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Relationship of Students' Engagement with Learning Management System and their Performance- An Undergraduate Programming Course Perspective

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Abstract

The Covid-19 pandemic forced the closures of universities across the United States, resulting in multiple modes of instruction. These transitions required both students and instructors to adequately use educational technology tools and applications. Most instructors used a learning management system (e.g., Canvas, Blackboard) and an online conference tool (e.g., Zoom, Teams) to ensure students' access to course material, class participation, and engagement. In the new normal time, although the in-person classes started in many universities, the hybrid of Hyflex mode (i.e., students in both in-person and on zoom sessions) is more prevalent. Students and instructors find educational technology tools as an easier way to disseminate the course information (e.g., videos), material (e.g., course videos, study guides, and notes), and assessments (e.g., quizzes). Considering the reliance on technology tools, it is crucial to understand the relationships between students' application engagement and performance.

This paper examined the relationship between students' engagement with an educational Learning Management System (LMS) and their performance. In addition, we also evaluated the way students' engagement with the LMS changed over time during a semester (15 weeks). For this purpose, we collected the data from two sections, 84 students of the introductory engineering programming (MATLAB) course. For students' engagement with the LMS (Canvas in this case), we collected the timestamps each week, indicating the number of hours spent by each student on the LMS. As the timestamps were cumulative, we collected the data at the end of each week at the same time and calculated the weekly time spent by each student on the LMS. We used students' performance scores in two exams for students' performance.

We used Pearson correlation and multiple regression analysis for this semester-long study to understand the relationship between students' engagement with the LMS and students' performance. We also conducted the repeated measures ANOVA to understand the trends of students' engagement with the LMS. The study results bring an interesting perspective indicating a significant relationship between students' app engagement in three weeks and programming parts of exam1 and four weeks on the programming part of exam2. Although instructor-based variations were significant in PartII of both exams, app engagement significantly predicted exam2 and PartII of exam1. The paper discusses these results with course content, limitations, and future directions.

Introduction

The era of Covid-19 brought unprecedented challenges at a staggering speed for humankind in all areas of life. These challenges were multi-fold for Higher Education across the globe. In higher education systems, institutions prioritized people's health and adapted various existing tools and technologies to transition to Emergency Remote Teaching (ERT) effectively. Instead of the gradual and systematic integration of educational technology tools, the transition was more rapid. These rapid shifts required tools to share course materials such as lecture notes, assignments, and activities, which were primarily convened using an LMS

[1-3]. Also, the tools were needed to conduct exams online with the surety of minimal plagiarism and conduct classes online, which were often integrated into the LMS [4]. Although technology integration was the need of the hour, it had several drawbacks. These include: 1) the rapid integration was done without validating its effectiveness on various factors of students' learning or any alignment with the course content, assessment, and pedagogy [5]. 2) the rapid transition overlooked the preparation of faculty and students to adopt such tools and stay engaged. 3) the rapid transition assumed the availability of other resources [6] such as high-speed internet, ownership of adequate devices, the place to study and concentrate for students and faculty, and 4) the rapid transition perceived that students' would keep engaged in the content and material as they would have in a face to face classroom.

During Covid-19, another model of instruction took its limelight called Hybrid or HyFlex (Hybrid+Flexible) instruction [7], [8]. This model added another layer to the adaption of the technology tools and gave students the flexibility to attend either an online or in-person version of the same class. In addition, to the existing demand for teaching the course in ERT or online modality, the faculty faced another challenge by offering a simultaneous course for both in-person and online students. Such a model required effective integration of all technology tools to be effectively usable by both in-person and online students and with similar engagement. The use of multiple pedagogic models also increased the reliance on technology tools. The faculty and the students use various online conferencing tools like zoom, Microsoft teams, etc., that were not utilized in a standard traditional setting. Prior studies suggested various benefits of hybrid/Hyflex models, including working from the convenience of their home, flexibility and time management, and easier collaboration with the faculty through online meetings [9]. However, this technological reliance generated another paramount concern regarding how effective this integration is? Especially in light of the previous studies, which suggested that online teaching or ERT was a more challenging mode of instruction for intrinsically hard concepts, courses with lab components, or large class sizes such as programming courses [10]. Along with this, one emerging question arose regarding the impact of students' engagement with these technological tools and their academic performance [11],[12].

Considering these concerns about students' engagement and effective integration of educational technology tools in an engineering course, in this paper, we aim to explore the relationship between students' educational application engagement and their learning outcomes. More specifically, we address the following research questions:

RQ1: How do students' engagement with educational applications (i.e., Canvas - learning management system) relate to their performance in an engineering programming course?

