FEATURES OF AND STUDENT RESPONSES TO MICROSOFT TEAMS AS A LEARNING MANAGEMENT SYSTEM

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INTRODUCTION

A wide range of digital computing tools are used by chemical engineers and chemical engineering students. More general tools, such as spreadsheets, mathematical solvers, and programming languages, are easily adapted to chemical engineering problems in both professional and educational settings. More specific tools for chemical engineers include process simulation, computational fluid dynamics, molecular simulation, and multiphysics tools. The overall usage of computing tools in chemical engineering education was recently reviewed as part of a national survey,[1] and a special issue in 2020 highlighted cyber-assisted chemical engineering education.[2] However, learning management systems, the application of interest in this paper, were not included in these contributions.

A learning management system (LMS) fills numerous roles, has changed over many years, and has an evolving definition.[3, 4] Storing and organizing content have been the primary function, which usually included documents, like the syllabus, and homework assignments. Next, as a secure platform that adheres to regulations, including the Family Educational Rights and Privacy Act (FERPA), the LMS allowed grades to be shared with individual students efficiently. New features and tools have continuously been added and include auto-graded homework/quiz environments for multiple choice, numeric, and other auto-graded formats. In addition, documents could be submitted via the LMS, which saves class time when both collecting and returning assignments. The growth of online courses added features including video storage, web calling, and cloud-based file storage. More recently and spurred by campus closures due to COVID-19, both asynchronous and synchronous online courses, office hours, and all facets of many engineering courses were shifted to the LMS or a suite of tools, such as Zoom® or WebEx®.

With the shift from a secure content depository to a multifunctional platform, the LMS has seeded a number of studies on student engagement and usage for engineering classes. Examples include examining student success on auto-graded homework problems [5, 6] and learning analytics related to enrollment and interventions to improve student success.[7, 8] Specifically for chemical engineering, some recent papers highlighted the dependence of faculty and students on LMSs for remote coursework.[9-11]

Another relevant topic of computing and chemical engineering is training students with industrially relevant tools.[12] Spreadsheets and mathematical solvers have been integrated over many years.[13] Simulation tools for either transport (e.g., computation fluid dynamics) or design (e.g., process simulators) are also used in the chemical engineering curriculum.[14] Similarly, coding has included departments using Microsoft Visual Basic®, FORTRAN, C, MATLAB®, and Python®. Very recently, data science tools have also started to become important for chemical engineers.[15] While a myriad of perspectives on digital tools actively evolves in chemical engineering education and research, little has been

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discussed about more general communication and multiuse applications, such as Slack® or Microsoft Teams® (Teams).

Our goal is to introduce Teams as a learning management system for engineering courses. By providing both instructor and student feedback, we detail multiple perspectives on using Teams as an LMS. Thus, this contribution is not a meta-analysis of LMS features and uses, since this topic has been recently covered for engineering students.[16] The organization of the paper begins with a description of the technology and platform, then two different instructor perspectives on transitioning to and fully adopting Teams are presented, and finally student feedback related to this new adoption of technology completes the paper.

MATERIALS AND METHODS

The general Teams interface is shown in Figure 1, which illustrates the different sections and functions.

In a classroom context a team within the Teams app would be the students in a course, their instructor(s), and other support staff, including teaching assistants. While the screenshots shown here are from a desktop application, Teams functions as a standalone application on Microsoft Windows® and Apple MacOS®, as a mobile app on Android™ and iOS®, and as a web-based tool inside a web browser. The interface shown in Figure 1 illustrates the layout for all team members, with the menu sub-divided into the upper section called "Instructor Tools" and a lower section called "Course Content" in this paper. Instructor Tools are links to analytics about the course as well as summaries related to Assignments and Grades. Teams met all accessibility, privacy (e.g., FERPA), and security rules at both universities. The Course Content Sections are called channels in Teams and is where content ranging from documents to videos can be found.

Each channel is organized as illustrated in Figure 2, with the channel content organized by the tabs at the top of the channel. These channel tabs are like the tabs you would find in a web browser, where each tab represents a different page.

