Learning Management System Feature Use in Mechanical Engineering Second- and Third-Year Courses Before, During, and After a Disruption

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Abstract

Significant and sudden disruptions can bring normal university classroom activity to a halt and have many effects on how instructors teach going forward. There is little research that follows mechanical engineering instructors' practices and strategies through a disruption. Results of such investigations can contribute to the design of new professional devolvement strategies for mechanical engineering instructors to mitigate or capitalize on the impact of disruptions. This study focused on instructors' use of learning management system (LMS) features to support course delivery. The research question addressed was "How do mechanical engineering instructors' LMS feature use change before, during, and after a sudden disruption to higher education?" The research took place at a Midwest Research Intensive (R1) university using LMS data from a mechanical engineering department's core second- and third-year undergraduate courses. LMS feature use data was collected for five Spring semesters (2019–2023) which included a disruption in Spring 2020. Descriptive statistics and visualizations were used to summarize LMS feature use. While some LMS features were never used, those that were used were found to be used most often during the disruption and the following spring. The years following showed a mix of sustained and discontinued LMS feature use. The intention of this study was to inform mechanical engineering instructors decision-making relative to LMS feature use generally and during disruptions.

I. Introduction

Disruptions to educational systems affect the work of university instructors, often prompting social distancing, remote learning, web conferencing, etc. These disruptions affect how instructors deliver their courses and interact with their students. Epidemics, such as H1N1 (2009) and COVID-19 (2020), depict such educational disruption events. Natural disasters and social unrest, as well as fires, hurricanes, floods, and other emergencies [1] may also cause disruptions. Such disruptions, on the student side, may lead to, among other things, feelings of isolation, anxiety, and stress [2]; reduced motivation, self-efficacy, and achievement [3]; and retention issues [4]. The use of a learning management system (LMS) has been shown to mitigate challenges associated with disruptions, prompting researchers to better understand the degree to which LMS features are used and how they can be used more effectively. This study was conducted to discover how instructors utilized a LMS before, during, and after a disruption. Findings from this study can be used by policy makers and educators to plan how best to use LMS features given the possibility of a disruption event. This study follows the LMS feature use by mechanical engineering instructors through five spring semesters and seeks to identify LMS feature use trends.

II. Background

Characteristics of instructors who follow a more learner-centered instruction format typically: (1) prioritize student learning over covering material, (2) share decisions regarding attempts to improve student learning, (3) foster a knowledge base and develop learning skills based on prior knowledge, (4) encourage students to take initiative in their learning, and (5) primarily utilize assessment to promote learning rather than evaluating performance [5]. A 2016 study including 30 engineering faculty members from freshman and sophomore level courses revealed that the top half of instructors who followed this format had 8.7% less failure rate [6]. The use of a LMS was shown to have the ability to follow these guidelines for a learner-centered instructional format [7].

Emergency remote teaching (ERT) has become the phrase used to describe "a temporary shift of instructional delivery to an alternate delivery mode due to crisis circumstances" [8]. ERT is the educational system response to a disruption. The response prompts instructors to use instructional methods they may not have used before. This includes the use of an LMS and the selection of LMS features to support instruction. During the process of selecting alternative delivery methods and supports, instructors focus on their students' needs as well as intended course outcomes, pedagogies they want to employ, and assessment strategies [9]. These considerations likely impact LMS feature use during a disruption.

Whether alternative delivery modes and complementary supports, like LMS feature use, are adopted during and sustained after the disruption depends on various factors. In the case of LMS use overall, instructors who used an LMS before the COVID-19 pandemic continued to use an LMS afterwards [10]. Research has shown that acceptance and incorporation of an LMS was reliant upon faculty members' innovativeness, facilitating conditions, and LMS user-interface design [11]. Innovativeness has been described as a faculty member's tendency to seek creativity and make innovation [12]. Facilitating conditions are a faculty member's belief in their degree of control in technological aspects [13]. User-interface design is the overall display and functionality of an application. Research has shown that a well-developed user-interface design is one that segregates important information, orders information as per user, presents the big picture, has link and button consistency, and has a feedback system [11]. When an LMS reflects these qualities, there is a positive effect on the perceived usefulness and perceived ease of use of the LMS [11]. Perceived usefulness is described as an instructor's perception of how an LMS enhances task performance, effectiveness, and productivity [14][15]. Perceived ease of use describes ease of implementing LMS use in a curriculum. Other researchers have found that there is a positive relationship between a feature's perceived ease of use and instructor intention to continue its use as a useful tool in assisting course delivery [11].

Recent research has also shown a difference in LMS use in lower-level courses as compared to upper-level courses before and after a disruption. Findings indicated that the lower-level courses continued their LMS use while upper-level courses typically returned to pre-pandemic in-person instructional modes [16]. This difference could be an effect of a decrease in student engagement during the pandemic due to asynchronous and synchronous video recordings being used in place of face-to-face learning [17]. When in-person learning returned, greater student engagement occurred, perhaps making an LMS less of a necessity for course delivery.

III. Purpose and Research Question

The purpose of this study was to identify trends in LMS feature use by mechanical engineering instructors in response to an education system disruption. Most research studies conducted in the space of LMS use trends during the COVID-19 time period focused on K-12 education [18], first-year university education, and graduate level education [19]. These works focused more on student and instructor views rather than quantifiable data, about LMS feature use, which is the focus of this study. The research question for the current study was "How do engineering instructors' LMS feature use change before, during, and after a sudden disruption to higher education?"

IV. Methods

A. Setting

This study examined LMS feature use in second- and third-year courses taught in a Midwest R1 University in a single department in a college of engineering. The selection of the second- and third-year was due to reports that these academic years in higher education are generally under-studied despite retention issues in these years [e.g., 20].

The focus of the study was on Spring semesters from 2019 to 2023. This timeframe was selected to allow tracking of LMS feature use before (2019), during (2020-2021), and after (2022-2023) the disruption. Only Spring semesters were considered to maximize the similarity of course offerings when comparing LMS feature use across semesters; a different selection of courses were offered in Fall semesters. The disruption officially occurred in Week 10 of Spring 2020 (March 16) when in-person classes were first cancelled. Emergency remote teaching began in Week 12 (March 30th) after students and faculty returned from Spring Break [21]. Table 1 displays the number of courses taught each semester with the delivery methods that were included in this study. The number of courses exceeds the number of instructors in most semesters as some instructors taught multiple courses in a single semester. There were very few 200 level courses because the curriculum specified more foundational courses taken outside of the department in that academic year of the program. The large number of 300 level courses is due to large enrollments necessitating multiple offerings of the same course with different instructors using separate LMS courses.

