Adoption of Software in the Post-Secondary Agricultural Classroom as a Result of the COVID-19 Pandemic

K. Tasci[1], M. L. Drewery[2], and R. G. Anderson[3]
Texas State University
San Marcos, TX

M. Swafford[4]
Eastern New Mexico University
Portales, NM

Abstract

Covid-19 required educational institutions to respect social distancing guidelines, forcing faculty to adapt their face-to-face courses into an online format. The diffusion of innovations theory provides the framework for this study, which evaluated faculty adoption of software, with a focus on Learning Management Software (LMS) features, in the post-secondary agricultural classroom before and as a result of Covid-19. Our data indicate large shifts in the percentage of faculty who adopted recording software, video conferencing software, and collaborative software for teaching as a result of Covid-19. With specificity to LMS, more faculty used these features to administer tests or quizzes and post lectures as a result of Covid-19. Further, faculty reported heavier reliance on LMS features, with shifts from lower frequency of use categories to those representing more frequent use. Faculty were forced to adopt software and LMS features to maintain communication and continuity of education in an online environment. This forced adoption likely caused permanent changes in post-secondary agricultural education, as many respondents who did not previously use recording software, video conferencing software, and LMS for teaching reported that, as a result of Covid-19, they intend to incorporate these tools in future courses, even when face-to-face instruction resumes.

Introduction

The Coronavirus 2019 (Covid-19) pandemic created unprecedented challenges for public health services, the economy, global trade, and education systems. During March 2020, millions of schools closed and there was a sudden loss of physical interaction on a global scale. With Covid-19 cases steadily increasing, educational institutions abruptly and swiftly transitioned from face-to-face to online instruction while attempting to maintain minimal disruption to learning. The forced adoption of online learning posed challenges in technology access and literacy for both faculty and students. In higher education, many faculty had not received online instructional training and lacked confidence to continue teaching in an online environment; when the Covid-19 pandemic began, 56% of faculty members teaching sciences at a Pakistani University were anxious about e-learning usage and 64% lacked adequate or appropriate computer skills (Rahim et al., 2020). Ultimately, Covid-19 highlighted the preparedness of educational institutions and faculty to enter a new digital age.

Software was used in the post-secondary classroom before Covid-19. Specifically, software has been used to offer flexible class times and distribute learning materials remotely (Walters et al., 2017). There are data indicating software use in higher education enhances student perceptions of and engagement in courses. In a study which examined student satisfaction with a learning management software (LMS) website, students strongly agreed with the questions “The website contributed to the course”; “I wish

[1]Department of Agricultural Sciences; kdt91@txstate.edu
[2]Department of Agricultural Sciences; 512.245.2130; m_d553@txstate.edu; PhD
[3]Department of Agricultural Sciences; 512.245.3325; r_a461@txstate.edu; PhD
[4]Department of Agriculture, Food Science and Kinesiology; 575.562.2526; marshall.swafford@enmu.edu; PhD

my other courses had a website"; and "I wish other courses would post teaching materials on the website" (Naveh et al. 2010, pg. 131). Further, students were more likely to utilize the LMS website if it had a forum (Naveh et al., 2010), suggesting this LMS feature encouraged student interaction with course content and facilitated collaboration. Overall, these data indicate that the presence of software in the higher education classroom may enhance student learning.

With specificity to the post-secondary agricultural classroom, LMS features have been integrated into courses to provide supplemental materials and/or complement face-to-face learning in blended (hybrid) instruction. For example, a Croatian university used Moodle to aid in teaching agricultural terminology and reading comprehension (Vulic, 2013). This was sparked by a self-identified need to create an online support system with the ultimate purpose of enhancing student performance. Although the researchers did not formally evaluate the effectiveness of Moodle in enhancing student learning outcomes or satisfaction, it stands to reason that this and other software make courses more interactive and help students visualize or apply the practical concepts that characterize agricultural sciences. This is especially true and important for blended or online learning in which structure and support beyond lecture may not otherwise exist.

