

Learning Management Software (LMS) For Teaching Agricultural Sciences: The Role of Age in Faculty's Adoption Before and During COVID-19

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Abstract

Public health guidance during Covid-19 required educators to transition their face-to-face courses to online platforms. Accordingly, faculty adopted technology into their pedagogy to maintain continuity in the online classroom. The objective of our study was to determine how time, age (Millennial versus Generation X versus Baby Boomer), and the interaction of time and age impacted post-secondary faculty adoption of LMS for teaching agricultural sciences before and during Covid-19. Our data indicate that general LMS use for teaching significantly increased during Covid-19. Faculty from the Baby Boomer and Generation X generations, overall, used LMS for teaching less often than Millennial faculty; however, when analyzing use only during Covid-19, there were not differences between generations. Cumulatively, this indicates that Millennial faculty are more likely to voluntarily adopt LMS for teaching but that faculty from previous generations will adapt and use LMS when conditions necessitate it. We observed similar outcomes for the use of LMS to facilitate certain classroom functions (e.g., post PowerPoint slides and grades). To ensure proper use of LMS, post-secondary institutions should invest in training for faculty. This training should be geared towards the learning style and technological competency of Baby Boomer and Generation X, rather than Millennial, faculty.

Introduction

In March 2020, the novel coronavirus, Covid-19, was declared a global pandemic (WHO, 2020). The virus spread quickly with the number of reported cases in the United States spiking from November 2020 to January 2021 (CDC, 2021). Covid-19 continues to challenge society; at the time of writing (August 2021), there were approximately 45,000 new cases in the United States in the past week for a total of 34.4 million cases since the onset of the pandemic (CDC, 2021). To slow the spread of Covid-19, the Centers for Disease Control (CDC) and World Health Organization (WHO) released guidance and recommendations for the public, such as quarantining, "social distancing", wearing a mask, and sanitizing surfaces. These precautions, which effectively discouraged physical interactions with those outside of one's immediate household, caused most institutions to halt physical operations and move to online platforms.

Educational institutions were greatly impacted by Covid-19 as instruction was typically delivered in a face-to-face format that was impossible to continue whilst obeying guidance from public health officials. Thus, educators adapted to online learning and rapidly transitioned their face-to-face courses online (Murphy, 2020), requiring them to navigate new technologies in a short timeline often without prior knowledge or training (Benito et al., 2021). Before the pandemic, many post-secondary institutions had already integrated online learning into their mission and strategic plans (Walters et al., 2017). Undoubtedly, Covid-19 accelerated the implementation of online learning at the post-secondary level with potential lasting impacts,

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such that online courses will be offered at a higher rate after rather than before the pandemic.

Faculty are often given latitude in how they conduct courses; this remained true during Covid-19. Previous data indicate that faculty teaching agricultural sciences adopted Learning Management Software (LMS) systems (e.g., CANVAS or TRACS) for teaching during the pandemic (Tasci et al., 2021); however, it was not determined if age impacted their decision to use LMS during Covid-19. As the millennial generation is currently matriculating into faculty positions and have functioned in a more technologically rich environment than previous generations (Sandeem, 2008), they may be more likely to adopt LMS for teaching than their older counterparts. It is critical to determine if faculty age affected adoption of LMS for teaching during Covid-19 to identify populations which could benefit from targeted training and/or resources to maximize their effectiveness in using LMS for teaching.

Theoretical Framework

The Technology Acceptance Model (TAM) and TAM 2 guided our study. These theoretical frameworks explain behaviors and decision-making surrounding technology adoption (Davis, 1986), especially as these behaviors relate to perceived usefulness and perceived ease of use of that technology (Venkatesh and Davis, 2000). Perceived usefulness is the degree to which a person believes a given technology will enhance their job performance (Davis, 1993). Perceived ease of use is how easy that technology is to use or understand (Rogers, 1983; Zeithaml et al., 2002); the output or advantage from use should outweigh the effort to use it. Further, TAM 2 incorporates different factors that determine if an individual will adopt or reject a given technology. Two of these factors are 1) voluntariness, or the extent to which potential adopters perceive their adoption as non-mandatory (Venkatesh and Davis, 2000), and 2) demonstrability of results, or how the outcome of using the technology will directly influence perceived usefulness of it over time (Moore and Benbasat, 1991).