RQ2: How does students' engagement with educational applications (i.e., Canvas - learning management system) change during the semester?

Literature review

Prior research studies have discussed the role and use of various LMS as standard educational tools across the globe [13]–[15]. Some examples of LMS include Canvas, Blackboard, Schoology, Brightspace, Moodle, etc. LMS is defined as an educational application that helps plan, implement, and assess learning processes, providing instructors with ways to deliver content and monitor students' participation [15]. Further, the tool has interactive features for keeping students engaged (e.g., discussion forums).

Many studies have utilized students' engagement with the educational application (app engagement) to measure successful integration. In educational tools, app engagement refers to students' use of the application. Chapman [16] defines application engagement as the ability of a system to captivate the user's attention. Similarly, application engagement can be defined as the user's involvement with the application's interface and tasks [17]. Also, studies have used various factors of students' app engagement, including usage analytics [18], time spent with the application, number of times the application was used, etc. [19], and investigated their relationship with students' performance.

Although fewer studies have explored the relationship between students' use of LMS and their performance, students' desire to use and stay engaged with LMS has impacted students' learning [20]. However, there doesn't seem to be a consensus on whether LMS usage leads to better student performance. While some studies indicate a strong relationship between LMS usage and higher student grades [21]–[23], others have found no evidence for it [24], [25]. For instance, Swart [26] examined the relationship between students' use of LMS (blackboard) and their academic grades for an undergraduate engineering class. The author found a strong positive statistical relationship between LMS use and students' final grades. Similarly, Wei and colleagues [21] found a direct relationship between students' self-reported frequency of logging in to LMS and their exam scores.
In contrast, Mijatovic and colleagues [25] compared students' active participation in class and interactive LMS usage. The authors investigated the impact of both on students' achievement. They reported class participation as the primary contributor to students' achievement. Also, Venugopal and colleagues [24] found no relationship between LMS use and students' scores.

Due to increased reliance on educational tools during the pandemic, several studies investigated their usage, accessibility, and engagement (e.g., [20], [27]). For example, Alturki and colleagues [20] examined the factors that promote LMS use and students' engagement in university students during the COVID-19 pandemic. They found that students' use of the application tool is driven by their perceived ease of use and effectiveness. In a similar study, Cavus and colleagues [27] suggested supportive conditions, attitude, satisfaction from use, ease of use, and beliefs about the effectiveness as predominant factors of successful LMS integration in the courses.

The mixed results from these studies indicate the need for further investigation. A more comprehensive view of the entire LMS is also required to determine its effectiveness and impact on students' performance holistically. Considering the scarcity of studies that investigated the relationship between students' app engagement with LMS and their academic performance, in this study, we aim to investigate this relationship in a conceptually hard programming course.

Research Methods

This quantitative correlational study uses a multi-method approach [28] to investigate the relationship between students' app engagement and performances. Further, we accounted for instructor-based variations to answer both research questions.

Site and Participants

We collected data from two sections, a total of 84 undergraduate engineering students enrolled in a large R1 South-Eastern university during Fall 2021. A different instructor taught each section in a HyFlex modality (N=42 students each). The data were collected from students enrolled in an introductory programming course titled 'Introduction to Computer Programming with MATLAB.' This course content advances students' skills in problem-solving and programming. This course is built on weekly building blocks of coding constructs. Every week students are trained on problem-solving using a new construct of programming, which also requires transferring knowledge from previous weeks. In addition, during class, students are prepared to engage in teamwork activities, enhancing their communication and problem-solving skills with their peers.

Both instructors engaged students in the same class activities and gave similar exam questions designed for average-ability students using the same format. As the course was in HyFlex mode, each section had the flexibility for students to attend either zoom or in-person sessions. Additionally, all course material and class activities were conducted using LMS. Also, the exams were conducted using an honor lock system connected to the course LMS.

Measures and Data collection

For both instructors, we collected the data on students' app engagement (i.e., engagement with the LMS in terms of time spent) and students' performance in two exams. For app engagement, we used the students' measure of interaction with the LMS and used the weekly time stamps indicating the amount of time spent by each student. For this purpose, we relied on LMS-provided timestamps. Both instructors recorded the timestamp at identical days and times each week. In this semester-long study, we collected the data for 10 weeks. We used the exam scores from two exams for' students' performance. Each exam consists of two parts (Part-I=40 marks, and Part-II =60 marks). Part-I of both exams was based on conceptual programming questions, including finding and correcting errors, stating the output of a given program, or writing small programs in pseudocode form without using a development interface. The Part II of both exams comprises real-time problem solving and coding of a given problem.