While Covid-19 created difficulties for educational institutions, it also set the stage for new innovations in the classroom; this is especially true for disciplines with practical applications such as agricultural sciences. A case study on post-secondary agricultural education in India suggested that, after the Covid-19 pandemic, many agricultural institutions will adopt 3-D animation software for class activities, such as measuring soil and water composition; demonstrating harvesting techniques; and teaching medical concepts (Thammi-Raju et al., 2020). Although the post Covid-19 landscape is currently unclear, it is likely the forced adoption of the online classroom amidst the pandemic has permanently altered the nature of agricultural education.

Theoretical Framework

The diffusion of innovations (DOI) theory is the process by which an innovation is communicated through certain channels over time among the members of a social system (Rogers, 2003). There are four components to the DOI theory: innovation, communication, time, and social system. The perception of the innovation by members of the social system determines the rate of adoption. Factors that contribute to adoption of innovations are the relative advantage, compatibility, complexity, trialability, and observability of the innovation. If an innovation is perceived to be more advantageous than that already in use; compatible with ideas and technology already present; not difficult to understand and able to be tested before adoption; or is easily visible and demonstrates positive results, then rate of adoption will be faster and accepted with less certainty.

Timing of adoption also varies greatly; individuals can be categorized as initial innovators, early adopters, early majority, late majority, or laggards based on when they adopt the innovation. The innovation is developed by innovators, initially implemented by early adopters, then adopted by the early majority, late majority, and laggards, respectively. The social structure surrounding an innovation impacts what type of adopter an individual will be. The DOI theory involves several components working together simultaneously where the level of adoption and rate of diffusion depend on the innovation itself, degree of communication, timing, and the social structure at hand.

Adoption of an innovation can be voluntary or forced. Voluntary adoption is an autonomous decision made by an individual without force and freely chosen. Forced adoption is mandatory and is a decision placed on an individual. The fundamental difference between voluntary and forced adoption is whether the individual adopts the innovation before or after the organization at which they are employed or affiliated with (Zhou, 2008). If the individual adopts the innovation before the organization, it is voluntary adoption. If the individual adopts the innovation after the organization, it is forced adoption. Key factors regarding voluntary versus forced adoption include innovation perceptions, individual traits, and social norms (Rogers, 1995). A study regarding internet adoption by journalists indicated age is also a key determinant in adoption where younger journalists were more likely to be voluntary adopters while their older counterparts tended to be forced adopters (Zhou, 2008). The young journalists were also male and had positive perceptions of internet usage in society. These factors (age, gender, usability, advantage) align with the DOI.

Covid-19 forced educational institutions, faculty, and students, to adopt online learning. Similarly, the pandemic shifted the adoption of technology and software in the classroom from a voluntary or optional to a forced collective decision. Before Covid-19, some faculty opted to use software and LMS features in their courses. Within the context of the DOI, these faculty would be initial innovators or early adopters. In contrast, before Covid-19, other faculty members did not use software nor LMS features in their classrooms and were skeptical of non-traditional teaching styles (Walters et al., 2017).

Offering training and institutional support for online teaching creates more positive feedback from faculty (Walters et al., 2017). This reinforces the idea that, by aiding faculty and, in turn, minimizing the complexity of the innovation, the rate of adoption will be faster. The role of faculty shifted when they were forced to adopt online teaching during the Covid-19 pandemic. Not only were they required to learn new technology and software, they also were responsible for teaching students how to navigate these tools and adjust to a new style of learning (Thammi-Raju et al., 2020). Thus, the impact of Covid-19 on faculty extended beyond mode of instruction, also creating new responsibilities related to the learning and implementation of tools that ensure continuity of education.

Although we do not have a clear picture of what higher education "looks like" after Covid-19, it is likely that software will be incorporated into the post-secondary classroom at increasing rates. The progression towards a more technologically reliant education system justifies the need for research focused on the integration of software in the post-secondary classroom.

Purpose And Objectives

The purpose of our study was to analyze the adoption of software, with a focus on LMS features, in the post-secondary agricultural classroom in response to Covid-19. To achieve this, our study addressed the following objectives:

1. Determine the frequency in faculty use of software before and after the Covid-19 pandemic.
2. Determine the frequency in faculty use of LMS features before and after the Covid-19 pandemic.
3. Capture faculty's plans for continued adoption of software and LMS features not used prior to the Covid-19 pandemic.

