Can Videos Be a Useful Tool to Enrich Classroom Learning in an Applied Science Such as Vegetable Production?

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California has an aging vegetable-crop producing workforce and well-trained workers are urgently needed. The State's public universities with agricultural programs thus have a critical role in preparing the future workforce to sustain the State's economy. The aim of this project was to develop educational materials to train the next generation of workers with the technical, agronomic, economic and ecological skills required to keep California's vegetable crop sector innovative and competitive. Thirty high-quality instructional videos on vegetable crop production, marketing, and postharvest processing and handling systems were created. Students were surveyed on the utility of selected videos, by assessing various parameters of knowledge before and after watching the videos. The videos made positive and significant changes in the knowledge of the topics among students. Therefore, incorporation of videos into agricultural curricula should contribute to effective communication and understanding of concepts by post-secondary students.

Keywords: agricultural workforce, applied sciences, online education, YouTube videos

INTRODUCTION

Vegetable production and processing is an important component of California agriculture. In 2017, there were 4,868 vegetable farms in California farming a total of 1,170,573 acres (USDA, 2017). These farms represent about 57% of national vegetable production worth $7.9 billion which is approximately 15.1% of the gross cash income generated from agriculture in California. Some vegetable crops such as artichokes, garlic, and honeydew melons are almost exclusively grown in California, whereas more than 90% of the broccoli, celery, and processing tomatoes, and over 70% of all lettuce is grown in California (CDFA, 2018; USDA, 2019). Therefore, vegetables are not only economically important in California, but the State also meets the demand of other US states.

In 2017, the average age of all agricultural producers in California and the US was 59.2 and 57.5 years, respectively (USDA, 2017). Therefore, it is obvious that Federal and state governments as well as the agricultural industry urgently need to encourage and recruit young people into the industry to sustain current and future vegetable production. It is vitally important that those entering the workforce receive adequate training and that this training aligns with the current production practices and needs of the vegetable industry.

The shortage of a trained workforce in agriculture is a both a national and global issue. As early as 2010, Goecker et al. (2010) predicted more than 54,000 agriculturally-related job openings in the US between 2010 and 2015. Rivera and Alex (2008) emphasized the need to develop human resources to modernize the agricultural workforce. Similar concerns were echoed from other developed and developing parts of the world (Njagi, 2011; Royal Society of UK, 2009).

Gewin (2010) stated that, "Concerns about food shortages, land use, climate change and biodiversity have created a huge need for interdisciplinary researchers focused on agriculture." The National Academy of Sciences (2009) posited: "During the next ten years, colleges of agriculture will be challenged to transform their role in higher education and their relationship to the evolving global food and agricultural enterprise. If successful, agriculture colleges will emerge as an important venue for scholars and stakeholders to address some of the most complex and urgent problems facing society." This statement implies a need for updated curricula which will result in highly-trained and effective agricultural workers and researchers.

Agricultural production systems need to be dynamic in order to keep pace with often unpredictable economic, social, environmental, and regulatory changes (Thompson and Scoones, 2009). Thus, production systems must continuously adapt by rapidly developing innovations (Martin et al., 2013). Among the numerous factors driving changes in vegetable production in California is the lack of availability of and increase in labor costs. Labor represents 20% to 40% of the costs to produce fruit and vegetables in California (Martin et al., 2016) and shortages in labor and trained personnel can put a further strain on production economics. A survey in 2019 indicated that 56% of California farmers reported that from 2014 to 2019, they had not been able to hire needed labor for production of their main crop and had been forced to use mechanized technology for production and harvests (CFBF, 2019). Concurrently, California's specialty crop growers improved and adopted efficient irrigation and fertilizer systems as a part of best management production systems (Shaffer and Thompson Jr., 2013). Most changes in crop production were driven by growers' efforts to reduce production costs (CFBF, 2019).

In order to sustainably produce specialty crops, California growers may have to further adjust their production practices based on the recommendations and strategies developed by governmental and non-governmental agencies. It is therefore important that students enrolled in agricultural institutions in California – and producers interested in learning about adaptive processes through non-formal education – be made aware of and trained appropriately to work in dynamically-changing agricultural environments.

The role and importance of agricultural colleges and institutions in the modernization of agriculture was highlighted more than two decades ago (Kirkendall, 1986). Though agricultural programs deliver both the theory and practice of agriculture, they often do not take an interdisciplinary approach to problems to meet the needs of sustainable agricultural education (Parr et al., 2007). Student experiences in both the classroom and the field was the single-most agreed upon suggestion for improving sustainable agriculture education (Parr et al. 2007). Other important suggestions to improve student education included on-farm internships, opportunities to apply theories to practice, visits to sustainable farming operations, and in-person conversations with farmers. Although these are excellent suggestions, budgetary constraints, liability issues, and internships overlapping semesters make the implementation of these practices very challenging. Furthermore, the restrictions placed by universities, industries, and farms on student and faculty travel for field trips because of Covid-19 pandemic concerns has further diminished the opportunities for students to watch farm and industry operations in action.

Another issue that has surfaced in recent years in the agricultural sciences is the shift in enrollment from students with farming backgrounds to those from urban areas. Only 28% of the students who enrolled in secondary agriculture courses at California Polytechnic State University, San Luis Obispo were raised in a rural setting, of which only 24% were from a farm or ranch background (Swan and De Lay, 2014). Similar trends were reported for land grant universities (Parrish et al., 2015).