Table 1. Course and Instructor Data per Semester

Semester	No. Second-Year Courses[a]	No. Third-Year Courses[a]	No. Instructors	Enrollment Range
2019	2(2,0,0,0,0)	14(13,0,0,0,1)	15	36-110
2020[b]	2(0,2,0,0,0)	12(0,7,5,0,0)	14	49-103
2021	3(1,1,1,0,0)	14(3,0,7,4,0)	17	45-109
2022	3(3,0,0,0,0)	15(12,0,0,1,2)	16	27-114
2023	4(3,0,0,0,1)	19(14,0,0,0,5)	20	32-86

[a]Number of courses(In-person, Asynchronous, Online Synchronous, Hybrid, No Information)
[b]Up until midspring 2020 all courses were in-person

B. Data Collection

LMS feature use data was collected from each Canvas course for spring semesters from 2019 to 2023. This data included LMS feature use at two points in time each semester: mid-Spring and at the end of the semester. For comparison purposes to Spring 2020, mid-Spring (denoted m19-m23) LMS feature use data were recorded at the end of the 9th week of the semester (i.e., when in-person instruction stopped). Spring data accounts for all LMS feature use across the semester. LMS feature use data were provided to the research team by the university IT department. Descriptions of each LMS feature used in this study can be found in Table 2. The data included binary (on/off= 1/0) data which represented whether a course used an LMS feature or not, as well as numeric ("count") data which reflected the number of times a LMS feature was used.

Table 2. Description of LMS Features [22]

LMS Feature	Description
Announcements	Communication tool allowing instructors to post announcements for all users in a course
Assignments	Any activity created by the instructor. May include Assignments, Discussions, and Quizzes
Assignment Groups	Tool that separates students into smaller course units to facilitate collaboration on assignments.
Discussions	Forum designed to facilitate informal communication between students, either for free discussion or for grading purposes.
Gradebook Entry	Entries into Canvas about numerical or letter-grade assessments.
Modules	Tool that can unify all content into smaller, structural components. Typical groupings are by week, topic, or day.
Outcomes	Statements describing knowledge, skills, and abilities that learners will develop that enable tracking of student progress through their use in rubrics
Peer Reviews	An Assignment feature used to facilitate students reviewing each other's submissions
Quizzes	Displays all quiz assessment types, utilizing advanced features for moderation and accommodation
Rubrics	Assessment tool for communicating quality expectations and achievement
Submissions	Instances of student work being submitted through the LMS
Syllabus	Course navigation link that shows content and outlines course activities Note: The Syllabus feature does not indicate whether the course had a syllabus or not

C. Data Analysis

Data analysis involved generating graphical representations to discern patterns and trends in LMS feature use. Features were categorized into Grading, Instructor Communication, and Student Activity (Table 3) to allow for analysis of features with a similar purpose. Radar plots and box-and-whisker plots were employed to show LMS feature use for each of these categories. Analysis focused on the identification of peaks in LMS feature use, least-used LMS features, and

trends across the five semesters with an emphasis on comparisons between before, during, and after the disruption in Spring 2020.

Table 3. Categories by LMS Feature

Category	LMS Features
Grading	Quizzes, Outcomes, Rubrics, Gradebook Entries
Instructor Communication	Syllabus, Announcements, Discussions, Modules
Student Activity	Assignments, Assignment Groups, Peer Reviews, Submissions

To show changes in LMS feature use across the Spring semesters, radar plots were generated using Excel using percentages of courses utilizing each LMS feature. Two separate Radar plots were created for each category. The Mid-Spring plot depicted the percentage of LMS feature use nine weeks into the semester, while the Spring plot visualized the percentage of feature use at the conclusion of the Spring semester. The disrupted-semester (Spring 2020) was highlighted yellow within the plots to distinguish LM feature use before, during, and after the disruption to learning. Box-and-whisker plots were used to capture the frequency and distribution of LMS feature use.

V. Results

Results for each LMS feature category (Table 3) are presented below. A description of how to read the radar plots is first provided. Then, for each category, the LMS feature use is shown followed by an examination of the extent of use.

A. Radar Plots

Radar plots (Figures 1, 4, and 6) were used to visualize the difference in LMS usage across the Spring semesters. Radar plots are a type of graphical tool used to display multiple variables for the purpose of identifying patterns. They may also be used to compare different sets of data. In this study, the variables are the percentage of courses using the LMS features, and the datasets are each mid-Spring and Spring data collection. Radial axes extend from a center point. The number of radial axes equals the number of variables, and each variable is assigned to an axis. The scale on the axis typically represents percentage, with the center representing 0% and the end of the axes (outmost edge) representing 100%. A graduated scale then is marked between the center and end of the axes. For the radar plots used in this study, graduations of 25% establish the gridlines. Data points are then plotted on the radial axes.

B. Grading

The LMS feature use for the Grading category are provided in Figures 1-3. The percentage of courses that used each feature at the mid-point and end of each semester are represented in the radar plots (Figure 1a and 1b, respectively), while the extent of use of each feature is represented in the box-and-whisker plot (Figures 2 and 3).

From the radar plots (Figure 1), it is evident that neither Outcomes nor Rubrics were used in any courses throughout the study timeframe. This can be seen on the radar plot as the Outcomes and

Rubrics data points both sit at the center of both radar plots, indicating 0% of the courses used these features. The mid-Spring data (Figure 1a) shows that in Spring 2020 there was increased use of Quizzes prior to the shutdown as compared to the similar point in time for 2019. Further, in Spring 2021, Quiz use was well established by the mid-point of the semester. For Gradebook Entries, there was a similar pattern though not as exaggerated. Use was lowest in 2019, peaked in 2020, and declined thereafter, but not to the pre-disruption level. As can be seen in Figure 1b, at the end of each semester, the percentage of courses using the Quizzes feature was low before the disruption in 2019 (19%), then peaked during the disruption in 2020 and 2021 (~60%). As the impact of the disruption subsided, courses using the Quizzes feature declined, but not back to the 2019 use-level.