The purpose and objectives of this study align with the National Research Agenda of the American Association for Agricultural Education's focus on digital technologies in online learning environments (Roberts, et al., 2016). Using electronic resources is necessary to continue the learning process without restrictions of time nor place during the Covid-19 pandemic (Raza et al., 2020).

Methods

This study was part of a larger study that employed a mixed methods approach to data collection, facilitated through an electronic survey-based questionnaire. The questionnaire was designed to assess the impact of Covid-19 on teaching in agricultural-based disciplines at the postsecondary level. The Texas State University Institutional Review Board approved this research as exempt (#7380) and all participants were provided written informed consent prior to participation. The population was faculty and instructors who held a formal teaching appointment based in agricultural sciences during the Covid-19 pandemic (spring 2020, summer 2020, fall 2020) at colleges and universities across seven southern states. Our participants were identified by searching college and departmental websites in the target states, conducted in summer 2020. Using a total population of 1,795 faculty and instructors, a sample size of 317 with a 95% ± 5 confidence interval was calculated.

Data was collected using a researcher-developed instrument that contained five sections. Section 1 consisted of nine questions including personal and institutional demographics. Section 2 consisted of three questions related to formal, informal, and non-formal training in teaching. Section 3 consisted of seven questions related to the use of technology, including electronic devices, software, and social media, before and as a result of Covid-19. Section 4 consisted of fifteen questions related to teaching experiences during Covid-19, including questions related to course and career impacts. Finally, Section 5 included eight questions related to future training and professional development in relation to online teaching. The data presented here are from Sections 1 and 3.

Following recommendations of Gates et al. (2018) on establishing a face-validated instrument, we identified a panel of experts outside of the research team and participant group. The panel included ten Agricultural Education faculty with expertise in survey design and online teaching. The panel assessed the questionnaire for face, content, and construct validity. Based on initial panel recommendations, we revised the questionnaire and resubmitted it for further review until the final version was approved.

To establish reliability, the questionnaire was piloted by agriculture faculty from multiple sub-disciplines who were not part of the research team, participant group, or expert panel. We sent 14 faculty a prenotice informing them of the pilot study. Three days later, we sent them a link to the questionnaire. Within seven days, we received six completed questionnaires, yielding a response rate of 43%. One week after the survey was distributed, a reminder was sent to the non-respondents. Within two weeks, two additional faculty responded for a total response rate of 57%. Data from the pilot study were coded and entered using the Statistical Package for the Social Sciences (SPSS) 25.0 software. We calculated a Cronbach's alpha reliability coefficient (α = 0.790) which, based on interpretations provided by George and Mallery (2003), was good.

Our questionnaire was available to participants from early September to mid-October 2020. Dillman et al. (2014) recommends the use of a five-point contact data collection model, including a prenotice, the questionnaire, a reminder, a second reminder, and then the invocation of a special procedure during a five-week window. Using Qualtrics, we sent a prenotice to 317 participants. Three days later, we sent an email containing the link to access the questionnaire. Over the next three weeks, we sent three reminder emails to non-respondents. These reminder emails were sent weekly on Wednesday mornings to allow participants time to respond at the beginning of the workday. Two hundred and fifty-five participants provided usable data and eighteen participants did not teach in the spring of 2020; overall, our response rate was 86.1%. With a response rate exceeding 85%, no additional procedures were used to account for non-response error, following recommendations of Lindner et al. (2001).

Using SPSS 25.0, data were analyzed using descriptive statistics and measures of central tendency to report the frequency and percentage of faculty use of software and LMS features for teaching. We also reported the frequency and percent of faculty planning to incorporate specific software and LMS features in the classroom as a result of Covid-19. Additionally, descriptive statistics were calculated for the demographic characteristics of the participants and their institutions of employment.