One method of addressing the challenges outlined above would be to incorporate video technology into classrooms and non-formal educational settings. Bobek and Tversky (2016) stated that many concepts in science are difficult for students to comprehend and learn. They conducted a study comparing visual and verbal explanations of two scientific concepts to seventh and eighth grade students and found that the visual method was superior to the verbal for student learning. However, the visuals used in this study were figures. Pictures and figures are used as a part of PowerPoint lectures regularly in recent years. However, in an applied field like agriculture, dynamic videos of processes in action may be of more educational value than static figures. Barry et al. (2016) also reported on the popularity and effectiveness of educational videos posted on YouTube for undergraduate medical and radiation therapy students. Although the videos were on highly specific surgical techniques, it can be argued that similar conditions apply especially with highly mechanized and often modern robotic technologies in agriculture today in California. Evidence of the increase in use of educational videos, and future demand, is provided by Kaufman (2009).

We hypothesized that visual educational tools could enhance the learning process of students in the agricultural sciences, specifically, vegetable production. The importance of videos in education has been strengthened by the COVID-19 pandemic which is forcing all higher education institutions in California to adopt virtual methods to train students. We believe this study will provide insights on students' perspectives on videos and their potential utility in virtual education as applied to agriculture. The objectives of this project were to: a) develop innovative video instructional materials for students at four California universities and sister community colleges to increase student knowledge and skills and to inspire them to pursue professions in the vegetable production and processing industries, and b) to assess the impact of the videos on access to content, use of information, and student learning at the four universities.

MATERIALS AND METHODS

Instructors of vegetable and plant protection courses from four California institutions (California State University, Chico; California State University, Fresno; California Polytechnic State University, San Luis Obispo; and the University of California, Davis) met and identified the types of visuals that would aid in the vegetable production courses that are taught at their institutions. The videos would not only supplement classroom teaching but would also be informative and useful for non-formal educational purposes. It was also decided that, although most of the videos would be shot in California, some of the filming would be done in other countries to provide some international perspective to students.

Each team member decided the topics they would develop as videos. They decided on the theme and general approach of the video in advance and visited various sites and operations in California, Texas, The Netherlands, and Nepal. Filming was done using professional-grade, hand-held video cameras with WIFI lavalier microphones and/or boom microphones connected to each video camera. In many cases, a tripod was used to stabilize images. Verbal or written permission to be filmed was obtained from both company executives as well as the people to be interviewed. In several cases, multiple visits had to be made to sites to record or re-record various activities. After filming, each member viewed the clips for clarity of presentation (both visually and aurally), arranged them in sequential order based on theme, and scripted the narration. The bundled clips were sent to a professional video editing company (North by Northwest, Spokane, WA) to produce the final videos. Sub-titles were inserted in each video to make them Americans with Disabilities Act (ADA) compliant. A total of 26 videos were developed.

Five videos were randomly selected to be viewed by students in classes at the four participating universities. These classes included upper-division undergraduate classes as well as graduate-level classes. The videos viewed by students were those on organic tomato production, potato production, processing tomato production, sweet corn production, and urban agriculture. A pre- and post-viewing survey questionnaire was developed to assess students' perception of learning. Students viewed the videos in-class or were associated with a graded assignment or were treated as supplemental course material.

After piloting the survey with students across the institutions to test for reliability, an IRB-approved study of student responses was conducted (IRBNet 1336444 Project, UC Davis). A pre/post survey design was used to assess the impact of the videos on a student's: a) ability to define the terms used in the video, b) ability to explain the topic of the video, c) importance of the selected topic to the student's future career, d) clarity of explanation in the videos, and e) level of knowledge of the selected topic. To understand and expand on current levels of knowledge, students were asked to report their ability to define and explain the topic, with defining and explaining linked to measures for learning (Ambrose et al., 2010). In addition, the type of device used for viewing was also surveyed. The respondents were instructed to provide their opinion on each survey question using ranking scales (e.g., 1= not at all knowledgeable, 2 = slightly knowledgeable, 3 = moderately knowledgeable, 4 = very knowledgeable, and 5 = extremely). The mean values and standard deviations of the responses for each video were calculated. A paired t-test ($\alpha = 0.05$) on the level of knowledge derived from the videos (overall mean of the five videos) before and after viewing was also conducted. The survey was conducted to provide information to improve future videos and to indicate when and where best to incorporate the videos in specialty crop vegetable production courses.

After final approval by the team members, the videos were released sequentially, one per week, on a YouTube channel hosted by the University of California's Division of Agriculture and Natural Resources (UCANR), for use by all educational institutions as well as the public (https://www.youtube.com/playlist?list=PLLjlfxpbNglYF2m7tvApfiR5NXParpvGP). The number of views of each video was tracked and recorded.

RESULTS AND DISCUSSION

The survey sample size for the 5 videos that were assessed ranged from 12 to 31 students. Respondents viewed the videos during the Fall 2018-Winter 2019 terms at the participating institutions. The number of respondents for the organic tomato production, potato production, processing tomato production, sweet corn production, and urban agriculture videos were 12, 19, 31, 12, and 12, respectively for a total of 96 respondents. The most common method used by the students to view the videos was a laptop computer (82%), followed by smartphones (9.6%), desktop computer (9%), tablets (2.6%), or other means (0.8%). The responses of the students to each video before and after viewing was determined. The overall views for all project videos posted to YouTube, whether by students or the public, was also determined (Table 1). Glasshouse production in the Netherlands, onion production in California, and sweet corn production in California were the videos with the greatest number of academic and public views. As of December 21, 2021, the 26 videos were accessed 449,756 times.