A channel typically comes with two default tabs: Posts and Files. The Posts tab is the default home page for the channel and serves as a messaging/communication interface, while the Files tab shows a directory structure and serves as cloud storage for that channel. Additional tabs can be added by the instructor and are too many to list here; however, a few examples useful in an LMS context include Microsoft OneNote® (for capturing text and notes), Microsoft Stream® (for links to recorded videos), and Microsoft Forms® (for in-class surveys or

***Figure 1**. The typical interface of a team in Teams with the left-hand column showing the Menu items and the right-hand column showing the contents of the highlighted menu item. The Menu section can be further sub-divided into Instructor Tools and Course Content. A menu item selected on the left will generate the details shown on the right side, specific to that selected menu item.*

***Figure 2.** The interface of a channel in Teams, with the left side showing the selected channel (highlighted) and the right side showing the content of that channel. The top of the channel content has the Tabs for navigating within the channel, while the bottom will contain the content within that Tab. In this case, the Posts tab is selected and below are messages from the instructor since this tab is for messaging/chat.*

feedback). Since Teams is a Microsoft product, integrating other Microsoft tools is encouraged and well-integrated in some cases (e.g., OneNote class notebook). Thus, using Microsoft Word®, Microsoft Excel®, and Microsoft PowerPoint® within Teams is possible, and in the authors' experience, integrating these standard Micrsoft Office® applications in other LMSs is cumbersome, e.g., having to download documents before use.

The accessibility features of Teams and related tools are worth documenting as both authors have observed their utility. First, video calls used for streaming classes have real time captioning, and thus posted recordings have captioning natively included. Microsoft Forms has a built-in screen reader, so the problems can be read to the student for homework or during an online quiz or exam. A similar screen reader is built into Teams and OneNote also, but the ability to read handwritten content has not been extensively tested by the authors.

The student populations were studying engineering at medium-sized, public research universities in Ohio. However, further demographic information is outside the scope of this work and could be considered a limitation (or an opportunity for future work).

FINDINGS

This section describes how Teams was used as an LMS by the two authors at their respective universities. In addition to the instructors' perspectives, feedback was collected from students and summarized here.

Instructor's Perspective at Ohio University

I started teaching higher education classes as an instructor in Fall 2017, and I began introducing elements of Teams into the classroom in Fall 2019, mainly as a repository for lecture slides, class communication, and 1-on-1 communications with students. Additional positives from an instructor's perspective were the interface and the availability of a mobile app that replicated the desktop experience. The main LMS used at Ohio University is Blackboard® (Bb), and I combined the use of Bb and Teams within courses I taught with increasing reliance on Teams over a 3-year period (Table 1).

As noted in Table 1, Teams was implemented gradually as Microsoft extended the capabilities of Teams as a learning platform that included the integration of assessments and insights into student activity. In most cases the instructor would only introduce a Teams feature in the succeeding semester after the feature became available. In other cases, e.g., the onset of the pandemic and the university's guidelines, external pressures determined how the tool was integrated into the classroom.

The details in this sub-section highlight the most recent iteration of the use of Teams in the Fall 2022 semester for an elective course titled Principles of Engineering Materials. This class typically consists of students across all college levels (1st year to 4th/5th years) and multiple disciplines in both Engineering (Chemical, Mechanical, Industrial, Civil and Electrical) and Science (Physics, Nursing, Biology, etc.). Most of the students are Chemical or Mechanical Engineering students in their 1st or 2nd years since this course is required for those majors, and the 1st/2nd years are when the elective is most conducive to their schedule.

TABLE 1
Courses, Modality, and LMS Usage for Daramola

Term	Course	Enrollment	Modality	LMS-related tools
Fall 2019	Principles of Engineering Materials	85	In-person	Blackboard (90%), Teams (10%)
Spring 2020	Principles of Engineering Materials	76	In-person then remote	Blackboard (80%), Teams (20%)
Fall 2020	Principles of Engineering Materials	71	Remote (asynchronous)	Blackboard (40%), Teams (60%)
Spring 2021	Principles of Engineering Materials	52	Remote	
Fall 2021	Alternative Fuels and Renewable Energy	48	In-person	Blackboard (10%), Teams (80%)
Spring 2022	Chemical Engineering Modeling	22	In-person	
Fall 2022	Principles of Engineering Materials	66	In-person	Blackboard (5%), Teams (95%)

The class was taught in a hybrid format with all lectures delivered in-person (unless the instructor was traveling). There was an option for students to attend remotely by connecting to a channel specifically for synchronous broadcasting of the in-person lectures. This option was provided considering a COVID-19 outbreak was still a primary concern and contact tracing was still prominent on the campus. A key advantage of this hybrid approach is the simultaneous transcribing that is done during the lecture, fostering student accessibility.