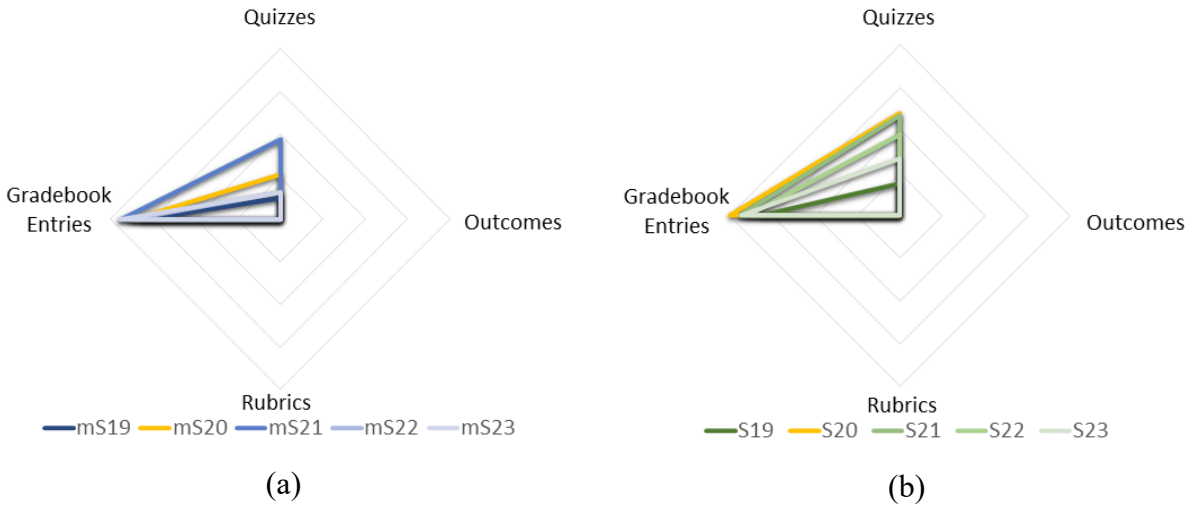


Figure 1. Percentage of courses that used Grading LMS features, (a) Mid-Spring, (b) Spring

To better understand the use of the Quizzes and Gradebook Entries features, box-and-whisker plots were created. Figure 2 shows the distribution in the number of quizzes the courses administered. It is very evident that the average number of Quizzes (shown using the line connecting the bars) administered via the LMS for each course peaked in Spring 2020 and Spring 2021 though the median number of Quizzes (shown as the line within the bars) had already dropped from five in Spring 2020 to two in Spring 2021. As the number of courses using Quizzes dropped in Springs 2022 and 2023 (Figure 1b), those courses using Quizzes also did so less frequently.

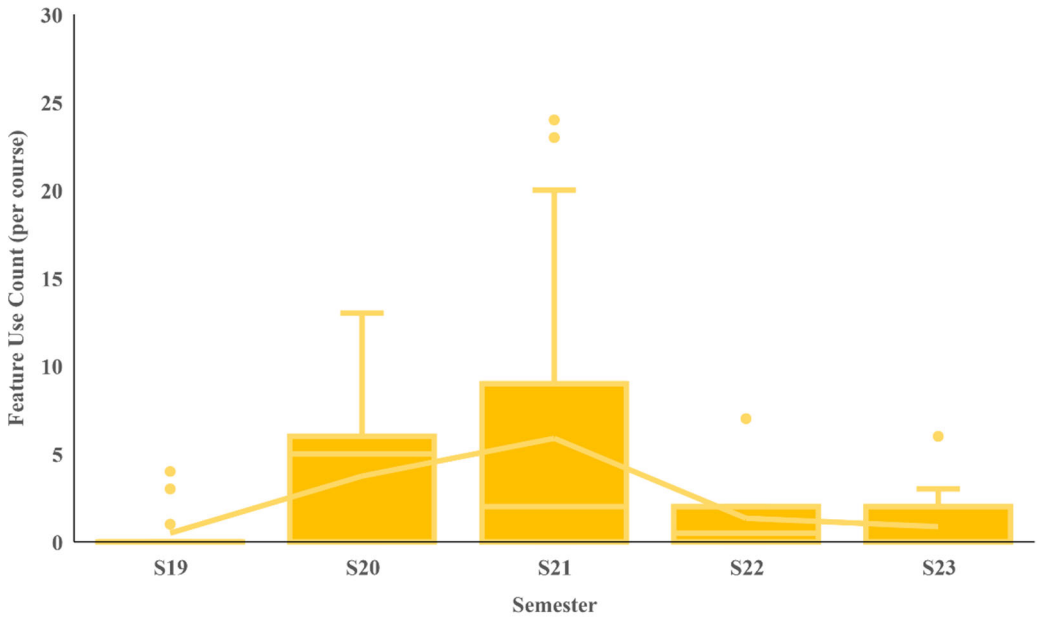


Figure 2. Quizzes per course

Figure 3 shows the distribution in the number of gradebook entries that were made per student (e.g., number of graded assignments, quizzes, etc. in the course). The average and median number grade entries greatly fluctuate over the timeframe. Median usage began Spring 2019 at 14 entries per student, then rose in Spring 2020 (23), fell in Spring 2021 to its lowest level (13), rose again in Spring 2022 (14), then rose again in Spring 2023 (18).