Although older adults are adopting technology at increased rates (Anderson and Perrin, 2017; Matlabi et al., 2012; McCausland and Falk, 2012; Uei et al., 2013), it is more difficult for them to use these technologies (Anderson and Perrin, 2017; Gitlow, 2014) and adapt to abrupt changes in the workplace (Dalton and Thompson, 1971) than younger adults. Thus, they are more resistant to accepting new technology than their younger counterparts (Chen and Chan, 2014) and tend to use familiar methods to complete tasks or solve problems (Dalton and Thompson, 1971). This relates to TAM and TAM 2 because age is closely related to a worker's job-related attitudes, preferences, and behaviors (Rhodes, 1983), all of which could affect perceived usefulness or perceived ease of use of technology (McFarland, 2001) under the scope of TAM and TAM 2.

In the context of our study, technology adoption for teaching during the pandemic may have been driven by the abrupt mid-semester need to transition courses to an online format. Before the pandemic, faculty often used LMS

for teaching, largely on a voluntary basis. It is interesting to evaluate how this use changed during Covid-19, when adoption was perhaps no longer voluntary but necessary, with consideration to faculty age. As there is a demonstrable relationship between age and perceived usefulness or perceived ease of use of technology, in addition to the unique lack of voluntariness in adopting technology for communication during Covid-19, we used TAM and TAM 2 to guide our inquiry and inform our interpretation of the data.

Purpose and Objectives

The purpose of our study was to address the National Research Agenda of the American Association for Agricultural Education's Research Priority 4: "Meaningful, Engaged Learning in All Environments" with a specific focus on digital technologies in online learning environments (Roberts, et al., 2016). As faculty used technology more often for teaching during Covid-19 (Carrasco et al., 2021; Tasci et al., 2021) and 23% of those who did not previously use LMS in their classrooms indicated they will use it in future semesters not affected by the pandemic (Tasci et al., 2021), it is imperative that faculty receive effective training in these technologies. Accordingly, the specific objective of our study was to determine how time, age (Millennial versus Generation X versus Baby Boomer), and the interaction of time and age impacted faculty adoption of LMS for teaching before and during Covid-19. As learning style and technological competency varies between generations (Urlick, 2016), our findings may identify populations who require targeted training and resources to ensure proper use of LMS for teaching, thus maximizing effectiveness in the online and face-to-face classroom.

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. We identified a total population of 1,795 faculty and instructors, our participants were identified by searching college and departmental websites in the target states, conducted in summer 2020. A sample size calculator determined that we needed a sample size of 317 participants to establish a 95% \pm 5 confidence interval. These participants were selected using a random number generator.

Data was collected using a researcher-developed instrument that contained five sections. The data presented here are from Section 1, which consisted of nine questions including personal and institutional demographics, and

Section 3, which consisted of eight questions related to the use of LMS, including taking attendance, administering assignments, tests and quizzes, messaging students, posting PowerPoints and lectures, and posting grades before and as a result of Covid-19.

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 ($\alpha = 0.790$) 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 the 317 randomly selected 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, descriptive statistics were calculated for the demographic characteristics of the participants and their institutions of employment. Using R Core Team (2018), an Ordered Logit Model was used to analyze how time, age, and the interaction of time and age impacted faculty adoption of LMS before and during Covid-19. As the responses to our questions were categorical, our data was not normally distributed. Further, our dependent variable was ordinal rather than continuous. Accordingly, the Ordered Logit Model is an appropriate analytical method (Williams, 2016). The dependent variable for our analysis was LMS use and the independent variables were age (categorized into generation); a time indicator variable with a value of 1 if the

observation was during Covid-19 and of 0 if the observation was before Covid-19; and an interaction of age and the time indicator variable. We established statistical significance as $P \leq 0.05$.