The Teams interface was organized such that each of the nine total topics had its own channel, and all relevant material for that topic resided within the channel (Figure 1 and Figure 2). Two additional channels were created: a Lectures channel, used for hybrid lectures and student/office hours, and an Assessments channel for files and notifications related to assessments, including prior versions of quizzes and exams, exam review sheets, and announcement of assessment dates. As an example of structure, the channel for the topic on Metal and Ceramic Structures contained seven messages, four slide decks, one practice worksheet, eight pages of problem solution, and 19 pre-recorded clips (5 – 15 min long), with each item housed within tabs as described below.

Each topic channel had the two default tabs: Posts and Files. The Posts tab was used for announcements relevant to the channel and was typically the instructor notifying the students that a slide deck was available for their review. In some cases the instructor would post images from the interactive textbook for additional practice problems relevant to the topic. The Files tab contained the slides and any handouts related to the topic. Additional tabs in the topic channels were Notes, Videos, and Surveys (Figure 3).

The Notes tab was a Microsoft OneNote interface used to collate solutions to problems discussed in class (Figure 3a). This alleviated any concerns of students who attended remotely as they could still follow along during problem-solving exercises and the entire class could revisit the solutions outside of the lecture period. At several points

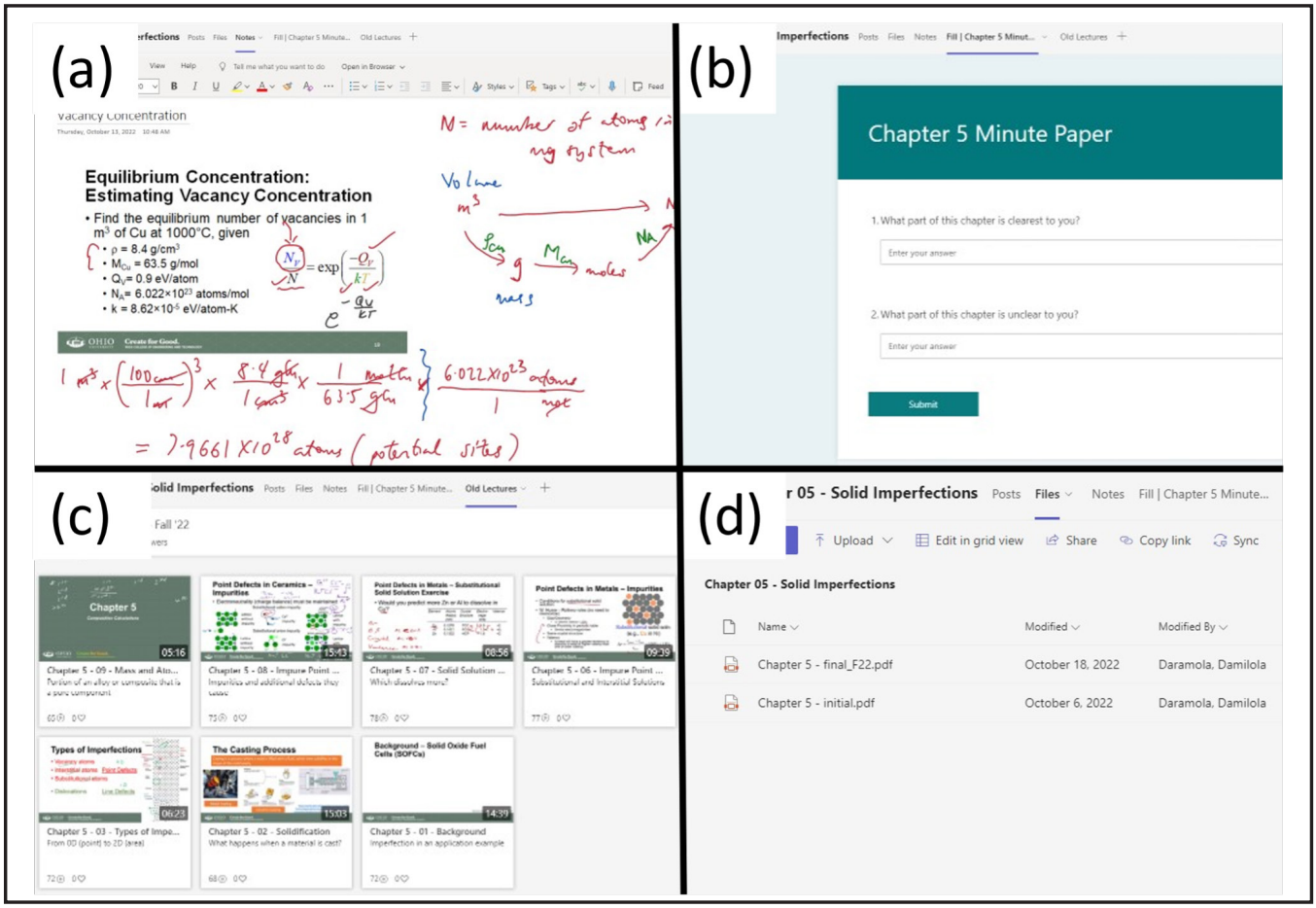

Figure 3. *Illustration of the different tabs used by the Ohio University instructor showing the interface for (a) Microsoft OneNote for problem-solving, (b) Microsoft Forms for in-class surveys, (c) Microsoft Stream for pre-recorded lectures and (d) Files. Each of these tabs are reproduced within each channel and contain content specific to the topic/chapter discussed in that channel.*

during the semester, the instructor took a survey via Microsoft Forms after a topic was presented to assess the portions of the content where students struggled (Figure 3b). The instructor was able to integrate these student responses into lectures by discussing in-person as well as providing additional examples and problem sets relevant to the unclear topics highlighted in the survey. Microsoft Forms was also used for peer assessment during the group project presentations at the end of the semester. The Videos tab provided access to previously recorded lectures from an earlier (pandemic) semester when classes were fully remote (Figure 3c). This additional option was for students who missed class entirely or who wanted to study ahead when possible.