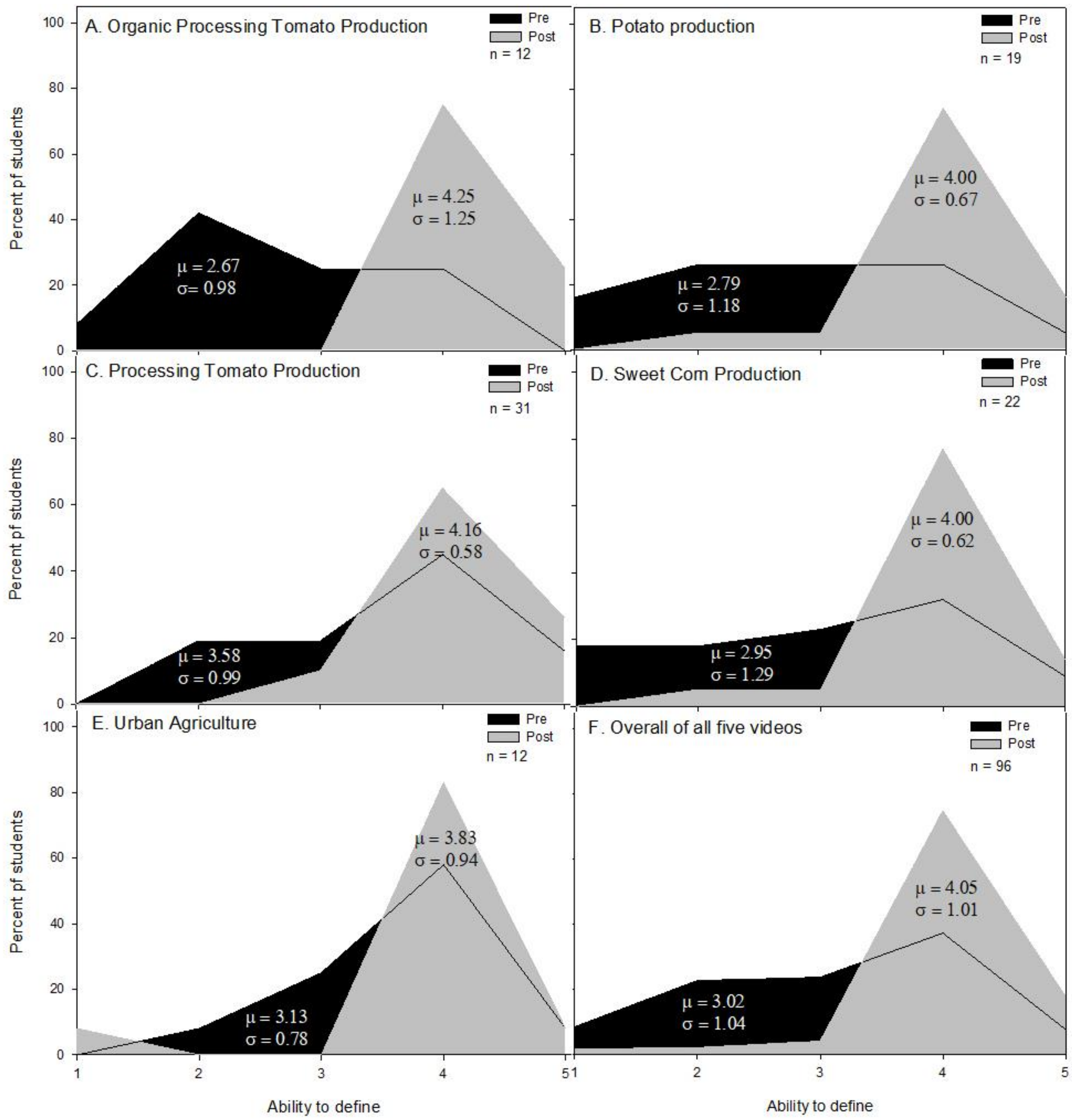
TABLE 1
LIST OF VIDEOS DEVELOPED AND NUMBER OF VIEWS ON YOUTUBE AS OF DECEMBER 21, 2021

No.	Topic	No. of views
1	Amaranths and millets as specialty crops in developing countries	252
2	Aquaponics	1,009
3	Artichoke production	11,657
4	Civic agriculture	332
5	Cover crops in specialty crops production systems	1,606
6	Garlic production from harvesting to packing	28,687
7	Glasshouse vegetable production in the Netherlands	152,543
8	Glasshouse vegetable production Part 2: Rob Baan	13,789
9	Horticulture therapy, growing vegetables for physical and mental well-being	3,891
10	Lettuce production in the Salinas Valley	23,587
11	Mechanization and innovations for the sustainability of specialty crop vegetables in California	1,050
12	Onion Packing	3,531
13	Onion production in California	74,535
14	Organic processing tomato production	4,718
15	Potato production	8,073
16	Precooling vegetables	8,988
17	Processing leafy greens	17,815
18	Processing onions into value-added products	20,145
19	Processing tomato production	21,311
20	Seed and variety improvement	4,281
21	Sweet corn production in California	29,843
22	Tomato production in low cost hoop houses in Nepal	1,607
23	Urban agriculture	12,662
24	Vegetable transplants	1,924
25	Weed management in specialty crop production	1,749
26	Why eat vegetables?	171
	Total views all videos	449,756

