos of virtual reality and would probably recommend the videos to their peers. This suggests that the videos have successfully captured the audience's attention and made a positive impression.

Spearman's correlation-based analysis revealed a statistically significant correlation between the change in awareness and the effectiveness rating the audience gave to the videos. This suggests that the participants who experienced a shift in their consciousness were likely to rate the videos as effective.

Although this pilot study offers relevant information and knowledge for agricultural extension programming, some limitations include (1) the small sample size of this study, caused by the low participation rate of the target populations. This phenomenon in survey studies extends to all social and behavioral sciences due, but not exclusively, to the bad experiences of participants in other studies, the non-perception of benefits from the study, and poor practices in developing research instruments[80,81]. Collecting survey data during in-person events/activities is recommended to achieve a higher response rate. Additionally, ensuring that the content and format of the instrument respond to the characteristics of the study's target population could increase participation and quality of the information. (2) Although all participants received the same information (videos) and the possibility of access, the level of consumption was differentiated between the individuals and groups included in the study. The number of videos viewed by each participant was not a variable considered in the data analysis of this study. Therefore, it is recommended to incorporate this variable in future research and interpret our results with caution.Overall, the study results suggest that virtual reality videos can effectively educate the public about manure management technologies and mortality. This will allow growers, extensionists, researchers, and other interested groups to gain immersive experience in manure and mortality management technologies without experiencing the challenges associated with in-person farm visits, including time and money, travel, and exposure to health hazards. Simultaneously, this study leads to new lines of research, including implementing VR technologies in other domains of agricultural knowledge and different geographic regions.

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org.

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