Results and Discussion

Demographics of our sample population and the institutions at which they are employed are in Tables 1 and 2. Respondents were predominantly male (62.6%), white or Caucasian (81.9%), and hold a doctoral degree (84.6%). There was a fairly even distribution in the date range born – 23.1% in 1981-1996, 36.9% in 1965-1980, and 38.0% in 1946-1964 – indicating similar representation from the Millennial, Generation X, and Baby Boomer generations. Similarly, most respondents held the titles of

Table 1. Demographics of sample population

	Frequency	Percent
Gender identity		
Male	159	62.6
Female	95	37.4
Date range born		
1981-1996	59	23.1
1965-1980	94	36.9
1946-1964	97	38.0
1928-1945	4	1.6
Prefer not to disclose	1	0.4
Ethnic identity		
Asian	12	4.6
Black or African American	9	3.5
Hispanic or Latino	11	4.2
White or Caucasian	212	81.9
Other	6	2.3
Prefer not to disclose	5	1.9
Highest degree		
Doctoral	219	84.6
Masters	33	12.7
Bachelors	3	1.2

Full Professor (34.6%), Associate Professor (25.2%), or Assistant Professor (26.4%). A majority of respondents were employed at 1862 Land-Grant (52.2%) or Regional institutions (30.3%). We strived to reach respondents throughout the southern region states, as defined by North American Colleges and Teachers of Agriculture (NACTA), and our respondents were overwhelmingly employed in Texas (55.9%), followed by Arkansas (14.6%), then Georgia (13.8%). Courses taught were all within the umbrella of agriculture, by design, with most respondents reporting teaching Animal Science (20.8%); Crop and Soil Sciences (14.5%); or Agricultural Education, Extension, Leadership, and Communication (13.7%).

Faculty use of collaborative software, such as Microsoft TEAMS, for their teaching needs increased for all frequencies except never, which decreased from 71.1% to 38.9% (Table 3). Similarly, the use of video conferencing software, such as Zoom and Skype, increased in the once a day frequency category, from 5.2% prior to 53.6% as a result of Covid-19. The percent of faculty reporting never using video conferencing for their teaching appointment was 42.4% before Covid-19, which decreased to 2.9% as a result of Covid-19. This indicates large-scale forced adoption of video conferencing to facilitate learning amidst social distancing guidelines. Indeed, the pandemic made it difficult, if not impossible, to responsibly maintain regular physical interactions. This greatly impacted educational institutions where communication and collaboration are fundamental. Using collaborative and video conferencing software are two solutions to fill the void of face-to-face student-faculty and student-student interaction, enhance student engagement in course curriculum, and provide clarity on course content – all of which are integral to a positive learning environment. Previous data indicate agricultural undergraduate students agree that absence of face-to-face conversations and experiences with other students and instructors make online courses less attractive than face-to-face (House et al., 2007). Further, these students disagree that online teaching is more effective than face-to-face (House et al., 2007). Borokhovski et al. (2016) reported that technology which supports student-student interaction significantly improves student learning. As faculty continue to integrate collaborative and video conferencing software in their courses, there will be more opportunities for students and faculty to interact which will ensure continuity of education and, hopefully, make online learning more attractive to students.

Faculty adopted LMS and used it more frequently as a result of Covid-19 (Table 4). The inclusion of a course website increases student satisfaction with that course; Naveh et al. (2010) reported students agreed that posting materials on the course website positively contributes to the course and that they recommend other courses use similar websites. Thus, our observation that faculty are integrating LMS in their courses as a result of Covid-19 is in alignment with approaches that enhance student perception of courses. As faculty gain experience with LMS and other software over time, adoption will likely increase as the above cited literature indicates LMS provides a relative advantage over the product it replaces, one of the factors of the DOI theory that affects adoption of innovations (Rogers, 2003).