All homework problems were offered through the Assignments option on Teams and were mostly either multiple choice or short answer problems to facilitate auto-grading.

Instructor's Perspective at the University of Toledo

I was in my 15th academic year as a faculty member during 2019-2020 when normal higher education was disrupted. I teach one traditional chemical engineering course most semesters, maintain research projects in rheology and engineering education, and sustain both internal and external service roles. Having a long-term interest in educational technology has led me to adopt online homework many years ago,[17] create a pedagogy that generates YouTube™ problems,[18] author interactive textbooks and auto-graded homework,[19] and co-lead virtual communities of practice.[20] These past and ongoing experiences led to investigating and adopting Teams over several academic terms (Table 2).

Our campus's LMS is Blackboard, which I used for my courses since 2005. During Spring 2020 when the initial remote classes were delivered, I pivoted to WebEx for course delivery since I had about a decade of experience via research collaborations with this tool and the university provided support. WebEx was more user-friendly and more intuitive than Blackboard's Collaborate tool. However, WebEx lacked breakout room capabilities that were available on Zoom. Since Zoom was not an option on my campus, I re-investigated Teams during summer 2020 to discover many new features that were not available during my initial product testing during the abrupt transition in March 2020. Fall 2020 was taught both in-person, streamed live, and recorded, so Teams was used for the main class delivery. Blackboard was still used for document posting and homework submissions. However, the general student feedback was that the inclusion of too many tools were confusing. Thus, I moved my classes to using only Teams as the LMS from Spring 2021 to the present. Remote in Table 2 signifies that classes were delivered online synchronously; synchronous class streaming continued in Fall 2021 and Spring 2022 to some extent.

While inefficiencies with streaming and recording classes, posting course notes, and doing formative and summative surveys during and after class seeded the move to using another LMS, discussions with local engineers in industry solidified the decision to adopt the platform that was available for higher education and commonly used by chemical engineers in industry. As mentioned in the introduction, this same industrial tool usage has motivated curricular changes for process simulation, programming language, etc. for many years. Detailing a typical week for the Material and Energy Balances course will provide sufficient details on how Teams provided a unique and comprehensive experience for both instructor and students without repeating the features introduced earlier.