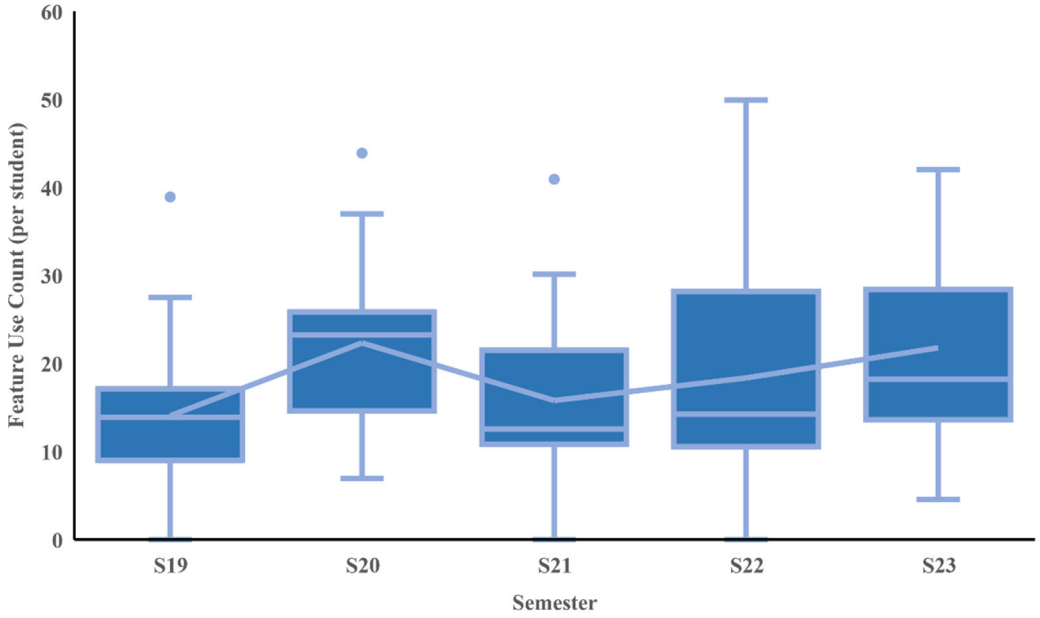


Figure 3. Gradebook Entries per student

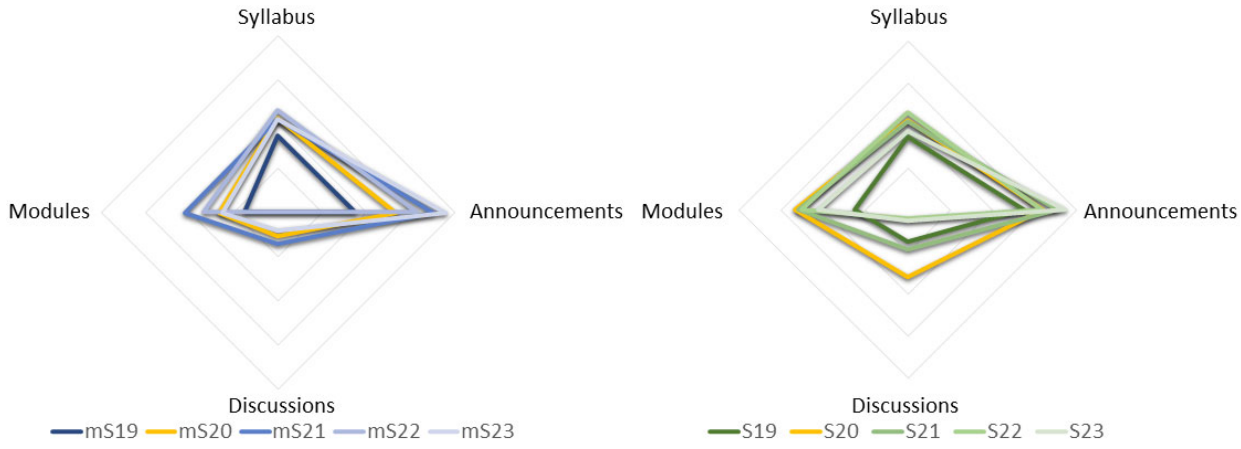
C. Instructor Communication

Results for the Instructor Communication category of LMS features are provided in Figures 4 and 5. The percentage of courses that used each feature at the mid-point and end of the semester is represented in Figure 4, while the extent of use of select features is represented Figure 5.

In terms of percentage of courses using the Syllabus, Announcements, Discussions, and Modules features (Figure 4), it can be seen in both the mid-Spring data (Figure 4a) and Spring data (Figure 4b) that the Syllabus feature was turned on in 44% of courses in Spring 2019; this increased to 61% of courses by Spring 2022, but fell back to 44% in 2023. There was no change in the Syllabus feature use between the mid-point and the end of semester, even in the disrupted semester, indicating that this feature, if used, was turned on in the first half of the semester.

In 2019, the percentage of courses that had used Announcements at least once by mid-Spring was 44%. In each successive semester, up to mid-Spring 2023, the percentage of courses using announcements at least once by the mid-point steadily rose to nearly 100% in 2021 and remained at that level thereafter. Looking at the end of the semester results, the percentage of courses that had used Announcements generally increased from 2019 (68.8%) to 2023 (100%). In 2020, the percentage of courses using Announcements rose from 67% at mid-semester to 80% by the end of the semester.

Discussions were rarely used before the disruption (2019, 18.8%), then shot up to nearly half of all courses in 2020. Use slowly trailed off to less than pre-disruption use (2021, 24%; 2022, 6%; 2023, 9%). Similarly, Modules saw little use before the disruption, as only 31% of courses utilized the feature in 2019. In 2020, that changed; 67% of courses used the feature. The percentage of courses using this feature declined in the following years (2021, 65%; 2022, 61%; 2023, 56%).



(a) (b)

Figure 4. Percentage of courses that used Instructor Communication LMS features, (a) Mid-Spring, (b) Spring

Figure 5 shows the distribution in the number of Announcements, Discussion, and Modules evident by the end of each semester for each course. The use of the Syllabus feature could not be explored in this manner due to the nature of the variable; the Syllabus feature is either on or off; there are no counts associated with it. Discussions were seldom used before, during, or after the disruption. Even though half of the courses used Discussions at least once in Spring 2020, that was the maximum use. In Spring 2020, each course on average used at least one discussion (1.1 discussions per course), then the average number of Discussions fell to pre-pandemic levels (2019, 0.3; 2021, 0.6; 2022, 0.1; 2023, 0.2).

With Announcements, in Spring 2019, the average number of posted accountments was 7.3 per course. In 2020, the average was 23 announcements per course. The average number continued to rise to 30 announcements per course in Spring 2021. Then the average number settled at 21 announcements per course in 2022 and 2023. Across Springs 2020-2022 there was wide variation in the number of announcements posted in each course, with some courses being heavy users.

The average number of Modules created within each course was three in Spring 2019. Thereafter, the average peaked at nine in 2020 and remained between six and eight in subsequent semesters. The distribution of the number of Modules was greater in 2020 than in 2019 and remained greater through to Spring 2023, though the median number somewhat fluctuated.