An ordered logit model is appropriate when there is an ordinal dependent variable, represented by Y . The dependent variable is a function of the non-measurable variable Y^* . This latent variable Y^* has various threshold values which determine the observed Y variable. If there are three categories of Y variables, then:

$$\begin{aligned} Y_i &= 1 \text{ if } Y_i^* \leq k_1 \\ Y_i &= 2 \text{ if } k_1 < Y_i^* \leq k_2 \\ Y_i &= 3 \text{ if } Y_i^* > k_2 \end{aligned}$$

A rational consumer chooses a category that maximizes their utility. For example, the consumer will choose category j over category k if the utility from category j is greater than that from category k . Thus, the probability individual i will choose category j if the utility from category j is greater than category k is expressed as:

$$P(Y_i > Y_j) = \frac{\exp(X_i \beta - k_j)}{1 + [\exp(X_i \beta - k_j)]}$$

Where, X_i = explanatory variables (e.g., age, time, interaction of age and time) and β = the coefficient associated with the explanatory variables.

Results and Discussion

The demographics of our sample population ($n = 255$) are in Table 1. A majority of respondents identified as male (62.6%), were White or Caucasian (81.9%), and/or held a Doctoral degree (84.6%). The three date ranges in which most of our respondents were born were 1981-1996 (23.1%), 1965-1980 (36.9%), or 1946-1964 (38.0%). These ranges correspond with different generations: Millennials, Generation X, or Baby Boomers, respectively. As the overwhelming majority of our respondents fell within these three generations, we opted to only use these in further analysis, disregarding faculty who were born from 1928-1945 (1.6%), representing the Silent Generation, or preferred not to disclose the year in which they were born (0.4%).

Most of our respondents worked at an 1862 Land-Grant (52.2%) or Regional (30.3%) institution (Table 2). There was a fairly even representation of respondents who were employed as Full Professors (34.6%), Associate Professors (25.2%), or Assistant Professors (26.4%) with the remaining employed as either Lecturers (3.9%), Instructors (7.9%), and Adjuncts (2.0%). We asked respondents how many years of experience they had teaching at the post-secondary level: 22.4% had taught 5 or fewer years, 21.4% had taught 6-11 years, 16.4% had taught 12-19 years, 20.4% had taught 20-29 years, and 19.0% had taught 30+ years. The goal of our distribution strategy was to reach respondents in states throughout the Southern region, with respect to the defined regions of the North American Colleges and Teachers of Agriculture (NACTA). The majority of our respondents were employed in Texas (55.9%), Arkansas (14.6%), or Georgia

Table 1. Demographics of sample population

	Percent
Gender identity	
Male	62.6
Female	37.4
Date range born, generation	
1981-1996, Millennial	23.1
1965-1980, Generation X	36.9
1946-1964, Baby Boomer	38.0
1928-1945, Silent Generation	1.6
Prefer not to disclose	0.4
Ethnic identity	
Asian	4.6
Black or African American	3.5
Hispanic or Latino	4.2
White or Caucasian	81.9
Other	2.3
Prefer not to disclose	1.9
Highest degree	
Doctoral	84.6
Masters	12.7
Bachelors	1.2

(13.8%). All respondents taught courses under the umbrella of Agricultural Sciences.

We asked respondents about their general use of LMS for teaching before and during Covid-19, then asked more specifically about their use of certain LMS features. Use of LMS for teaching was our dependent variable. "Time" was one of our independent variables and was categorized as either "before" or "during" Covid-19. As our survey was available from September to October 2020, our respondents' responses "during Covid-19" reflect their use of LMS for teaching in the second half of the spring 2020, entire summer 2020, and/or early fall 2020 semesters. Our other independent variable, age, refers to faculty age categorized into generation (Millennial, Baby Boomer, or Generation X). Accordingly, our findings are presented as: how time (before or during Covid-19) affected faculty use

Table 2. Academic demographics of sample population and institution

	Percent
Academic title	
Full Professor	34.6
Associate Professor	25.2
Assistant Professor	26.4
Lecturer	3.9
Instructor	7.9
Adjunct	2.0
Years teaching in higher education	
2-5	22.4
6-11	21.4
12-19	16.4
20-29	20.4
30+	19.0
Institution classification	
1862 Land-Grant	52.2
1890 Land-Grant	8.0
Regional	30.3
Private Four-year College or University	4.4
Two-Year College	5.2
State institution is located	
Alabama	4.3
Arkansas	14.6
Florida	1.6
Georgia	13.8
Louisiana	7.5
Mississippi	2.4
Texas	55.9

of LMS for teaching; how age (categorized into generation)

affected faculty use of LMS for teaching; and how the combined effect of time and age affected faculty use of LMS for teaching.