Ability to Define the Topics

The responses of the students to the prompt, "I can define this topic," for each video and the overall means of the responses were determined (Figure 1). For each video, student responses suggested large positive shifts in the ability to define the topics. For example, prior to watching the organic tomato production video, only 25% (N=3) of the respondents agreed they could define the topic whereas, after viewing the video, 75% (N=9) reported being able to define the topic with 25% (N=3) strongly agreeing that they were able to define the topic. Similar increases in the ability to define a topic were recorded for each of the videos. The overall ability to describe the topic for the five videos, on a 1-5 scale, was 3.02 and 4.05, before and after viewing the videos, respectively, and the ability to define the topic after viewing the videos was significantly (P = 0.002) higher than before viewing.

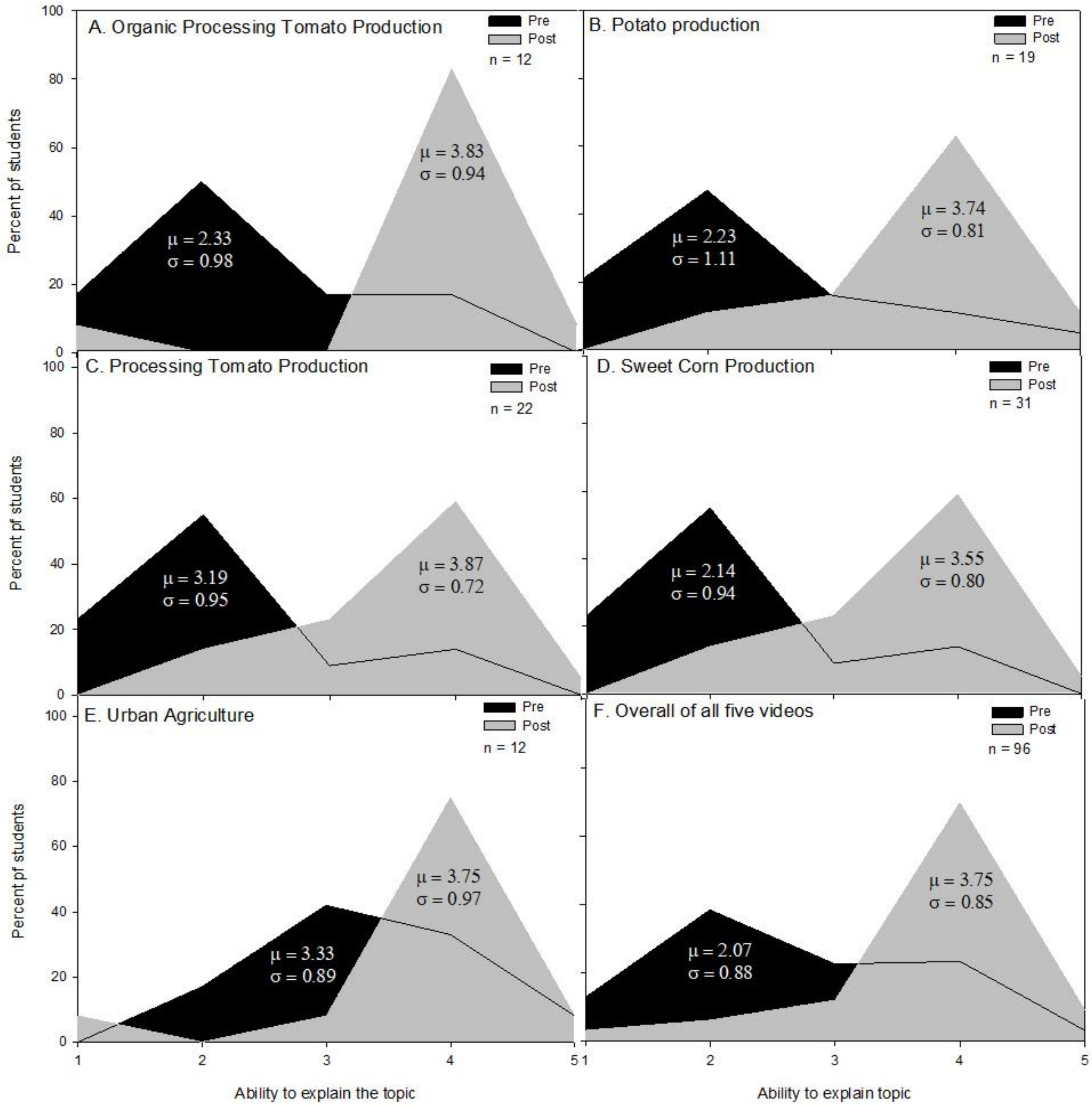
FIGURE 1
STUDENTS' ABILITY TO DEFINE THE TOPIC OF THE VIDEO BEFORE (PRE) AND AFTER (POST) VIEWING WHERE 1 = STRONGLY DISAGREE, 2 = DISAGREE, 3 = NEUTRAL, 4 = AGREE, AND 5 = STRONGLY AGREE



Ability to Explain the Topics

The responses of the students to the prompt, "I can explain this topic," for each video and the overall mean for the five videos was determined (Figure 2). Student responses suggest large positive shifts in the ability to explain the topics. For example, prior to watching the potato production video, only 11% (N=2) of the respondents agreed they could explain the topic whereas, after viewing the video, 63% (N=12) reported being able to explain the topic with 11% (N=2) strongly agreeing that they were able to explain the topic. Similar increases in the ability to explain the topic was recorded for each of the videos. The overall ability to explain the topic for the five videos, on a 1-5 scale, was 2.07 and 3.75, before and after viewing the videos, respectively, and the ability to explain the topic after viewing the videos was significantly (P = 0.004) higher than before viewing.