Three 75-minute class sessions focus on short recaps of main points, followed by several active learning exercises focusing on problem solving. The traditional in-person delivery was detailed previously.[21] Arriving at least ten minutes before class time ensured sufficient time to troubleshoot the in-person and remote course delivery. The Teams class meeting was initiated on a laptop and connected to the projectors in the classroom. Then a tablet was used to also join the Teams meeting using the same login to share the slides and notes. Once the technology was running, chat messages or in-person questions could be addressed. Class time centered on a combination of slides and hand-written notes that are compiled in OneNote. The use of OneNote was documented by the virtual communities recently,[20] so the most important feature relevant here is the OneNote notebook being integrated into Teams. Thus, notes are available in real time to all students, and no additional instructor or teaching

TABLE 2
Courses, Modality, and LMS Usage for Liberatore

Term	Course	Enrollment	Modality	LMS-related tools
Spring 2020	Material and Energy Balances	104	In-person to fully remote	Blackboard (90%), WebEx (10%)
Fall 2020	Separations	39	In-person and remote	Blackboard (60%), Teams (40%)
Spring 2021	Material and Energy Balances	78	Fully remote	Teams (100%)
Fall 2021	Graduate Fluid Mechanics	10	In-person	Teams (100%)
Spring 2022	Material and Energy Balances	64	In-person	Teams (100%)

assistant time is needed to digitize and post notes. In class participation – for both in-person and remote students – was promoted using Microsoft Forms (a multi-functional survey tool) or using the chat feature in the Teams' call environment. Commonly, a photo of handwritten work was requested for participation points and uploaded through Microsoft Forms.

Homework assignments were posted through the Assignments tab in Teams. These assignments include reading participation (Mondays) and auto-graded problems (Wednesdays) via zyBooks®[19, 22] (or Perusall® assignments for other courses[23]) as well as traditional handwritten assignments being due each Friday. Since assignments are submitted electronically through Teams via the built-in Assignments or via Microsoft Forms within the Assignments channel also, teaching assistants grading the work never had to alphabetize for handing back or enter grades into a grade sheet, which saves time. Some anonymous grading features are also available to help the grader avoid personal feelings or biases that may interfere with grading. While grades from Assignments are automatically integrated into a gradebook available to the students, some limitations of the gradebook environment exist. While grades are easily exported into Microsoft Excel as would be expected, limited importing of grades was available as of Spring 2022. Another useful feature of Microsoft Forms is the ability to branch questions. We used branching to have a single form for a quiz or exam that contained multiple versions of each question (i.e., rolling numbers).

The channels were used in several ways depending on the modality. Two types of channels are available – standard and private. Standard channels can be used by all members of the team (students and instructors in this case), while private channels have a fixed membership determined by the team's owner (the instructors in this case). Private channels are useful for group work and projects, and all private channel content is visible to both members of that channel and the instructor. In their group channel students share files, communicate via chat messages, or host video calls. Assigning students to groups using the channel framework was especially useful for remote and hybrid modalities. During active learning problem solving, students could leave the course's video call, talk to their group on a video call in their private channel, and complete work on a whiteboard, in Word, or using Excel. Instructors could then visit each private channel's video call to offer encouragement, answer questions, or just observe the groups. One limitation is that only 30 private channels are allowed in one team (team here indicates the individual course's site within Microsoft Teams). For example, a class of 120 students with groups of three students would require 40 private channels, which is not currently possible. Standard channels can be used for group work, but any student in the class can see the chat messages and any files posted, so academic dishonesty as well as gossip are concerns.

Another unique use of channels in a remote modality was to use individual channels as rooms for quizzes and exams. Assigning students to their own channel for assessments allowed cameras to be on while maintaining privacy. The instructors could then verbally talk to individual students with questions, share the screen for those having technical difficulties, or reassure students on time limits or submission completion. Finally, individual channels can be set up for each instructor or teaching assistant to host remote office hours, which eliminates the need for calendar invitations or posting links. A private channel is also extremely useful to consolidate communication between teaching assistants and faculty. Private channel chat threads eliminate the problem of messages being lost in a sea of non-course related emails.