For general LMS use, there was a statistically significant increase in faculty use of LMS for teaching during versus before Covid-19 (Table 3). When considering the effect of faculty age on the use of LMS for teaching both before and during Covid-19, we observed that Baby Boomer or Generation X faculty used LMS significantly less often than Millennial faculty and there was not a difference between Baby Boomer and Generation X faculty. Our interaction term, time \times age, allowed us to discern if the effect of faculty age on total LMS use was sustained as a result of the pandemic. We observed that these interaction effects were not statistically significant.

Ultimately, these data indicate that faculty used LMS more often during Covid-19 than before. Pre-pandemic, Millennial faculty used LMS for teaching more often than their Baby Boomer or Generation X counterparts. However, during Covid-19, faculty age did not affect LMS use. Our a priori hypothesis was that Millennial faculty would use LMS for teaching more than Baby Boomer or Generation X faculty, which was confirmed with our pre-pandemic data. However, we did not anticipate a similar percentage of faculty, regardless of age, to use LMS for teaching during Covid-19. These data align with the TAM 2 model, which explains the use of technology as it relates to voluntariness. Faculty likely did not perceive a voluntariness in adopting technology in their classrooms, which were shifted from face-to-face to online, during the pandemic. Thus, adoption of LMS for teaching may have been forced for older faculty

who had not already implemented this technology in their pre-pandemic classrooms, resulting in the similar general use of LMS we observed across generations. Given these findings – that Baby Boomer and Generation X faculty used LMS for teaching during Covid-19 but lacked the pre-pandemic experience of Millennial faculty – we recommend institutions provide training and resources tailored to the learning style of Baby Boomer and Generation X generations. While LMS training and support is important during Covid-19, it has implications for the post-pandemic classroom as previous data indicate that 23% of faculty who did not use LMS in their classrooms before Covid-19 intend to adopt it in future semesters (Tasci et al., 2021).

We asked faculty about their use of LMS features to post videos of synchronous and asynchronous lectures before and during Covid-19 (Table 4). For both, there was a significant effect of time such that faculty used LMS platforms to post videos of synchronous lectures 10.45 times as often and videos of asynchronous lectures 7.82 times as often during Covid-19 as compared to before the pandemic. This was expected – for synchronous lectures, it is likely faculty delivered these via Zoom or another platform that has a video recording option, thus facilitating recording the lecture and posting it for students who were unable to attend or wanted to re-watch the lesson. For asynchronous lectures, faculty were likely delivering content synchronously before Covid-19; as a result of the pandemic and transition to online instruction, they may have opted to shift their classroom to an asynchronous modality to allow students flexibility in progressing through the course content or, simply, because they were not confident nor

Table 3. The effect of time, faculty age, and the interaction between time and age on overall use of Learning Management Software (LMS) systems before and during Covid-19²

	Coefficient (std error)		Coefficient (std error)
Time [Base: Before Covid-19]			
During Covid-19	1.94 (0.39)*		
Age [Base: Millennial]		Age [Base: Generation X]	
Baby Boomer	0.33 (0.35)*	Millennial	2.12 (0.35)*
Generation X	0.47 (0.35)*	Baby Boomer	0.69 (0.29)
Time \times Age [Base: Before Covid-19 \times Millennial]		Time \times Age [Base: Before Covid-19 \times Generation X]	
During Covid-19 \times Baby Boomer	1.16 (0.15)	During Covid-19 \times Millennial	1.18 (0.49)
During Covid-19 \times Generation X	0.85 (0.49)	During Covid-19 \times Baby Boomer	1.37 (0.41)
Sample size	250	Sample size	250
AIC	1215.90	AIC	1215.90

²Models are differentiated on the base chosen, as specified in brackets
 *denotes statistical significance determined at 95% probability level

Table 4. The effect of time, faculty age, and the interaction between time and age on use of Learning Management Software (LMS) systems to post synchronous and asynchronous lectures before and during Covid-19²