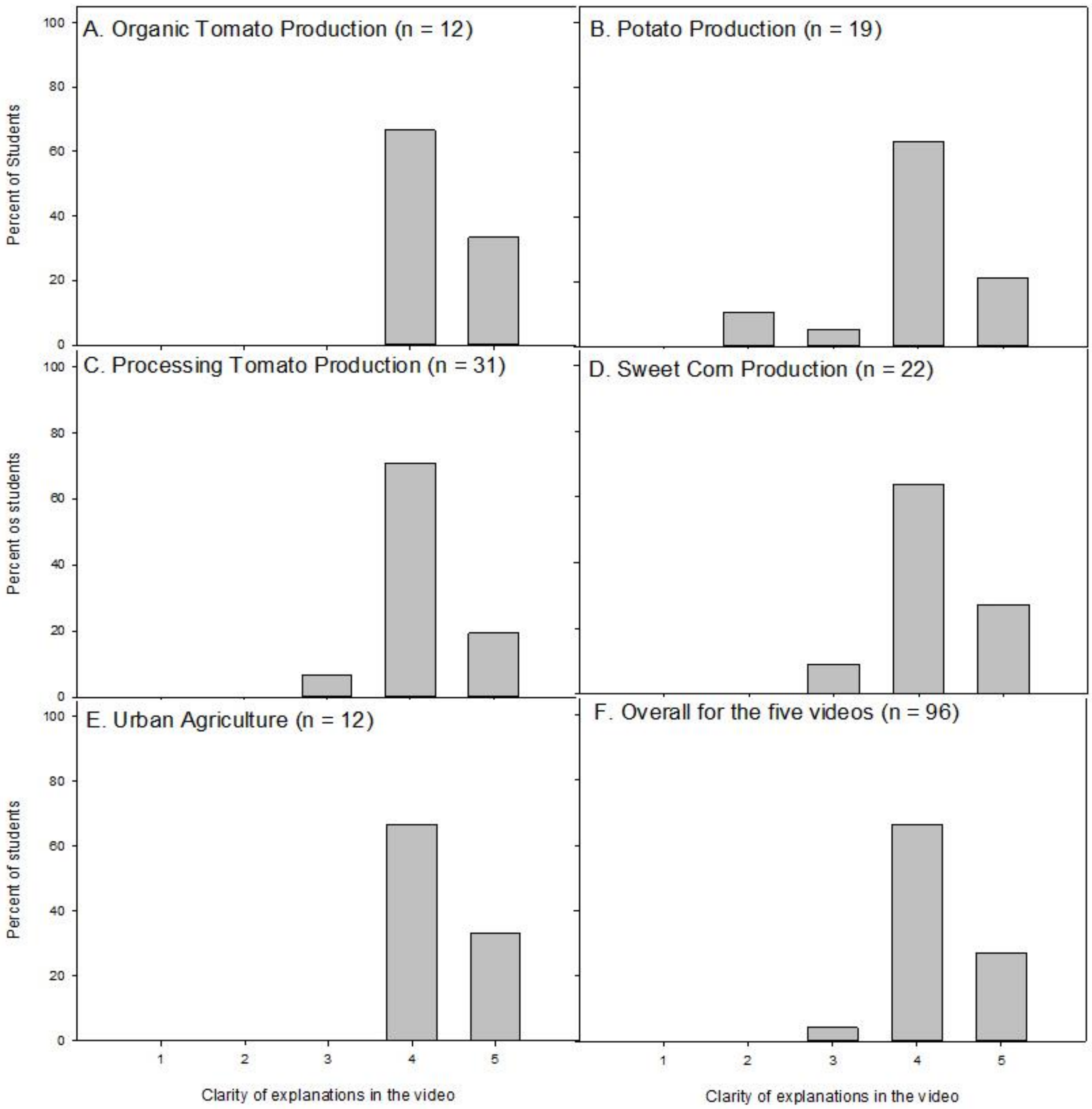
FIGURE 2
STUDENTS' ABILITY TO EXPLAIN THE TOPIC OF THE VIDEO BEFORE (PRE) AND AFTER (POST) VIEWING WHERE 1 = STRONGLY DISAGREE, 2 = DISAGREE, 3 = NEUTRAL, 4 = AGREE, AND 5 = STRONGLY AGREE



Perceptions of Video Content

Students responded to two questions about video content with regard to aural clarity and length. There was an overwhelming agreement that the videos were aurally clear (89 of the 96 responses were either "agree" or "strongly agree"; Figure 3). Two participants indicated disagreement with the statement regarding video clarity and both were in response to the potato production video. One indicated that the language used in the video was too technical, the other selected "Other", and provided this response: "It was hard to understand some of the dialog because of background noise." In total, 5 of the 96 responses or about 5% were "neutral" on selected "Other", and provided this response: "It was hard to understand some of the dialog because of background noise." In total, 5 of the 96 responses or about 5% were "neutral" on video clarity. In the future, background noises should be minimized so that the viewers can more readily hear the statements being made in each video.