Procedure and analysis

For students' engagement with the LMS, we collected the timestamps each week at an identical time. These timestamps indicate the time spent by each student on the LMS. As the timestamps were cumulative, we collected the data at the end of each week at the same time and calculated the weekly time spent by each student on the LMS. As the LMS reported time was in Hours: Minutes: Seconds format, we converted this time to the number of seconds spent by each student each week for accuracy reasons. Additionally, we used students' performance scores in two exams (two parts each) for students' performance.
We used SPSS 28.0 to conduct the statistical analysis. Initially, we examined skewness, kurtosis, multicollinearity, and singularity and found no outliers. We examined linearity using scatter plots and tested for data homogeneity. In addition, we found no multicollinearity issues in the data.

For the first research question to examine the relationship between students' app engagement and performance, we used two methods 1) Pearson correlation and 2) multiple regression analysis while accounting for instructors-based variations. We used a dummy-coded variable for instructors' variation where 0 was coded for instructor1, and 1 was coded for instructor2. We conducted repeated-measures ANOVA for the app engagement across 10 weeks for the second research question. We used instructors as a covariate while conducting the analysis. We used 'Mauchly's W test of sphericity. The epsilons (ε), which are estimates of the degree of sphericity in the population, were calculated. We used the cut-off value of 1.0 to validate the assumption. We used the Huynh-Feldt epsilons for adjusting the degrees of freedom if the value is greater than 0.75 or Greenhouse-Geisser otherwise.

Results

RQ1: How do students' engagement with educational applications (i.e., Canvas-LMS) relate to their performance in an engineering programming course?

At first, we calculated the Bi-variate Pearson correlation to examine the relationship between students' application engagement (time spent with LMS each week) and students' performance in both parts of exam1 and exam2. The results of the significant correlation are presented in Table 1.

Table 1. Significant correlations between app engagement each week and students' performance

Weeks	Exam1 – PartII	Exam2 – PartI	Exam2 – PartII
2	.230*	-	-
3	-.286**	-.364**	.275*
4	.238*	.222*	-
5	-	-	.293**
6	-	-	.227*
10	-	-	.235*

**p<.05, **p<.01*

The results indicate no significant relationship between students' app engagement and Exam1-PartI. There was a significant relationship between students' app engagement of week2, week3, and week4 with students' performance in Exam1-PartII. Also, students' app engagement in week 3 and week 4 is related to students' performance in Exam2-PartI, and weeks 3,5,6, and 10 are positively correlated with performance in Exam2-PartII. It is noteworthy that app engagement in week3 is most significantly contributed with 3 out of the four parts of the exams.

We conducted the multiple regression analysis with the independent variables as total time spent on app engagement (i.e., the aggregate total of time spent each week) and students' performance in each exam. We also accounted for instructors'-based variation. The results of the regression analysis are presented in Table 2.

Table 2. Results of regression analysis between students' app engagement and performance

Estimate	R^2	B	SE	*t*	*p*	sr^2
Exam1- PartI						
App engagement (time spent)	.003	-4.108E-6	.000	-.314	.754	-.035
instructor		.687	2.667	.258	.797	.038
Exam1- PartII						
App engagement	.147	1.702E-5	.000	1.676	.098*	.172
instructor		7.516	2.070	3.632	<.001***	.373
Exam2- PartI						

App engagement	.203	-4.254E-6	.000	-.383	.705	-.038
instructor		9.847	2.278	4.322	<.001***	.429
Exam2- PartII						
App engagement	.148	2.318E-5	.000	1.771	.080*	.182
instructor		-7.503	2.666	-2.814	.006***	.289

**p<.10, **p<.05, ***p<.01*

The results of multiple regression analysis indicate that both app engagement and instructor do not relate with students' performance in Exam1 – PartI with $F(2,81) = .107$, $p=.899$. However, for Exam1-PartII, both app engagement and instructor-based variation significantly predict students' performance with $F(2,81) = 6.964$, $p=.002$. The results further indicate that the app engagement and instructor-based variations account for a 14.7% variance in students' Exam1-PartII performance. For Exam2-PartI, instructor based variation significantly predicted students' performance with $F(2,81) = 10.346$, $p<.001$. Also, for Exam2-PartII, both app engagement and instructor-based variations predicted students' performance with $F(2,81) = 7.057$, $p=.001$. Also, 20.3% variance of students' performance in Exam2-PartI and 14.8% variance of students' performance in Exam2-PartII is accounted for by the app engagement and instructors based variations. One noteworthy aspect is that both PartII exams' app engagement and instructor-based variations were significant.