LMS use to post synchronous lectures			
	Coefficient (std error)		Coefficient (std error)
Time [Base: Before Covid-19]			
During Covid-19	10.45 (0.51)*		
Age [Base: Millennial]		Age [Base: Generation X]	
Baby Boomer	1.74 (0.49)	Millennial	0.90 (0.52)
Generation X	1.11 (0.52)	Baby Boomer	1.57 (0.39)
Time × Age [Base: Before Covid-19 × Millennial]		Time × Age [Base: Before Covid-19 × Generation X]	
During Covid-19 × Baby Boomer	0.31 (0.60)	During Covid-19 × Millennial	1.08 (0.62)
During Covid-19 × Generation X	0.93 (0.62)	During Covid-19 × Baby Boomer	0.33 (0.49)
Sample size	250	Sample size	250
AIC	866.14	AIC	866.14
LMS use to post asynchronous lectures			
	Coefficient (std error)		Coefficient (std error)
Time [Base: Before Covid-19]			
During Covid-19	7.82 (0.41)*		
Age [Base: Millennial]		Age [Base: Generation X]	
Baby Boomer	0.92 (0.36)	Millennial	1.11 (0.37)
Generation X	0.90 (0.37)	Baby Boomer	1.01 (0.32)
Time × Age [Base: Before Covid-19 × Millennial]		Time × Age [Base: Before Covid-19 × Generation X]	
During Covid-19 × Baby Boomer	0.67 (0.50)	During Covid-19 × Millennial	1.06 (0.51)
During Covid-19 × Generation X	0.95 (0.51)	During Covid-19 × Baby Boomer	0.70 (0.43)
Sample Size	250	Sample Size	250
AIC	1036.26	AIC	1036.26

²Models are differentiated on the base chosen, as specified in brackets

*denotes statistical significance determined at 95% probability level

willing to navigate the technological demands of an online, synchronous course without adequate training or planning. There was not an effect of faculty age on the overall use of LMS to post synchronous or asynchronous lectures before and during Covid-19. Similarly, we did not observe a statistically significant time \times age effect. These data indicate that, even pre-pandemic, faculty age did not play a role in their use of LMS platforms to post lectures. However, given the large observed increase in use of these LMS features across generations, we recommend future training and resources should incorporate and emphasize best practices of posting lectures on LMS platforms to ensure student accessibility is adequate.

It is common to use LMS for communicating with students; these features become especially important in an online environment. Favale et al. (2020) reported that online individual and group messaging applications were among the most popular collaboration tools for workers during early phases of the pandemic. Accordingly, we asked faculty about their use of LMS features to send students individual or group messages before and during Covid-19 (Table 5). For individual messages, there was a significant effect of time such that faculty used LMS to send individual messages 1.89 times more often during versus before Covid-19. We did not observe the same outcome for group messages; there was no difference in use of LMS to send group messages before versus during Covid-19. It is not surprising faculty used LMS to send individual messages to students more often during the pandemic; in an online environment, the opportunity for face-to-face instruction or physical office hours is limited. A case study published early during Covid-19 recommended that faculty provide students in online courses with sufficient support in the form of electronic communication outside of class hours (Bao, 2020). Indeed, there is a positive relationship between student outcomes and increased interaction in online courses (Bernard et al., 2009), underlining the importance of using LMS and other technologies to interact with students in online courses. We were surprised, then, that we did not observe more faculty reporting they used LMS to send group messages during Covid-19. Previous data indicate post-secondary faculty teaching agricultural sciences adopted social media (Carrasco et al., 2021) and messaging applications (Tasci et al., 2021), such as GroupMe, for teaching as a result of Covid-19; perhaps this is how faculty approached group communication instead of using LMS features.