FIGURE 3
STUDENTS' OPINIONS REGARDING THE AURAL CLARITY OF VIDEOS WHERE 1 = STRONGLY DISAGREE, 2 = DISAGREE, 3 = NEUTRAL, 4 = AGREE, AND 5 = STRONGLY AGREE



Across the videos there were only 6 respondents who thought the videos were too long, with Urban Agriculture receiving 4 of these responses. The length of the organic tomato production, potato production, processing tomato production, sweet corn production, and urban agriculture videos were 47.17, 39.11, 18.58, 14.21, and 46.05 minutes, respectively. These included time for title, credits, and acknowledgments. Based on these results, it appears that students' perception of appropriate length for a video may be based on the interest of the students in the topic because Organic Tomato Production was a longer video than the Urban Agriculture, yet the students only marked the latter as being too long. Brame (2016) suggested that videos used for educational purposes should be relatively short with developers managing the cognitive load of each video to maximize student engagement and active learning. Guo et al. (2014) reported that six minutes was the median engagement time for a video *of any length*. The study further suggested that videos longer than 6–9 minutes may be a waste of effort. However, this did not seem to be the general case for the five videos we tested as all of them were longer than 10 minutes.

Knowledge of Opportunities for Hands-on Learning

The importance of hands-on learning in an applied field such as agriculture has been stressed (Dailey et al., 2001; Parrish et al., 2015). The opportunities provided in schools for hands-on learning are often not sufficient, and students often seek additional opportunities for this type of learning while in school and after graduation. Knowledge of hands-on learning opportunities is important for students.

Students were asked to respond to the question, “I know where I can go to gain hands-on experience with the selected topic,” where 1 = No, 2 = Not sure, and 3 = Yes. Student responses suggested large positive shifts in the ability to identify where to gain hands-on experience with the particular topics (Table 2). For example, prior to watching the urban agriculture video, 41% (N=5) of respondents reported that they did not know (response = No) or were not sure where to gain hands-on experience with the topic, whereas after viewing the video, 0% of students reported no knowledge (response = No) or not sure on where to obtain hands-on experience on the topic. The overall response values for all five videos before and after viewing were 2.07 and 2.97, respectively, indicating a significantly (P<0.0001) higher number of students saying “yes” to having gained knowledge after viewing the videos regarding where to find hands-on learning opportunities.

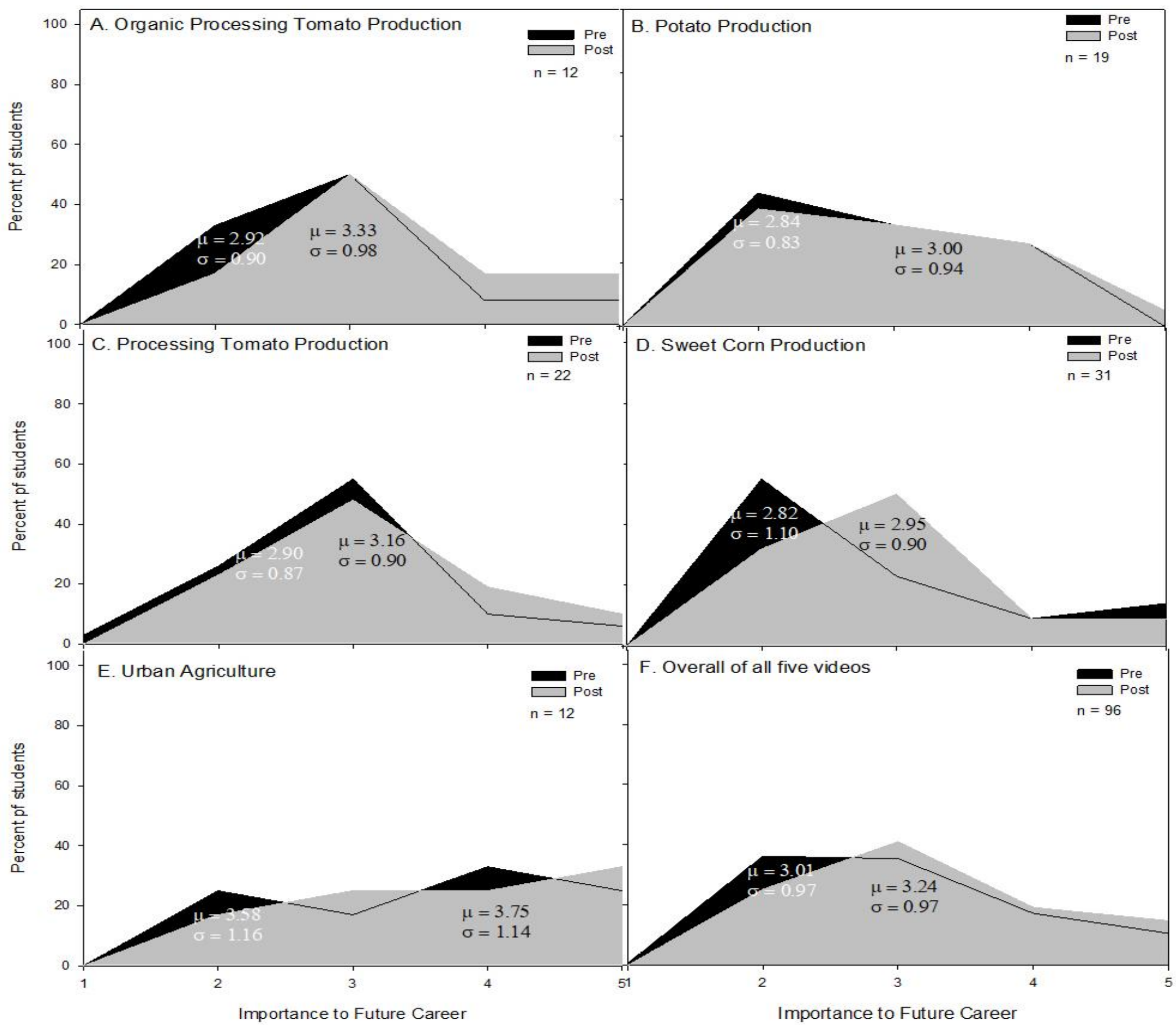
TABLE 2
STUDENTS' RESPONSE TO KNOWING SOURCES OF HANDS-ON LEARNING OPPORTUNITIES BEFORE (PRE) AND AFTER (POST) VIEWING THE VIDEOS; 1 = NO, 2 = NOT SURE, 3 = YES