RQ2: How do students' engagement with educational applications (i.e., Canvas - learning management system) change during the semester?
We determined the direction of change in students' time spent on LMS from the beginning to the end of the semester. We used the repeated-measures ANOVA for 10 weeks of the data. The results of Mauchly's $W(44) =.054$ test of sphericity indicate that sphericity assumptions were violated. To adjust the degrees of freedom, we used Greenhouse-Geisser adjustment if epsilon was less than 0.75. The results of the repeated measures ANOVA are presented in Table 3. Also, Figure 1. shows the trends of time spent by students each week.

Table 3. Results of the repeated measures ANOVA

	W	ε	χ^2	$F(5.552,455.233)$	p	η^2
Weeks	.054	.617	229.691	27.914	<.001**	.254
Weeks*Instructors				17.585	<.001**	.177

**p<0.05, **p<.01*

The result indicates a significant mean difference of time in 10 weeks of the whole semester. Also, the results indicate a significant difference between the students of the two instructors.

The results from the Bonferroni post-hoc analysis indicate that students spent the most time in the early part of the semester. These app engagement times drastically dropped in week2 and 4 and then stayed relatively the same for weeks 5, week 6, week 7, and 8.

The results of the tests between subjects (instructors) indicate significant variations in the time spent by students of each instructor. The results are presented in Table 4.

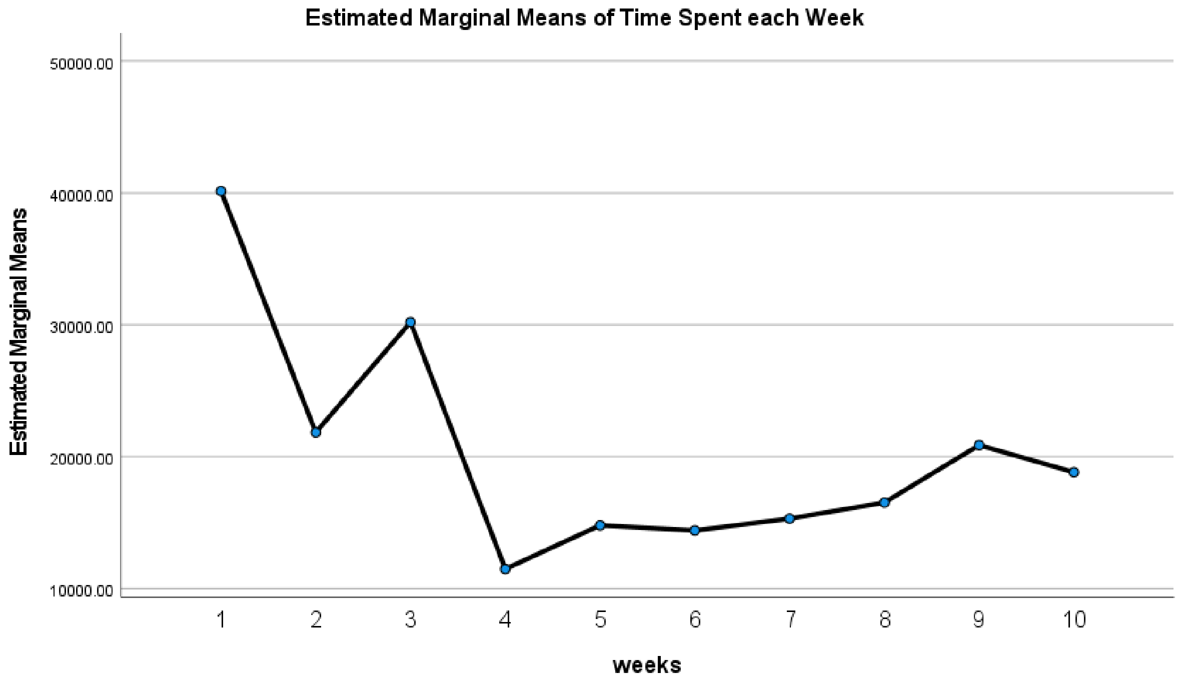

Figure 1. Trends of time spent by students on LMS each week

Table 4. Instructor based variation in the average time (in seconds) spent by students