Our data indicate that faculty posted lectures on LMS platforms more often as a result of Covid-19 (Table 4). We observed increases in faculty posting either asynchronous or synchronous lectures for all frequency categories except never and once a month. For those who posted asynchronous lectures, the most noticeable shift was in the frequency category once a day which increased from 8.0% prior to Covid-19 to 33.5% as a result of Covid-19. Similarly, for posting synchronous lectures, the most noticeable shift was in the frequency category once a week which increased from 9.0% prior to Covid-19 to 28.9% as a result of Covid-19. Our data does not indicate faculty preference for either approach to content delivery; rather, it indicates that faculty adopted both asynchronous and synchronous approaches to teaching during the pandemic. Recent data demonstrate that 18% of faculty strongly agree that synchronous lectures are preferable for online education while only 6% strongly agree that asynchronous lectures are preferable (Rahim et al., 2020). Further, findings from that same study indicate 29% of faculty strongly agree that a blend of synchronous and asynchronous lectures is the preferred approach to online teaching (Rahim et al., 2020). Using both asynchronous and synchronous content delivery may be beneficial as it could appeal to a variety of learning styles. This aligns with previous research which demonstrated that students felt an online synchronous and asynchronous course was flexible, provided an opportunity to participate, and eliminated passive non-present students (Yamagata-Lynch, 2014). In research focused on a “flipped

Table 2. Academic demographics of sample population and institution

	Frequency	Percent
Academic title		
Full Professor	88	34.6
Associate Professor	64	25.2
Assistant Professor	67	26.4
Lecturer	10	3.9
Instructor	20	7.9
Adjunct	5	2.0
Years teaching in higher education		
2	14	5.7
3	15	6.1
4	11	4.5
5	15	6.1
6-8	30	12.1
9-11	23	9.3
12-14	22	8.8
15-19	19	7.6
20-24	31	12.4
25-29	20	8.0
30+	47	19.0
Institution classification		
1862 Land-Grant	131	52.2
1890 Land-Grant	20	8.0
Regional	76	30.3
Private Four-year College or University	11	4.4
Two-Year College	13	5.2

	Frequency	Percent
State institution is located		
Alabama	11	4.3
Arkansas	37	14.6
Florida	4	1.6
Georgia	35	13.8
Louisiana	19	7.5
Mississippi	6	2.4
Texas	142	55.9
Courses taught		
Agricultural Education, Extension, Leadership, and Communication	35	13.7
Agricultural Economics and Business	28	11.0
Agricultural Engineering, Systems, and Mechanics	9	3.5
Animal Science	53	20.8
Crop and Soil Science	37	14.5
Horticulture	19	7.5
Natural Resource and Wildlife Management	13	5.1
Nutrition and Food Science	18	7.1
Other[z]	43	16.9

[z]Advising, Facilities Operator/Manager, Judging Coach, Alumni Relations, Curriculum Specialist

classroom" approach, it was reported that students only watched 70% of the asynchronous online lectures (Gardner, 2012), suggesting that student engagement in a fully asynchronous environment may be lacking. Perhaps these previous data combined with our present findings will encourage faculty to approach online teaching with a mixed (asynchronous and synchronous) lecture style, reducing the pressure to commit to an exclusive asynchronous or synchronous course early in the semester and allowing them to remain flexible in response to their student's learning styles.

We also observed a shift in the percent of faculty administering tests or quizzes via LMS software as a result of the pandemic (Table 4). Before Covid-19, 27.6 and 3.9% of faculty used LMS features to administer tests or quizzes once a week and once a day, respectively. As a result of Covid-19, this shifted to 53.2 (once a week) and 12.2% (once a day) of faculty. As faculty shift to delivering formal assessments of content mastery online, they should consider the limitations. Allowing students to complete tests or quizzes online may allow for cheating or using notes which could decrease the effectiveness of the course content. A study conducted by Conner et al. (2014) demonstrated that online quizzes are ineffective and not challenging enough due to student access to course resources or exclusive inclusion of questions that do not quiz beyond material provided verbatim in lecture notes. To combat this and ensure adequate academic rigor, faculty should consider testing over material that extends beyond that which can easily be found in the notes. Development of many conceptual or applied questions will, however, require a heavy time investment from faculty. Alternatively, faculty may want to implement test proctoring software, a technology we did not ask about in our survey. While these recommendations will likely require more time and effort from faculty, they could ultimately increase content mastery by students and ensure academic rigor does not suffer from an online environment during Covid-19. It should be stated that these recommendations do not account for the mental and psychological burden placed on students during the Covid-19 pandemic and we advise faculty to use their best judgement in developing quizzes or tests during times of extreme stress and hardship.