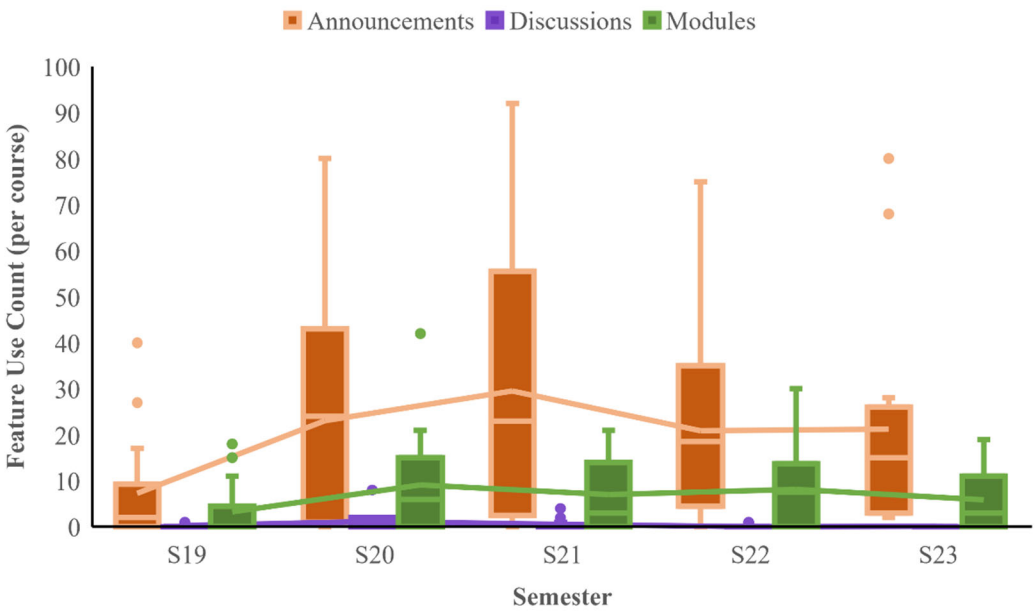


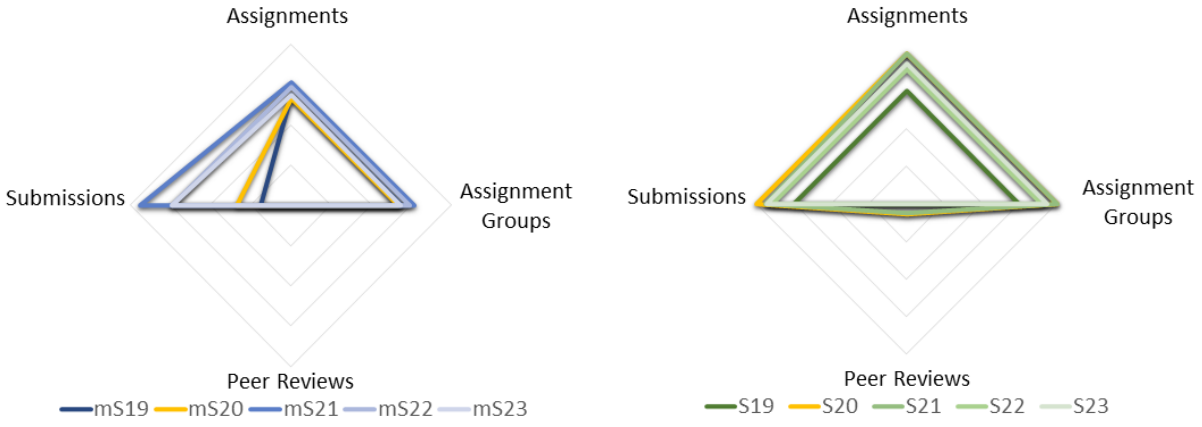
Figure 5. Number of Instructor Communication feature use per course

D. Student Activity

The Student Activity LMS feature use (i.e., Assignments, Assignment Groups, Peer Reviews, Submissions) results are shown in Figures 6 - 8. The percentage of courses that used each feature at the mid-point and end of the semester is represented in radar plots (Figure 6), while the degree of utility of each feature in each course is represented in a box-and-whisker plot (Figures 7 & 8). Data from the Spring semesters show similar trends in the use of the Assignment and Assignment Group features (Figure 6). These features were seen to be used in 75% of courses in Spring 2019, then 100% of courses used this feature in Spring 2020. This 100% use was carried over into Spring 2021, then decreased to 90% in Spring 2022 and 93% in Spring 2023.

The trend in Submissions across the timeframe was similar to Assignments and Assignment Groups, with the only disparity coming in Spring 2021. In that semester, while 100% of courses were using Assignments and Assignment Groups, only 94% of courses had students submit work through the LMS. Also worth noting is the large difference between Mid-Spring and Spring Submissions feature use across the timeframe. In Spring 2019 and 2020, the percentage of courses with at least a single submission of work at the midpoint of the semester was low (2019, 19%; 2020 33%). But by the end of the semester more courses had at least one submission (2019, 75%; 2020 100%). From Spring 2021 to 2023, most courses had established by the midpoint in the semester whether they were using the Submissions feature. In 2021, there was no difference in the percentage of courses using this feature from the midpoint to the end of the semester (94%). Springs 2022 and 2023 data shows only a 15.8% and 19.6% change respectively in Submissions use from the mid-point to the end of the semester.

The Peer Reviews feature was used little throughout the timeframe. The highest use came in Spring 2020 at only 7% of courses. Peer Reviews were subsequently used in Spring 2021 by 6% of courses, and then never used again in the timeframe.



(a) (b)

Figure 6. Percentage of courses that used Student Activity LMS features, (a) Mid-Spring, (b) Spring

The number of times Student Activity features were used are shown in Figures 7 and 8. The number of Assignments and Assignment Groups are on a per course basis. The number of Submissions is on a per student basis Assignments and Submissions are grouped together (Figure 7) as every Assignment in a course would be expected to have one Submission from each student, but there is a disparity between those values. When Submissions numbers are greater than Assignments, this difference may be due to multiple submissions per assignment or resubmissions. When Submissions numbers are less than Assignments, this difference may be due to students failing to submit work or changes in enrollment over the course of the semester.

The average number of Assignments per course from Springs 2019-2023 varied from 13 in Spring 2019 to 24 in Spring 2020 to 16 in Spring 2023. Submissions per student tend to track with the assignments, varying from 13 in Spring 2019 to 22 in Spring 2020 to 21 in Spring 2023. This tracking indicates that most Assignments enabled online Submissions.