Week	B	SE	*t*	*p*	η^2
1	1686.357	4884.891	.345	.731	.001
2	14683.524	5070.758	2.896	.005**	.093
3	-37325.786	4483.563	-8.325	<.001**	.458
4	3134.167	1797.059	1.744	.085*	.036
5	-3418.214	2884.224	-1.185	.239	.017
6	-3078.405	2367.299	-1.300	.197	.020
7	-1528.929	2779.829	-.550	.584	.004
8	4148.905	4405.291	.942	.349	.011
9	-17412.214	4706.461	-3.700	<.001**	.143
10	-7994.167	3821.834	-2.092	.040*	.051

*$p<0.05$, **$p<.01$

The results indicate that, on average, in weeks 3, 9, and 10, students of instructor1 significantly spent more time than instructor2, while for week 2 and week 4, students of instructor 2 spent significantly more time than instructor 1.

Discussion

This paper is timely as in the era of the ongoing pandemic, instructors are constantly evolving their teaching methods. The use of educational technology tools is unprecedented, with higher reliance on tools such as LMS. The increased use of technology tools created a technology-mediated learning environment for both online and HyFlex courses. However, it is also essential to understand how engagement with these tools impacts students' performance. For this purpose, in this paper, we examined the relationship between students' engagement with the LMS and their performance in an engineering programming course while accounting for instructor-based variations. To elaborate on these results, we also investigated the changes in students' engagement during the semester.

The findings of this paper brought interesting discussions into consideration as they indicate a non-significant relationship between students' app engagement and exam1- PartI. However, the app engagement significantly predicted students' performance for Exam1 - PartII and Exam2 - PartII. One probable explanation of these results could be rooted in the differences between exams. It is noteworthy that Part II of both exams was related to writing programs in Matlab, while PartI was conceptual questions. As programming courses comprise intrinsically hard concepts [10], writing a program may be more challenging for students for both syntax and semantics, which may require the use of course material more than the conceptual questions. Our findings confirm the existing literature where authors reported mixed results where some found the relationship between the two variables [21],[22], and others reported non-significant relationships [24], [25].

Also, the findings indicate significant instructor-based variations in students' time spent in certain weeks of the semester. These variations could be rooted in the timings of major deliverables of the course. Students spend more time on weeks with a major deliverable due for both instructors. Also, these variations could be because of students' past experiences with the programming courses. Future studies may shed light on these variations by triangulating the process data of classroom observations and recording students' prior programming experiences. As students' use of the application is dependent on their perceived effectiveness [20] and supportive conditions [27], future studies may account for students' beliefs about the use and material support provided by the LMS, which could be higher in specific weeks for each instructor resulting in more engagement.

Limitations and Future Directions

The results of this paper may be interpreted with several limitations. First, this study investigated only one aspect of online education, the impact of LMS on students' performance. Other variables such as the modality of instruction and the faculty's classroom setting may also significantly impact. Future studies can be designed with more confounding variables. Second, although this correlational study provides a good starting point for this research, it only helps see the relationship between the students’ app engagement and instructor-based variation on students' performances but does not provide a cause-and-effect relationship. Future studies may employ a quasi-experimental design and process data to provide a holistic investigation. Third, since this is a semester-long study, this study only has data collected from one semester; hence, there is no baseline for comparisons causing a relatively small size. Future studies can consist of a larger sample size of engineering students from a varied number of courses. Fourth, we only use students' engagement from one perspective and one application in this study. Future studies can incorporate and evaluate the impact of multiple other applications like time spent on online conferencing tools like Zoom, Microsoft teams, etc., that have been inevitable in engaging the HyFlex and online audience. Also, future studies may include supplementary data on students’ engagement, such as classroom observation for holistic interpretation [29].

Conclusion

With emergency remote instruction, online instruction, and HyFlex teaching being the trend in 2020-2021, multiple overtime improvements were made to assist and improve students' learning. Though the transition to online modalities (emergency or otherwise) was new, the infrastructure provided additional flexibility and better tools to support students through breakout rooms, annotation, and better online personalized help.

This research provides valuable insights into the comparison of these modalities and provides evidence of the effectiveness of hybrid classrooms. Also, the study confirms the results of existing studies [21],[26], indicating the role of students' app engagement in predicting students' performance. With instructor-based variation taken into account, this study reiterates the relationship between students' time spent on LMS and their performance.

Further, the results and discussion highlight the reasoning for spikes in students' app engagement. This reasoning can be helpful to instructors in the design of their courses. Also, taking these reasonings into account, instructors may help the students to mitigate any struggles and conceptual difficulties in specific topics. Collectively, these results are novel as they provide an insight into how a specific topic in programming may impact students' performance.

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