Response	Type of Video									
	Organic Processing Tomato Production		Potato Production		Processing Tomato Production		Sweet Corn Production		Urban Agriculture	
	No. of respondents and percent									
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
No	4 (33%)	2 (17%)	7 (37%)	4 (21%)	7 (23%)	1 (3%)	11 (50%)	4 (18%)	4 (33%)	0 (0%)
Not sure	6 (50%)	0 (0%)	4 (21%)	0 (0%)	7 (23%)	0 (0%)	12 (9%)	0 (0%)	1 (8%)	0 (0%)
Yes	2 (17%)	8 (67%)	8 (42%)	12 (63%)	17 (55%)	19 (61%)	9 (41%)	14 (64%)	7 (58%)	10 (83%)
Missing	0 (0%)	2 (17%)	0 (0%)	3 (16%)	0 (0%)	11 (35%)	0 (0%)	4 (18%)	0(0%)	2 (17%)
Mean	1.83	2.83	2.05	2.74	2.32	3.29	1.91	2.82	2.25	3.17
Std. Dev.	0.72	0.94	0.91	0.99	0.83	0.64	0.97	0.96	0.97	0.39

Perceptions on Importance of the Topic to Future Careers

Students were asked to respond to the prompt, "How important is the selected topic to your future career?" Compared to the other responses, the results suggested smaller positive shifts towards an increase in their perception of the importance of the topic to their future careers (Figure 4). For example, prior to watching the urban agriculture video, 75% (N=9) of respondents reported that the topic was "moderately important" to "extremely important." After viewing this video, the number of respondents indicating the same sentiments increased to 83% (N=10). Similar modest increases were recorded the responses for each of the videos. Overall response values for all five videos before and after viewing were 3.01 and 3.24, respectively, indicating a significantly (P = 0.005) higher awareness of the importance of the topics to student future careers.

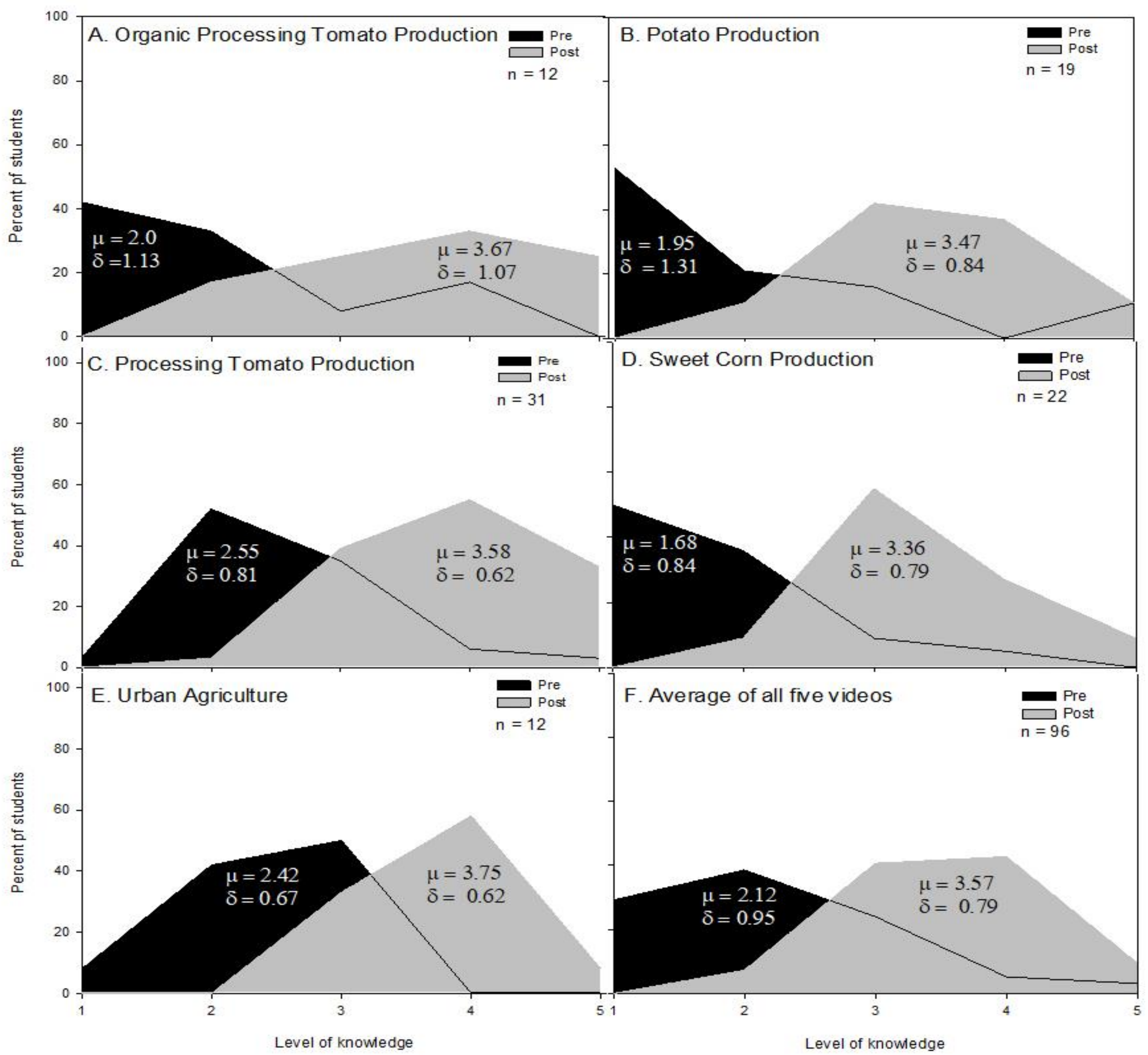
FIGURE 4
STUDENTS' PERCEIVED IMPORTANCE OF A TOPIC TO THEIR PERSPECTIVE CAREERS (PRE) AND (POST) VIEWING THE VIDEO WHERE 1 = NOT AT ALL, 2 = SLIGHTLY, 3 = MODERATELY, 4 = VERY, AND 5 = EXTREMELY