In line with the above data, our findings also indicate that faculty have adopted LMS features to communicate with students in response to Covid-19 (Table 4). Providing

Table 3. Frequency of agriculture faculty use of software for teaching

	Prior to Covid-19		As a result of Covid-19	
	Frequency	Percentage	Frequency	Percentage
Video conferencing software				
Never	89	42.4	6	2.9
Once a month	75	35.7	5	2.4
Once a week	34	16.2	43	20.8
Once a day	11	5.2	111	53.6
Once an hour	1	0.5	35	16.9
More than once an hour	0	0.0	7	3.4
	210	100.0	207	100.0
Video and audio recording software				
Never	127	64.1	68	35.1
Once a month	40	20.2	20	10.3
Once a week	23	11.6	43	22.2
Once a day	8	4.0	44	22.7
Once an hour	0	0.0	15	7.7
More than once an hour	0	0.0	4	2.1
	198	100.0	194	100.0
Polling software that utilizes an application				
Never	145	74.0	134	71.7
Once a month	25	12.8	21	11.2
Once a week	14	7.1	23	12.3
Once a day	10	5.1	9	4.8
Once an hour	1	0.5	0	0.0
More than once an hour	1	0.5	0	0.0
	196	100.0	187	100.0
Learning Management Software (LMS)				
Never	36	17.7	26	12.9
Once a month	5	2.5	2	1.0
Once a week	34	16.8	13	6.5
Once a day	76	37.4	70	34.8
Once an hour	30	14.8	51	25.4
More than once an hour	22	10.8	39	19.4
	203	100.0	201	100.0
Messaging applications				
Never	137	71.4	127	67.6
Once a month	21	10.9	15	8.0
Once a week	20	10.4	21	11.2
Once a day	14	7.3	19	10.1
Once an hour	0	0.0	4	2.1
More than once an hour	0	0.0	2	1.1
	192	100.0	188	100.0

Table 3 con't. Frequency of agriculture faculty use of software for teaching

	Prior to Covid-19		As a result of Covid-19	
	Frequency	Percentage	Frequency	Percentage
Collaborative software				
Never	140	71.1	75	38.9
Once a month	26	13.2	33	17.1
Once a week	22	11.2	54	28.0
Once a day	8	4.1	23	11.9
Once an hour	1	0.5	7	3.6
More than once an hour	0	0.0	1	0.5
	197	100.0	193	100.0
Conventional email				
Never	9	4.4	6	3.0
Once a month	0	0.0	1	0.5
Once a week	11	5.4	6	3.0
Once a day	35	17.2	32	16.0
Once an hour	67	32.8	57	28.5
More than once an hour	82	40.2	98	49.0
	204	100.0	200	100.0
Video email				
Never	188	100.0	180	97.8
Once a month	0	0.0	2	1.1
Once a week	0	0.0	2	1.1
Once a day	0	0.0	0	0.0
Once an hour	0	0.0	0	0.0
More than once an hour	0	0.0	0	0.0
	188	100.0	184	100.0
Other				
Never	18	94.7	15	93.6
Once a month	0	0.0	0	0.0
Once a week	0	0.0	0	0.0
Once a day	1	5.3	1	6.3
Once an hour	0	0.0	0	0.0
More than once an hour	0	0.0	0	0.0
	19	100.0	16	100.0

[z]Examples of videoconferencing software are Zoom, BlueJeans, Skype, or WebEx; of video and audio recording software are Camtasia, Panopto, or MediaFlo; of polling software that uses an application are TopHat or PollEverywhere; of LMS are CANVAS, TRACS, BlackBoard, or Moodle; of messaging applications is GroupMe; of collaborative software is Microsoft Teams; of conventional email are Microsoft Outlook or Gmail; and of video email is BombBomb

students clarity and feedback in an online classroom is important; previous data indicate faculty have high confidence in their ability to teach online, but are lowly confident in their ability to provide students feedback quickly enough (Walters et al., 2017). Before the pandemic, 40.2% of faculty reported never using LMS software features to message students individually and 45.9% reported never using them to facilitate group messages or chats. As a result of the Covid-19 pandemic, this decreased a similar amount for both individual and group messages, to 30.7% and 35.7% of faculty reporting never using these LMS features, respectively. For both uses of messaging LMS features, the frequency category that grew the most as a result of Covid-19 was once a day; 24.1 and 20.9% of faculty reported this is the frequency with which they message students individually or as groups, respectively. Cumulatively, these data indicate that, as a result of Covid-19, more faculty are messaging students using LMS features and this usage is occurring in more frequent intervals. Our data parallel that of Favale et al. (2020) who reported that private and group chat messages