There was not an effect of faculty age on overall use of LMS features to send individual messages (Table 5). Similarly, we did not observe generational differences in LMS use to send individual messages during Covid-19 (time \times age interaction). However, there was an age effect on overall LMS use to send group messages. Specifically, Baby Boomers sent group messages through LMS platforms 2.78 times more often than Millennial faculty. This statistical difference did not persist during Covid-19 as we did not observe a significant time \times age interaction effect for group messages. We hypothesize Baby Boomer faculty used LMS for group messaging more frequently due to their perceived ease of use of this technology under the scope of the TAM

model. As most educational institutions had LMS platforms in place before Covid-19, older faculty may have gravitated towards using these to communicate with students before the pandemic whereas Millennial faculty may have used GroupMe or similar social media applications that have been readily adopted by students in recent years. Group messaging provides undergraduate students with peer support (Apgar, 2020) which, when combined with other forms of support, is significantly related to a student's overall satisfaction of an online course (Lee et al., 2011). In a non-pandemic context, student support is paramount to the learning experience in an online classroom. However, with the additional challenges and burdens that Covid-19 placed on students (Harries et al., 2021; Ma and Miller, 2020), the importance of this support was intensified. It is unclear if our data indicate that Millennial faculty were not sending group messages before Covid-19 or simply opting to use non-LMS platforms that had perceived ease of use or demonstrability of results, such as GroupMe. Accordingly, we recommend follow-up research on student preference of messaging platforms to facilitate classroom communication (LMS versus non-LMS) and what messaging platforms faculty from different generations used to communicate with their students during Covid-19. These data could be combined with ours to determine if training in LMS versus non-LMS messaging platforms should be provided to faculty and for which generation the training should be tailored to.

We asked faculty about their use of LMS features to post PowerPoint slides and grades (Table 6). For both, there was not a significant effect of time, indicating faculty use did not change during the Covid-19 pandemic. Interestingly, however, we noticed an age effect: Baby Boomers used LMS features to post PowerPoint slides and grades less often than Millennials when considering use both before and during Covid-19. As with our data for group messages, the statistical difference between Baby Boomers and Millennials did not persist during the pandemic as we did not observe a significant time \times age interaction for posting either PowerPoint slides or grades. These data parallel those of general LMS use – older faculty did not perceive a voluntariness in adopting LMS features such as PowerPoint and posting grades in their online classrooms during the pandemic. Accordingly, Baby Boomers would benefit from targeted training in using LMS to post PowerPoint slides and grades as many adopted these features for the first time during Covid-19.

We also asked respondents about their use of LMS features to take attendance, post assignments, and administer quizzes (Table 7). For taking attendance, we did not observe an effect of time, age, or time \times age on use before or during Covid-19. However, for posting assignments and administering quizzes through LMS systems, there was a significant increase of faculty use during the pandemic. Specifically, faculty used LMS to post assignments 3.44 times as often and to administer quizzes 5.48 times as often during versus prior to the Covid-19 pandemic. We hypothesize this is a consequence of the pandemic restricting the ability of faculty to physically hand out assignments or proctor quizzes in-person, both of which are intrinsic components of a course used to monitor student

Table 5. The effect of time, faculty age, and the interaction between time and age on use of Learning Management Software (LMS) systems to send individual and group messages before and during Covid-19²

LMS use to send individual messages			
	Coefficient (std error)		Coefficient (std error)
Time [Base: Before Covid-19]			
During Covid-19	1.89 (0.38)*		
Age [Base: Millennial]		Age [Base: Generation X]	
Baby Boomer	1.34 (0.35)	Millennial	0.69 (0.35)
Generation X	1.45 (0.35)	Baby Boomer	0.92 (0.29)
Time × Age [Base: Before Covid-19 × Millennial]		Time × Age [Base: Before Covid-19 × Generation X]	
During Covid-19 × Baby Boomer	1.18 (0.48)	During Covid-19 × Millennial	0.98 (0.49)
During Covid-19 × Generation X	1.02 (0.48)	During Covid-19 × Baby Boomer	1.15 (0.42)
Sample size	250	Sample size	250
AIC	1094.01	AIC	1094.01
LMS use to send group messages			
	Coefficient (std error)		Coefficient (std error)
Time [Base: Before Covid-19]			
During Covid-19	1.69 (0.38)		
Age [Base: Millennial]		Age [Base: Generation X]	
Baby Boomer	2.78 (0.37)*	Millennial	0.59 (0.38)
Generation X	1.70 (0.38)	Baby Boomer	1.64 (0.30)
Time × Age [Base: Before Covid-19 × Millennial]		Time × Age [Base: Before Covid-19 × Generation X]	
During Covid-19 × Baby Boomer	1.01 (0.51)	During Covid-19 × Millennial	1.29 (0.53)
During Covid-19 × Generation X	0.77 (0.53)	During Covid-19 × Baby Boomer	1.31 (0.43)
Sample size	250	Sample size	250
AIC	1002.08	AIC	1002.08