Changes in Student's Knowledge

The overall goal of the project was to verify if student viewing of a video increased that student's knowledge on the topic. The results suggest that increases in student knowledge were directly related to video content, i.e., student familiarity with the crop or topic (Figure 5). However, the responses suggest large positive shifts in student knowledge after viewing the videos, regardless of topic. For example, with the processing tomato production video, the video with greatest sample size (N=31), prior to watching the video ~45% (N=14) of the respondents had mentioned that they were ‘moderate to extremely knowledgeable’ about the topic, whereas after viewing the video, 97% (N=30) reported being ‘moderate to extremely knowledgeable’ about the topic. Such increases in the ability to explain the topic were recorded for each of the videos. The overall change in value for knowledge of the topic, before and after viewing the videos, was 2.12 to 3.57 and this change was significant (P = <0.0001). These results agree with Schmid et al. (2014) who reported, from a meta-analysis of 897 samples, that cognitive support tools such as videos resulted in positive outcomes in student learning, and also echo the sentiments of Brame (2016) on the importance of educational videos in maximizing student learning.

FIGURE 5
LEVEL OF KNOWLEDGE OF STUDENTS BEFORE (PRE) AND AFTER (POST) VIEWING OF VIDEOS; WHERE 1 = NOT AT ALL KNOWLEDGEABLE, 2 = SLIGHTLY KNOWLEDGEABLE, 3 = MODERATELY KNOWLEDGEABLE, 4 = VERY KNOWLEDGEABLE, AND 5 = EXTREMELY KNOWLEDGEABLE



The results of this study serve as a first step in evaluating the effectiveness of incorporating videos as supplementary material in agricultural education courses, specifically vegetable production in California. How these videos contribute to pedagogical processes still need to be evaluated. We believe that such videos may become a part of lectures and labs of many courses not just in agricultural sciences but other fields as well. For example, Brame (2017) has highlighted how educational videos have become an important part of higher education in recent years as an important content-delivery tool in many forms of lecture delivery methods. The article further emphasized the need for instructors to manage cognitive load of the video, maximize student engagement with the video, promote active learning from the video. Noetel et al. (2021) reviewed the effectiveness of videos on learning in higher education and concluded that addition of videos to existing teaching was strongly beneficial and usually improved student learning. Similarly, in recent months, the internet is rife with non peer-reviewed articles and blogs about the use of videos to improve student learning. Although the videos we created were for incorporation into existing vegetable science courses in the four California universities, judging by the number of hits on YouTube, they may also be contributing to non-formal education not just in California but also in many parts of the world. However, it cannot be quantified who is accessing these videos and from which part of the world. Nevertheless, we believe that these videos have a bigger audience than just the students in the specific courses in the four California universities.

CONCLUSIONS

This project demonstrated the importance of incorporating videos into agricultural curricula to increase the understanding of concepts and production techniques for students studying specialty crop vegetable production. Although the study involved only 5 videos and a relatively small survey group, we believe that the results have a broader application to other topics in an applied major such as agriculture. In situations where various budgetary, liability, and physical limitations have prevented students taking field trips to see agricultural operations, videos may serve the purpose of visual education, both for agricultural concepts and production techniques. The videos have been disseminated beyond the four California agricultural post-secondary schools involved in this study as the videos were placed on YouTube in an open-access format, allowing for the greatest possible viewing and dissemination of knowledge.

ACKNOWLEDGEMENTS

California Department of Food and Agriculture Specialty Crop Block Grant Program, SCB16031, Expanding the Capacity and Training of a New Generation of California Vegetable Producers. We also thank the scores of farmers and private sector hosts who graciously provided interview and filming opportunities of their farms and operations. Without their help, this project could never have been realized.

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