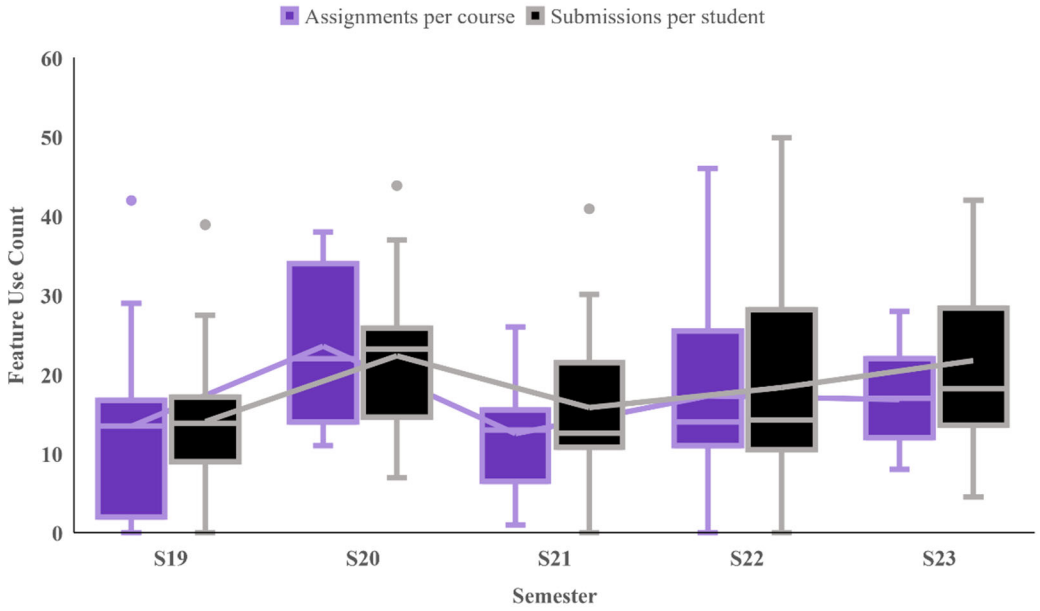


Figure 7. Number of Assignments per course and Submissions per student

The average number of Assignment Groups (Figure 8) varied between two and four throughout the timeframe. It should be noted that once one Assignment is created in the LMS, there is one Assignment Group. If there is more than one Assignment Group, there may be intention to the grouping of the assignments.

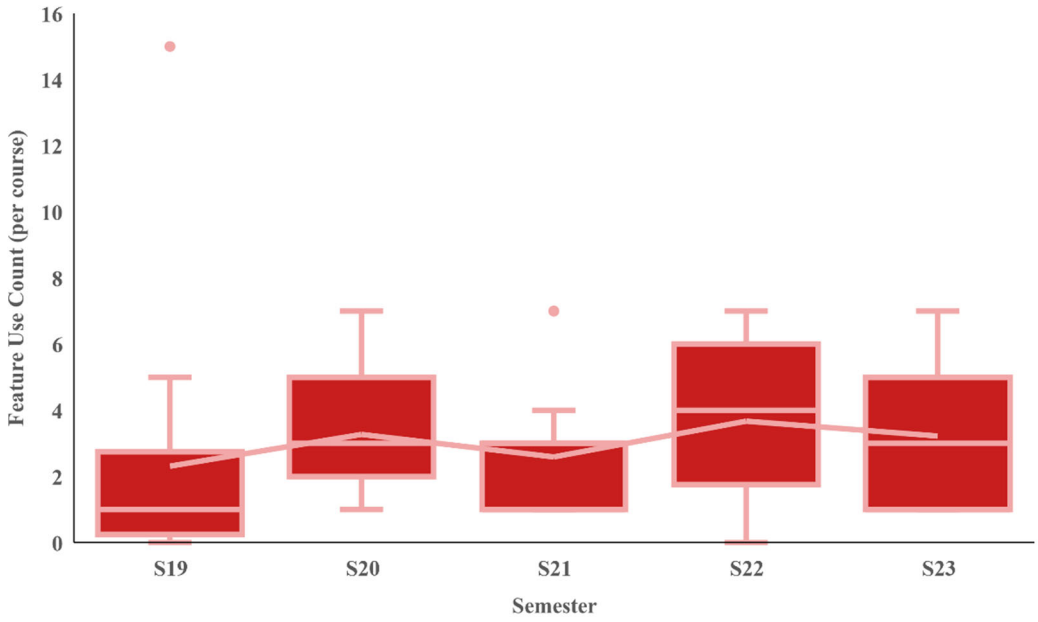


Figure 8. Number of Assignments Groups per course

IV. Discussion

Of the LMS features examined, there was an increase in use in many of the LMS features in Spring 2020 (at the beginning of the disruption) compared to Spring 2019 (before disruption). In Spring 2021 (still considered part of the disruption) some feature use declined; often times these features were interrelated (e.g., fewer assignments lead to fewer gradebook entries). After the disruption, LMS feature use varied by feature.

LMS feature use before, during, and after, as seen in this study can be organized into three groups: Limited/No Use, Discontinued Use, and Sustained Use. These groups were determined by examining the trends from the radar and box-and-whisker plots. Little/No Use describes a feature that showed either insignificant use during the timeframe or a feature that was never used at all. Discontinued Use reflects a peak during the disruption and a trailing off after restrictions and lockdowns ended. Sustained Use denotes either consistent usage throughout the timeframe, or heightened usage from the beginning of the disruption and maintained usage thereafter.

The LMS features in the Limited/No Use group were Peer Reviews, Outcomes, Rubrics, and Discussions. Outcomes and Rubrics were never used before, during, or after the disruption; Peer Reviews were scarcely used. These findings are likely related to the perceived utility of the pedagogy associated with the feature in particular courses and the demands of using the feature. When considering the Peer Reviews feature, one has to consider when peer review is most commonly used in engineering courses. Peer review, if it is employed by instructors, tends to be used in conjunction with project work, particularly design work, though it can be applied to many other types of student work and with learning benefits [23]. Project work in the curriculum under study tended to occur in senior-level courses. So, it is not surprising that Peer Reviews were not used in the second- and third-year courses considered in this study, as they focused on engineering science topics with more traditional homework and exam course elements [24].

When considering Rubrics and Outcomes, each of these features demands instructors have both advanced pedagogical skills and high techno-pedagogical skills, an ability to use technology effectively for teaching [25]. Take for example Rubrics. Instructors must be able to articulate clear criteria on which students will be evaluated (pedagogical skill), then use the LMS to construct rubrics using the criteria, associate the rubrics with assignments, and manage the logistics of using the rubrics for assessment (techno-pedagogical skill). The use of the Outcomes feature takes the demand up another notch as instructors need to be able to write learning outcomes and use them as the basis for assessment (pedagogical skill). Then the instructor must build a library of outcomes in the LMS and draw on this library to construct rubrics (techno-pedagogical skill). It seems reasonable to expect that if instructors are not using rubrics and outcomes outside of the LMS, they are less likely to use them in the LMS. Additionally, if the translation of the rubrics and outcomes to the LMS is difficult, time-consuming, or minimally supported, these features are not likely to be used [11].

Discussions seem to have been tried once during the disruption and then not used again in most courses. It may be that Discussions were attempted once to provide an additional means of communication among students and instructors, perhaps to address student isolation issues. This use of this feature requires a pedagogical skill in the form of an ability to facilitate discussions. Time restraints, student perceptions, and lack of facilitation may have curtailed its use.

The Discontinued Use group included Quizzes, though its use did not return to pre-disruption levels in the timeframe of this study. The discontinuity in this feature's use may be related to the return to in-person instruction and issues of academic integrity. Quizzes may just have been moved back to the classroom environment as in-person instruction resumed. Alternatively, the issues of detecting and preventing online academic dishonesty may have been too frustrating to continue.