One fun and unique feature is the short turn-in celebration animations.[24] These amusing cartoons were commonly mentioned by students during in-semester and post-semester feedback.

Students' Perspective at Ohio University

At the end of the Fall 2022 semester, a survey was conducted with questions that evaluated the student experience with Teams and comparison with the standard LMS. The questions were asked using a five-point scale (1 = strongly dislike, 5 = strongly like), with the performance numbers derived from the total number of students who rated the experience as a four or five. The level of familiarity and prior use strongly correlated with the level of preference for the tool in the classroom, i.e., the more familiar with the tool, the higher the preference for that tool. In general, students were more familiar with Blackboard (98%) versus Teams (37%) before taking the ET 2300 course (Fall 2022), and at the end of the semester, Blackboard was preferred by 86% of students compared to 30% for Teams. However, a limitation of this survey is the relationship between the year of the student (1^{st} – 5^{th} year) and their level of familiarity with either tool. This becomes more relevant when considering the LMS that a student might have used during the pandemic or how the LMS they use in other classes is integrated.

Additional preferences were provided via free-response questions asked about Teams' features: "List at least one feature of Teams that you like" (n = 63) and "List at least one feature of Teams that you do not like" (n = 71). The responses categorized into a small number of common themes are summarized in Table 3. More responses were recorded than the number of students (n = 57), since some students listed more than one feature they liked/disliked.

The top three categories of "like" responses captured 60% of the comments. The themes were Organization, Communication, and Navigation. Examples of specific comments

TABLE 3
Summary of Top Three Themes in Free-Form Responses from Ohio University Students about Teams

Feature you like about Teams		Feature you dislike about Teams	
Theme	**Responses (%)**	**Theme**	**Responses (%)**
Organization	24	Organization	21
Communication	19	Navigation	21
Navigation	17	Uncommon	17

were: "*Having a channel for each chapter organized on the sidebar made it easy to switch between chapters*." (Organization), "*I like how you can have meetings on there. And message your instructor personally*." (Communication), "*The notes tab on each of the chapters was super helpful, being able to come in online is nice*" (Navigation). These comments centered around the layout of the channels, the ability to communicate with the instructor easily, and the ease with which information could be found, especially in-class notes and recordings. These responses suggest the students' likes were a combination of features of Teams and how the instructor implemented those features. An instructor with a layout different from Figure 3 may get a different set of responses. As an example, if the channels were organized by weeks, an instructor might reach some threshold number where organization becomes a dislike. A combination of the 1st and 3rd highest percentage of responses suggest the organization of information made it easier to find relevant information that the student was looking for.

The top three categories of "dislike" responses captured 59% of the comments. Two of the three themes were similar to the "like" responses, namely Organization and Navigation. Examples of specific comments were: "*It's hard to zoom in sometimes and there's so many channels and files and notes it hard to find what you're looking for*" (Organization), "*One thing I dislike is that I cannot open multiple tabs to look at different chapter notes at one time*." (Navigation), "*Most classes use blackboard so it just adds another place I have to look for information*" (Uncommon). These comments centered around the difficulty of finding information and the inability to open multiple pages at the same time (e.g., notes side by side with assessments). Finally, the uncommon theme relates to the lack of Teams use in other classes. These responses suggest the students' dislikes were related to both the features on Teams and familiarity with the tool. A combination of the 1st and 3rd highest percentage of responses suggest the lack of familiarity with Teams made it more difficult to find information; however, it is also plausible that these two themes are not correlated since the connection between these responses was not evaluated. Overall, the instructor believes the dislike responses are related to the typical latency associated with adopting new technology when legacy tools are still available.[25] It is also plausible that the students prefer technology alignment across all their courses for convenience.

The students' perspectives at Ohio University highlight the necessary improvements the instructor must make to lower the barriers associated with the use of Teams. The first adjustment is to use only this LMS in the course, as is done at University of Toledo, which centralizes lecture material and removes the concerns with having to track multiple learning platforms within a single course. This will be facilitated by the recent (2023) change Teams has made to allow weighted grading, one of the advantages that Blackboard had (as seen in Table A1 of the Appendix). Another modification is the delivery of assessments, which made it difficult for students to simultaneously access assessments and lecture notes. For example, students typically have notes and the assignments side by side online when completing auto-graded assessments. The student responses to these modifications could potentially be integrated into a future study.