²Models are differentiated on the base chosen, as specified in brackets

*denotes statistical significance determined at 95% probability level

Table 6. The effect of time, faculty age, and the interaction between time and age on use of Learning Management Software (LMS) systems to post PowerPoint slides and grades before and during Covid-19²

LMS use to post PowerPoint slides			
	Coefficient (std error)		Coefficient (std error)
Time [Base: Before Covid-19]			
During Covid-19	1.55 (0.41)		
Age [Base: Millennial]		Age [Base: Generation X]	
Baby Boomer	0.46 (0.35)*	Millennial	1.55 (0.36)
Generation X	0.64 (0.36)	Baby Boomer	0.71 (0.29)
Time × Age [Base: Before Covid-19 × Millennial]		Time × Age [Base: Before Covid-19 × Generation X]	
During Covid-19 × Baby Boomer	1.17 (0.50)	During Covid-19 × Millennial	1.08 (0.51)
During Covid-19 × Generation X	0.92 (0.51)	During Covid-19 × Baby Boomer	1.27 (0.42)
Sample size	250	Sample size	250
AIC	1044.27	AIC	1044.27
LMS use to post grades			
	Coefficient (std error)		Coefficient (std error)
Time [Base: Before Covid-19]			
During Covid-19	1.76 (0.39)		
Age [Base: Millennial]		Age [Base: Generation X]	
Baby Boomer	0.37 (0.36)*	Millennial	1.59 (0.36)
Generation X	0.63 (0.36)	Baby Boomer	0.58 (0.30)
Time × Age [Base: Before Covid-19 × Millennial]		Time × Age [Base: Before Covid-19 × Generation X]	
During Covid-19 × Baby Boomer	1.03 (0.49)	During Covid-19 × Millennial	1.20 (0.50)
During Covid-19 × Generation X	0.83 (0.50)	During Covid-19 × Baby Boomer	1.23 (0.43)
Sample size	250	Sample size	250
AIC	1117.85	AIC	1117.85

²Models are differentiated on the base chosen, as specified in brackets

*denotes statistical significance determined at 95% probability level

Table 7. The effect of time, faculty age, and the interaction between time and age on use of Learning Management Software (LMS) systems to take attendance, administer assignments, and administer quizzes before and during Covid-19²

LMS use to take attendance			
	Coefficient (std error)		Coefficient (std error)
Time [Base: Before Covid-19]			
During Covid-19	1.55 (0.43)		
Age [Base: Millennial]		Age [Base: Generation X]	
Baby Boomer	1.13 (0.39)	Millennial	1.24 (0.42)
Generation X	0.81 (0.42)	Baby Boomer	1.39 (0.35)
Time × Age [Base: Before Covid-19 × Millennial]		Time × Age [Base: Before Covid-19 × Generation X]	
During Covid-19 × Baby Boomer	0.85 (0.53)	During Covid-19 × Millennial	1.07 (0.56)
During Covid-19 × Generation X	0.93 (0.56)	During Covid-19 × Baby Boomer	0.91 (0.22)
Sample size	250	Sample size	250
AIC	863.78	AIC	863.78
LMS use to administer assignments			
	Coefficient (std error)		Coefficient (std error)
Time [Base: Before Covid-19]			
During Covid-19	3.44 (0.40)*		
Age [Base: Millennial]		Age [Base: Generation X]	
Baby Boomer	0.52 (0.36)	Millennial	1.76 (0.36)
Generation X	0.57 (0.44)	Baby Boomer	0.91 (0.31)
Time × Age [Base: Before Covid-19 × Millennial]		Time × Age [Base: Before Covid-19 × Generation X]	
During Covid-19 × Baby Boomer	0.91 (0.49)	During Covid-19 × Millennial	0.93 (0.50)
During Covid-19 × Generation X	1.08 (0.50)	During Covid-19 × Baby Boomer	0.84 (0.43)
Sample size	250	Sample size	250
AIC	1065.37	AIC	1065.37

²Models are differentiated on the base chosen, as specified in brackets

*denotes statistical significance determined at 95% probability level

Table 7 con't.