Features that saw Sustained Use included Announcements, Modules, Assignments, Assignment Groups, Submissions, and Gradebook Entries. These features were either in use prior to the disruption and may have required lower techno-pedagogical skills to start using. Their sustained use indicates perceived utility and ease of use.

V. Recommendations

What is clear from the findings is that two LMS features that failed to be used or sustained, Rubrics and Quizzes respectively, indicate instructor needs for professional development. Given the known benefits of Rubrics related to student achievement and motivation [26][27][28][29][30], the absence of the use of Rubrics is concerning. Instructors should use Rubrics for the benefit of their students. Rubrics have been found to be useful for assessing student progress, as well as being used to articulate learning standards [26]. Having focused learning goals, criteria, and performance descriptions has been shown to enhance motivation and performance in courses, and an efficient, clear, and easily understood way to do this is by implementing Rubrics [27]. The use of Rubrics is related to inclusivity, transparency, and helps improve accessibility to learning for those who are not familiar with typical grading expectations [28]. Because of these benefits, post-secondary instructors should engage in professional

development in the use of rubrics as findings support the use of rubrics at all educational levels [29].

As for the use of Quizzes, frequent, low-stake, post-lecture quizzes should be implemented into a curriculum as doing so has been shown to improve course grades [30], increase motivation to learn and take notes, and boost student confidence in courses [31]. Reasons for the decreased use of Quizzes could be a mixture of the return to in-person course delivery as well as online academic integrity issues. Quizzes may have shifted from the online environment to the physical classroom. There are indicators that in other engineering disciplines, quiz use was maintained as part of the course instruction [32]. Instructors have cited that cheating relating to the use of online assessments was a significant concern during the disruption [33]. While academic integrity was a perennial problem among engineering students even before the pandemic, with 80% of engineering students admitting to engaging in academic dishonesty [34], strategies can be employed to mitigate this issue. To combat cheating on online assessments, making the quizzes low-stakes and frequent will diminish the desire to cheat as taking the quiz honestly would be seen as a benefit to them, rather than as a stressful situation [31]. Further, instructors should be made aware of and trained to use virtual proctoring tools, such as those provided by Respondus [35].

VI. Conclusion

This study of LMS use in second- and third-year courses in a mechanical engineering department from 2019 to 2023 sheds light on the dynamic use of an educational technology before during and after a disruption. Various Grading, Instructor Communication, and Student Activity features were sustained, discontinued, and never or little used. One lesson learned is that there is a need to prepare instructors to employ an adaptive and technology-driven approach to navigate challenges imposed by disruptions in education and developing a resilient education system.

A second lesson that may be inferred across LMS feature groups is that instructors need to be made aware of the potential for efficient LMS technology utilization in mitigating disruptions. The peaks in feature usage during disruptions, such as Quizzes, Announcements, and Assignments, highlight the instrumental role of these tools in maintaining educational continuity during challenging times. The sustained use of certain features, like Modules and Announcements, underscores their reliability and importance in communication when instruction must be delivered remotely. Thus, an efficient and strategic use of LMS features emerges as a key factor in making transitions during disruptions smoother for both instructors and students.

Future research work will focus on combining LMS data with instructor syllabi information over the same time period. This more holistic approach aims to provide a more comprehensive understanding of instructional strategies used and can lead to more robust recommendations. Exploring the synergies between LMS features and syllabus content will offer valuable insights into optimizing teaching methods, aligning curriculum with student needs, and enhancing the overall educational experience. This expansion in data collection and analysis will contribute to a more nuanced and informed perspective on the evolving role of educational technology in responding to disruptions.

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References

[1] F. Mello and C. West, "What has happened when campuses shut down for other disasters? A coronavirus case study," *The Hechinger Report*, May 4, 2020, [Online]. Available: https://hechingerreport.org/what-has-happened-when-campuses-shut-down-for-other-disasters-a-coronavirus-case-study/

[2] G. Gómez-García, M. Ramos-Navas-Parejo, J. C. de la Cruz-Campos, and C. Rodríguez-Jiménez, "Impact of COVID-19 on university students: An analysis of its influence on psychological and academic factors," *Int. J. Env. Res. Pub. He.*, vol. 19, no. 16, article 10433, 2022, doi: 10.3390/ijerph191610433.

[3] P. Aguilera-Hermida, "College students' use and acceptance of emergency online learning due to COVID-19," *Int. J. Ed. R. Open*, vol. 1, article 100011, 2020, doi: 10.1016/j.ijedro.2020.100011.

[4] J. Howell, M. Hurwitz, J. Ma, M. Pender, G. Perfetto, and J. Wyatt, "Fall 2021 Update on continued pandemic impacts," CollegeBoard, October 2022. [Online]. Available: https://research.collegeboard.org/reports/college-access/enrollment-retention-covid

[5] M. Weimer. *Learner-centered Teaching: Five Key Changes to Practice.* John Wiley & Sons. 2002.

[6] B. B. Smith, Y. S. Park, L. Ross, S. J. Krause, Y. Chen, J. A. Middleton, E. Judson, R. J. Culbertson, C. J. Ankeny, K. D. Hjelmstad, and C. Y. Yan, "Faculty characteristics that influence student performance in the first two years of engineering," in *ASEE Annu. Conf. & Expo.*, New Orleans, LA, 2016.

[7] S. J. Dooley, "Designing a reference training course and cultivating a community of practice: Utilizing the LMS for staff training and development," in *ASEE Annu. Conf. & Expo.*, Tampa, FL, 2019.

[8] C. Hodges, S. Moore, B. Lockee, T. Trust, and A. Bond, "The difference between emergency remote teaching and online learning," *EDUCAUSE Review*. Mar. 27, 2020. [Online]. Available: https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning

[9] K. Popovich and G. Pangborn, "TiPS for surviving pandemic teaching: A learner-centered framework," *Inform. Syst. Ed. J.*, vol. 20, no. 5, pp. 4-16, Dec 2022.

[10] M. Dindar, J. Hermes, M. Suorsa, P. Karppinen, and P. Näykki, "Comparing technology acceptance of K-12 teachers with and without prior experience of learning management systems: A Covid-19 pandemic study," *J. Comput. Assist. Lear.,* vol. 37, no. 6, pp. 1553-1565, 2021, doi: 10.1111/jcal.12552.

[11] I. Waris and I. Hameed, "Modeling teachers' acceptance of learning management system in higher education during COVID-19 pandemic: A developing country perspective," *J. Public Affairs*, vol. 23, no. 1, 2023, doi: 10.1002/pa.2821.