Table 4. Frequency of agriculture faculty use of Learning Management Software (LMS) features for teaching

	Prior to Covid-19		As a result of Covid-19	
	Frequency	Percentage	Frequency	Percentage
Taking Attendance				
Never	130	66.7	108	56.3
Once a month	4	2.1	8	4.2
Once a week	23	11.8	29	15.1
Once a day	33	16.9	36	18.8
Once an hour	5	2.6	10	5.2
More than once an hour	0	0.0	1	0.5
	195	100.0	192	100.0
Administering tests or quizzes				
Never	102	50.3	34	16.6
Once a month	34	16.8	30	14.6
Once a week	56	27.6	109	53.2
Once a day	8	3.9	25	12.2
Once an hour	3	1.5	6	2.9
More than once an hour	0	0.0	1	0.5
	203	100.0	205	100.0
Administering assignments				
Never	55	27.8	23	11.6
Once a month	46	23.2	17	8.6
Once a week	68	34.3	103	52.0
Once a day	26	13.1	47	23.7
Once an hour	3	1.5	7	3.5
More than once an hour	0	0.0	1	0.5
	198	100.0	198	100.0
Messaging students individually				
Never	80	40.2	61	30.7
Once a month	29	14.6	19	9.6
Once a week	66	33.2	61	30.7
Once a day	23	11.6	48	24.1
Once an hour	1	0.5	8	4.0
More than once an hour	0	0.0	2	1.0
	199	100.0	199	100.0
Group messages or chats				
Never	90	45.9	70	35.7
Once a month	31	15.8	15	7.7
Once a week	57	29.1	65	33.2
Once a day	18	9.2	41	20.9
Once an hour	0	0.0	5	2.6
More than once an hour	0	0.0	0	0.0
	196	100.0	196	100.0

Table 4 con't. Frequency of agriculture faculty use of Learning Management Software (LMS) features for teaching

	Prior to Covid-19		As a result of Covid-19	
	Frequency	Percentage	Frequency	Percentage
Posting PowerPoint slides				
Never	38	18.5	27	13.3
Once a month	15	7.3	8	3.9
Once a week	86	42.0	81	39.9
Once a day	61	29.8	78	38.4
Once an hour	4	2.0	8	3.9
More than once an hour	1	0.5	1	0.5
	205	100.0	203	100.0
Posting asynchronous lectures				
Never	112	56.0	38	18.7
Once a month	30	15.0	15	7.4
Once a week	41	20.5	75	37.0
Once a day	16	8.0	68	33.5
Once an hour	0	0.0	5	2.5
More than once an hour	1	0.5	2	1.0
	200	100.0	203	100.0
Posting synchronous lectures				
Never	146	76.8	70	36.1
Once a month	13	6.8	12	6.2
Once a week	17	9.0	56	28.9
Once a day	14	7.4	50	25.8
Once an hour	0	0.0	5	2.6
More than once an hour	0	0.0	1	0.5
	190	100.0	194	100.0
Posting grades				
Never	34	16.8	18	8.9
Once a month	27	13.3	29	14.3
Once a week	101	49.8	94	46.3
Once a day	31	15.3	50	24.6
Once an hour	6	3.0	8	3.9
More than once an hour	4	2.0	4	2.0
	203	100.0	203	100.0
Other				
Never	13	81.3	13	76.5
Once a month	1	6.3	1	5.9
Once a week	1	6.3	1	5.9
Once a day	1	6.3	1	5.9
Once an hour	0	0.0	0	0.0
More than once an hour	0	0.0	1	5.9
	16	100.0	17	100.0

were amongst the most popular online collaboration tools in March 2020, the beginning of the Covid-19 pandemic. It is encouraging we observed increased faculty adoption of these features to facilitate communication with students.