Students' Perspective at the University of Toledo

Student surveys are commonly given during and at the end of most semesters. Surveys give the instructor feedback on a range of topics, including both in-class and outside-of-class activities. A small subset of questions from Spring semesters 2020, 2021, and 2022 is relevant to learning management systems and will be presented here.

The abrupt transition from in-person to fully remote courses occurred during the Spring 2020 semester, so the students' familiarity with different learning-related technologies was a common survey topic at the end of this semester. Specifically, 76% of the class had no experience with Teams while only 30% had no experience with Zoom. Almost all students had experience with Blackboard Collaborate®and Webex, as these tools were used in the course in which the survey was given.

Both Spring 2021 and 2022 Material and Energy Balances classes used Teams as their only learning management system. While the modality of remote in 2021 and in-person in 2022 was different, the students' opinion of Teams changed from 57% at least satisfied to 96% (Table 4). This change in student opinion is likely multifaceted. Potential explanations include the new features of Teams introduced between 2021 and 2022 (such as the Assignments channel), being less dependent on the LMS for the course with in-person class time and office/student hours, and greater familiarity of the instructors in using Teams and communicating the features/advantages. Since these changes in modality and LMS were not foreseen, no control data were taken in previous years, which is a limitation of this work.

Another survey question asked about students' preferred LMS depending on modality of the course. Options included Blackboard (the default LMS at UToledo) or Teams (used exclusively during the course). A small number of other responses are not included in Figure 4, which accounts for percentages not adding up to 100. In 2021 both LMSs had about the same preference for in-person, while Blackboard was preferred for online courses. The advantages of Teams related to online exam taking and other features for a fully remote course are more important to instructors than students. In addition, some of the features related to assignments and improvements in the gradebook were not available until 2022, which also may be captured in these survey responses. In general, Teams was the strongly preferred LMS for 2022 (65 and 71%), independent of modality. The in-person course in 2022 (with some streaming/recording of classes) was significantly less dependent on the LMS than the fully remote course in 2021. Also, the new features and greater experience of the instructors in using Teams also likely contributed to the significant positive preference for Teams in 2022.

Returning to the motivation for using a tool that is commonly used by engineers in industry is captured by anecdotal evidence. UToledo is one of less than ten mandatory co-op chemical engineering programs in the United States. Thus, students take Material and Energy Balances in their first (freshman) spring semester. Half of the students then start interviewing for the first co-op during the fall of their second (sophomore) year. Several students have shared with the instructors that they were interviewed online via Teams for their co-op; they felt less stressed since they were familiar with Teams. Additionally, some co-op jobs have been partially or fully remote, which commonly leverages Teams as a tool.

Finally, college enrollments in the country and in many chemical engineering departments decreased in the last few years, so tighter budgets are also in place. Many campuses, like UToledo, are paying for both a primary LMS (Blackboard in this case) and Teams as part of being a "Microsoft campus" related to email, office applications, etc. The ubiquity of Teams in the working world inside and outside engineering should be enough evidence that a transition to using Teams as the primary LMS would seem like a logical and significant cost savings for the university. While changes of this magnitude would be resisted by many faculty, the abrupt shift to remote instruction shows that disruptive change is possible.

TABLE 4
Overall Student Satisfaction with Teams as a LMS (UToledo)

Term	Well (%)	Satisfactory (%)	Has Issues (%)
Spring 2021 Fully remote, n=46	24	33	43
Spring 2022 In person, n=50	52	44	4