[12] D. F. Midgley and G. R. Dowling, "Innovativeness: The concept and its measurement," *J. Consum. Res.*, vol. 4, no. 4, pp. 229–242, 1978, doi:10.1086/208701.
[13] V. Venkatesh and H. Bala. "Technology acceptance model 3 and a research agenda on interventions," *Decision Sci.*, vol. 39, no. 2, pp. 273–315, 2008, doi: 10.1111/j.1540-5915.2008.00192.x
[14] B. Herrenkind, A. B. Brendel, I. Nastjuk, M. Greve, and L. M. Kolbe, "Investigating end-user acceptance of autonomous electric buses to accelerate diffusion," *Transport. Res. D-Tr. E.*, vol. 74, pp. 255–276, 2019, doi: 10.1016/j.trd.2019.08.003
[15] F. D. Davis, "Perceived usefulness, perceived ease of use, and user acceptance of information technology," *MIS Quart.,* vol. 13, pp. 319–339, 1989, doi: 10.2307/249008
[16] Y. Guo and D. Lee, "Differential usage of learning management systems in chemistry courses in the time after COVID-19," *J. Chem. Ed.*, vol. 100, no. 5, pp. 2033-2038, 2023. doi: 10.1021/acs.jchemed.2c00850
[17] X. Zhao, M. Kung and L. Cai, "How instructors initially viewed teaching online in higher education in the UK during the COVID-19 pandemic," in *Learn. Technol. and Systems: 19th Int. Conf. on Web-Based Learn. (ICWL 2020)*, and *5th Int. Symp. on Emerg. Technol. for Educ. (SETE 2020)*, Ningbo, ZJ China, Oct 22–24, 2020, pp. 277-286, doi: 10.1007/978.3.030.66906.5.26
[18] P. Kumar, C. Saxena, and H. Baber, "Learner-content interaction in e-learning- the moderating role of perceived harm of COVID-19 in assessing the satisfaction of learners," *Smart Learn. Environ.,* vol. 8, no. 5, 2021, doi: 10.1186/s40561-021-00149-8
[19] S. Brown, L. Murphy, and K. Hammond, "Learning Management System adoption by academics: A perspective following the forced lockdown of NZ universities due to COVID-19 in 2020", *J. Open Flexible Dist. Learn.,* vol. 25, no. 2, pp. 55-65, 2021.
[20] M. Pitcher and K. Parsons, “More to the retention story: Exploring second- to third-year retention at 4-year colleges and universities,” American Institutes for Research, July 2023, Accessed: January 22, 2024. [Online]. Available: https://www.air.org/sites/default/files/2023-08/AIR-More-to-the-Retention-Story-July-2023-Final.pdf
[21] G. Panther and H. A. Diefes-Dux, "Application of cognitive, behavioral, and emotional adaptability lens for Interpreting the teaching experiences of engineering instructors during a switch to remote instruction," *Int. J. Eng. Ed.*, vol. 39, no. 5, pp. 1216–1233, 2023.
[22] Instructure Community. “How does canvas define the terms used to describe its features and functions?” Accessed Nov. 16, 2023. [Online]. Available: https://community.canvaslms.com/t5/Canvas-Basics-Guide/How-does-Canvas-define-the-terms-used-to-describe-its-features/ta-p/51
[23] M. Conde, L. Sanchez-Gonzalez, V. Matellan-Olivera, and F. J. Rodriguea-Lera, “Application of peer review techniques in engineering education,” *Inter. J. Eng. Ed.*, vol. 33, no. 2(B), pp. 918–926, 2017.
[24] H. Wulf, G. Panther, and H. A. Diefes-Dux, “Indicators of change in mechanical engineering instructors’ teaching practices across five years,” in *ASEE Annu. Conf. & Expo.*, Portland, OR, 2024.
[25] M. Mujtaba Asad, K. Aftab, F. Sherwani, P. Churi, A-J. Moreno-Guerrero, and B. Pourshahian, “Techno-pedagogical skills for 21st century digital classrooms: An

extensive literature review," *Ed. Res. Inter*., vol. 2021, article, 8160084, 2021, doi: 10.1155/2021/8160084.
[26] T. L. Rhodes, "Emerging evidence on using rubrics," *Peer Review*, vol. 13/14, no. 4, article 1, pp. 4–5, 2011.
[27] S. M. Brookhart and F. Chen, "The quality and effectiveness of descriptive rubrics," *Ed. Rev.*, vol. 67, no. 3, pp. 343–368, 2015. doi: 10.1080/00131911.2014.929565.
[28] K. Ragupathi and L. Adrian. "Beyond Fairness and Consistency in Grading: The Role of Rubrics in Higher Education." In *Diversity and Inclusion in Global Higher Education: Lessons from Across Asia*, edited by Catherine Shea Sanger and Nancy W. Gleason, 73–95. Singapore: Springer. doi : 10.1007/978-981-15-1628-3_3.
[29] E. Jayamani, S. K. Heng, and M. K. Bakri, "Effect of developing analytic/task specific rubric for an enhanced student learning in manufacturing subjects,"*Annu. Int. Conf. Comput. Sci. Educ.: Innov. & Technol.*, Singapore, 2016, doi: 10.5176/2251-2195_CSEIT16.21.
[30] M. M. Khanna, "Ungraded pop quizzes: Test-enhanced learning without all the anxiety," in *Teaching in Psychology*, vol. 42, no. 2, pp. 174–178, 2015, doi: 10.1177/0098628315573144.
[31] J. Case and D. Kennedy, "Using quizzes effectively: Understanding the effects of quiz timing on student motivation and knowledge retention," in ASEE Virtual Annual Conference. [Online], 2021, Available: https://peer.asee.org/37996
[32] S. Zavala, G. Panther and H. A. Diefes-Dux. "Shifts in grade weight of assessments in engineering syllabi," presented at Student Research Days, Lincoln, NE., Mar. 26, 2024.
[33] K. Beddoes and G. Panther, "Cheating, Fairness, and Equity: A Critical Examination of Teaching Discourses," *Discourse: Studies in the Cultural Politics of Education,* under review.
[34] G. M. Javaid Bukhari, J. Saleem, S. A. Javaid Bukhari, M. Ishaq and M. S. Butt, "Challenges in conducting online assessments in undergraduate medical and dental education: a scoping review," *Biomedia,* vol. 38, no. 3, pp. 123–128, 2022. doi: 10.51441/BioMedica/5-764.
[35] T. L. Giluk and B. E. Postlethwaite, "Big five personality and academic dishonesty: A meta-analytic review," *Personality Indiv. Diff.*, vol. 72, pp. 59–67, 2015, doi: 10.1016/j.paid.2014.08.027
[36] Respondus, Accessed: Jan. 28, 2024. Available: https://web.respondus.com/about/