We feel our data reflects one of the factors affecting the theory of DOI, complexity, or how difficult an innovation is to understand or use (Rogers, 2003). Our survey was distributed from early September to mid-October 2020, approximately six months after Covid-19 forced the adoption of online teaching and learning. As many faculty were balancing their personal struggles with the pandemic in addition to teaching and transitioning their courses to an online format, it is likely they first adopted the simplest innovations for the sake of time. Thus, those software and LMS features adopted at higher rates in our study were likely the least complex and easiest for faculty to understand.

Faculty reporting plans for continued adoption of software that was not utilized in courses prior to Covid-19 is displayed in Table 5. More than half of faculty (53.2%) reported their intent to continue using video conferencing software in courses after Covid-19. Many (24.2%) also reported an intent to use video and audio recording software, presumably to record and post lectures as stand-alone or supplemental materials. Further, 22.8% intend to adopt LMS software; we were surprised this intent was so high as it indicates many of our respondents did not utilize LMS software in their courses before Covid-19 but found value in it. Cumulatively, our data indicate that Covid-19 facilitated faculty discovery of educational tools that have value for their classrooms but were previously untapped resources.

Faculty must become comfortable teaching online. Before Covid-19 forced adoption of online classrooms, the number of students enrolled in online courses in the United States was increasing and estimated to continue to do so. In Fall 2013, 5.5 million students were enrolled in at least one online course at a post-secondary institution (Walter et al., 2017). Clearly, this number has increased dramatically as a result of Covid-19. Before the Covid-19 pandemic, factors that impacted faculty perception of online teaching included the high workload required before and during delivery of course content (Conciecao, 2006). Covid-19 forced faculty to undertake this workload, effectively removing that as a barrier to faculty instructing online courses in the future. If online courses become more prevalent in higher education after mitigation of Covid-19, it will be increasingly important that faculty effectively integrate software in their courses. In a study by Thapa et al. (2020), 82% of post-secondary agricultural students reported that Covid-19 negatively impacted their education, although the underlying reasons were not clear. Previous researchers suggest that student engagement in online environments will be higher if faculty integrate online tools into their curriculum for a specific, rather than general, purpose; for example, to provide detailed feedback, design simulations, use concept maps, or create word processing exercises (Schmid et al., 2014). Hopefully, as faculty and students become more experienced with online education and comfortable with integrating and utilizing software in the classroom, the above cited perceived negative impact will diminish, and the same or higher level of pre-Covid-19 student engagement and quality of education will be achieved. This relates to two of the five factors that influence adoption of an innovation within context of the DOI theory: trialability and observability (Rogers, 2003). We hypothesize that, as faculty gain experience with online teaching and share "lessons learned" with each other, they will trial new software and LMS features in their courses, which will ultimately encourage adoption in future semesters. It would be interesting to re-distribute our study in the future to assess the long-term impacts of the pandemic on software and LMS adoption in the post-secondary agricultural classroom.

Table 5. Software and Learning Management Software (LMS) features faculty did not use prior to COVID-19 but will incorporate in future courses

	Frequency	Percent
Video conferencing software	142	53.2
Video and audio recording software	64	24.0
Polling software that utilizes an application	32	12.0
LMS	61	22.8
Messaging applications	24	9.0
Collaborative software	54	20.2
Conventional email	51	19.1
Video email	9	3.4
Other	6	2.2

Summary

The Covid-19 pandemic limited social and physical interactions, effectively forcing adoption of online teaching and learning for educators and students at all levels of the education system. To capture faculty's response to Covid-19, we evaluated adoption of software in the post-secondary agricultural classroom. Overall, these data documented a major increase in adoption of software and LMS features for teaching as a result of Covid-19. Further, our data demonstrates that the forced adoption of software shifted how faculty intend to conduct their courses moving forward, even when we return to face-to-face instruction. This highlights that Covid-19 has likely permanently altered the landscape of higher education such that we will have an increased reliance on software in the online and face-to-face classroom. We recommend that future research should assess effective strategies for software integration in the post-secondary agricultural classroom with a focus on the software that our respondents adopted or intend to adopt as a result of Covid-19.

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