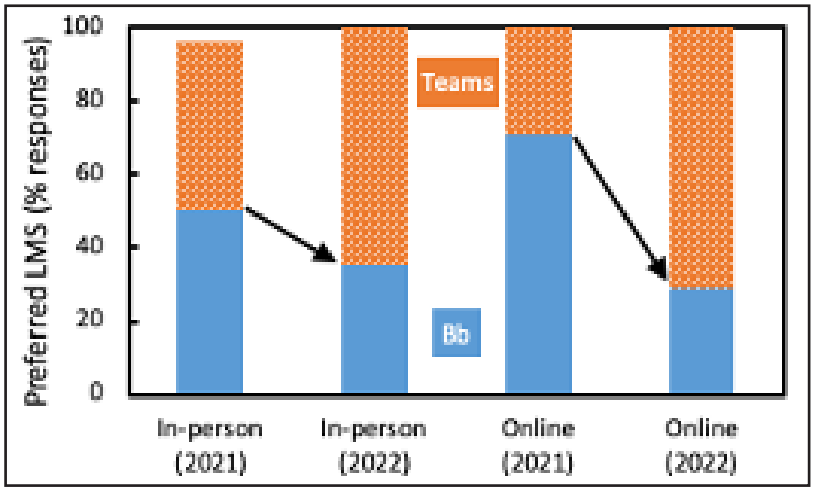

Figure 4. *Survey responses for preferred LMS based on modality (in-person and online) and cohort (n=46 in 2021 and n=48 in 2022). Textured bars for Teams and solid bars for Blackboard (Bb).*

CONCLUDING REMARKS

A learning management system is important for course organization, communication, transparency, and other best practices for both in-person and remote engineering courses. Features and usage of Teams as a LMS were detailed. Since Teams is also widely used by engineers in industry, this contribution adds to the discussion of skills and training related to industrially relevant tools, such as process simulators or coding languages. Two instructor perspectives summarized the transition to Teams, and their preferred features and student responses from surveys were presented. While student response was mixed, some data indicate a growing affinity for Teams. Student reception was better when a single LMS was used in the class as observed at UToledo, in comparison to splitting time between a legacy LMS and Teams as observed at Ohio University. Overall, Teams is much more likely than other LMSs to be used by students on internships and co-ops as well as after graduation, which should encourage faculty to consider integrating Teams into their chemical engineering courses and curricula. This usage can be linked to ABET considerations regarding

teamwork (Student Outcome 5), since group projects were facilitated by appointments on calendars, collaboration via screen-sharing, video, and instant messaging. Finally, future work related to Teams as an LMS could include evaluating the correlation between student familiarity and affinity for Teams, the effect of Teams layout on student usage/engagement, and comparison between length of student engagement with Teams versus a legacy LMS.

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APPENDIX

Abbreviations for LMS Features included in tables below: G – Grades, AA – Auto-graded assessments, MA – Manually-graded assessments, LSR – Lecture Slide Repository, ASR – Assessment Solutions Repository, IPS – In-lecture problem-solving, PLS – Pre-recorded Lecture Streaming, RLS – Remote Lecture Streaming, HLS – Hybrid Lecture Streaming, S – Surveys, N – Notifications

TABLE A1
Summary of the Different Features That Daramola Introduced Since the Initial Use of Teams Alongside Blackboard

Term	Course	Enrollment	Modality	LMS Features Implemented	
				Blackboard	Teams
Fall 2019	Principles of Engineering Materials	85	In-person	G, AA, ASR, N	LSR
Spring 2020	Principles of Engineering Materials	76	In-person then remote	G, AA, MA, ASR, N	LSR, IPS, RLS
Fall 2020	Principles of Engineering Materials	71	Remote (asynchronous)	G, AA, MA, N	LSR, ASR, IPS, PLS, RLS
Spring 2021	Principles of Engineering Materials	52	Remote		
Fall 2021	Alternative Fuels and Renewable Energy	48	In-person	G, N	LSR, ASR, IPS, PLS, RLS, HLS, S, N
Spring 2022	Chemical Engineering Modeling	22	In-person		
Fall 2022	Principles of Engineering Materials	66	In-person	G	AA, LSR, ASR, IPS, PLS, RLS, HLS, S, N

TABLE A2
Summary of the Different Features That Liberatore Introduced Since the Initial Use of Teams Alongside Blackboard

Term	Course	Enrollment	Modality	LMS Features Implemented	
				Blackboard	Teams
Fall 2020	Separations	39	In-person and remote	G, MA, ASR, S	LSR, HLS
Spring 2021	Material and Energy Balances	78	Fully remote	--------	LSR, HLS, G, MA, ASR, S
Fall 2021	Graduate Fluid Mechanics	10	In-person	--------	LSR, HLS, G, MA, ASR, S
Spring 2022	Material and Energy Balances	64	In-person	--------	LSR, HLS, G, MA, ASR, S