LMS use to administer quizzes			
	Coefficient (std error)		Coefficient (std error)
Time [Base: Before Covid-19]			
During Covid-19	5.48 (0.42)*		
Age [Base: Millennial]		Age [Base: Generation X]	
Baby Boomer	0.58 (0.37)	Millennial	1.31 (0.37)
Generation X	0.76 (0.37)	Baby Boomer	0.77 (0.31)
Time × Age [Base: Before Covid-19 × Millennial]		Time × Age [Base: Before Covid-19 × Generation X]	
During Covid-19 × Baby Boomer	0.83 (0.51)	During Covid-19 × Millennial	1.41 (0.53)
During Covid-19 × Generation X	0.71 (0.52)	During Covid-19 × Baby Boomer	1.16 (0.43)
Sample size	250	Sample size	250
AIC	1012.17	AIC	1012.17
^a Models are differentiated on the base chosen, as specified in brackets [*] denotes statistical significance determined at 95% probability level			

progress and are, thus, critical to faculty in a face-to-face or online classroom. Age did not factor into faculty use of LMS features to post assignments or administer quizzes, nor was there an effect from the interaction of age and time. As with our data about the use of LMS to post lectures, we recommend training should emphasize LMS use to post assignments and quizzes given the unilateral increase in use of these features we observed for all generations during Covid-19.

Limitations

Our study is limited in that we considered age, time, and the interaction of age and time as the only factors driving faculty use of LMS. Certainly, other factors (e.g., attitudes toward LMS, institutional expectations toward LMS use, training and resources provided by the institution, the specific LMS platform adopted by the institution and its perceived ease of use, course load, course size, course design) could have also played a role in faculty adoption of LMS for teaching before and during Covid-19. These additional factors would be interesting to explore with the existing dataset. Further, our study was conducted in the early stages of Covid-19 (September-October 2020) and faculty may have still been struggling to transition their courses online and/or balance the disruptions Covid-19 introduced to their personal lives and had not yet fully explored technology, such as LMS, to maximize their effectiveness in the online classroom. Follow-up analyses

would, thus, be interesting as faculty have now had more experience teaching online while Covid-19 continues to linger and affect educational institutions.

Conclusion

Covid-19 required post-secondary educational institutions to adopt online learning. As a result, faculty adapted their pedagogy to include technology to overcome the communication and educational barriers that were presented by online learning. For many faculty, this was the first time they were teaching online and/or integrating certain technology into their classrooms. Our study evaluated how time (before or during Covid-19), age (Millennial, Generation X, or Baby Boomer), and the interaction of time and age affected faculty's use of LMS for teaching. Without regard to generation, faculty increased their general LMS use and use of certain LMS features during Covid-19, indicating the pandemic caused faculty to rely more heavily on technology for teaching. However, our analysis indicated Millennial faculty used LMS more often than their Baby Boomer or Generation X counterparts before Covid-19, likely equipping them with the experience necessary to effectively integrate LMS into their online courses.

Ultimately, these findings suggest that targeted trainings should be developed with consideration to the specific learning style and technological competency of Baby Boomer and Generation X faculty as they had less pre-pandemic experience with LMS than their Millennial

counterparts. These trainings should assist them in building their LMS courses and maximizing available features, especially posting course content and grades. This support is timely as we anticipate online learning will be more prevalent in the wake of Covid-19.

Future research should build on our data, including student satisfaction with faculty use of LMS, student preference for LMS versus non-LMS messaging platforms, generational differences in specific LMS versus non-LMS messaging platforms used by faculty, and how LMS use has changed as we emerge from Covid-19. If it is observed that LMS is being used more frequently after Covid-19, this would indicate that faculty's perceived ease of use has changed over time, likely due to demonstrability of results from the non-voluntary use of LMS during the pandemic.

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