

Towards Connectivism: Exploring Student Use of Online Learning Management Systems During the COVID-19 Pandemic

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Abstract

The COVID-19 pandemic precipitated a global shift to fully remote learning via learning management systems (LMS). Despite this significant shift, there has been a paucity of research exploring how students of varying academic performance engage with online learning resources. This study investigates the utilization of LMS among students with different academic performances at an Australian public research university. Utilizing a dataset of 129,567 activity logs from 313 students, we examined their interactions with the course files, discussion forums, grade book, and online quizzes, underpinned by self-regulated learning theory and connectivism theory. Our methodology entailed a granular analysis of LMS log data to identify engagement patterns, using the Kruskal-Wallis H Test to detect variations in resource utilization across performance levels—above-credit, credit, and below-credit. The findings revealed significant disparities in the frequency of engagement with course files and online quizzes and participation in forums between students of varying academic standings, with higher engagement associated with superior academic performance. In addition, our results suggest no significant difference in gradebook views. These insights have profound implications for the design and implementation of online learning strategies. They suggest the necessity of fostering active engagement with learning materials and collaborative platforms for improved educational outcomes. In addition, these findings improve our understanding of online learning engagement during an unprecedented educational disruption and lay the groundwork for future inquiries into the intricate dynamics of student interaction with digital learning tools post-pandemic. The limitations of our study are also discussed.

Keywords: Learning management system; online learning platform; online learning; pandemic; connectivism theory; academic performance

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The unprecedented COVID-19 pandemic has catalyzed a paradigm shift in higher education, thrusting higher education into an involuntary experiment in mass online learning. According to McKinney & Company (2022), the COVID-19 pandemic caused the most substantial education disruption in history. The temporary closure of education institutions displaced 1.6 billion students from in-person instruction, including 220 million from higher education institutions (HEIs) (Farnell et al., 2021; UNESCO, 2021). This sudden shift not only tested the resilience of educational infrastructures but also challenged the pedagogical, technological, and psychological preparedness of institutions and individuals (Alshamrani et al., 2023; Mushtaha et al., 2022).

The response from HEIs comprised quickly migrating the existing curriculum to an entirely online environment to allow students to access course materials remotely. Online learning, or e-learning, comprises an ecosystem of human participants—educators, students, and nonhuman entities incorporating the relevant technologies (Mushtaha et al., 2022). A Learning Management System (LMS), also referred to as an Online Learning Platform (OLP), is a comprehensive internet-based application that melds content delivery, educational resource management, and instructional facilitation for online learning (Jaffar et al., 2022). LMSs enhance students' learning experiences by offering features such as interactive content and collaborative discussion forums, enabling them to engage actively with course materials (Tajuddin et al., 2023). LMSs increase the impetus for students to assume responsibility for their studies (Hsu, 2023; Taridi et al., 2023; Wang & Zhan, 2020).

As the crisis unfolded, LMSs became more than just tools; they evolved into complex ecosystems enabling interaction, engagement, and the replication of classroom dynamics to some extent. LMSs have gained prominence through improved Internet access and the necessity for adaptable, scalable educational solutions amid the growing demands of online education (Mhlongo et al., 2023). Many HEIs have been effectively using the LMS and exploring its impact on improving educational performance (Alturki & Aldraiweesh, 2021). Recent studies reveal that the LMS and associated tools increase student engagement (Alhazmi et al., 2021; Alturki & Aldraiweesh, 2021; Jones et al., 2021) and performance (Baragash & Al-Samarraie, 2018; Beatson et al., 2020; Cobo-Rendon et al., 2021). In addition, the LMS allows educators to track education activities, predict student performance, and then modify teaching practices (Gamage et al., 2022; Price et al., 2021). Educators continue adopting the LMS and technology-enhanced learning content (Gamage et al., 2022).

The transition was not without its issues, as disparities in access and use emerged, intensifying the call for inclusive and equitable online learning solutions. Farnell et al. (2021) highlight the need for research on the consequences of COVID-19 on teaching and learning. Rasheed et al. (2020) stress the importance of investigating the relationship between LMS adoption and academic performance to inform the ongoing development of these platforms, ensuring they can be tailored to enhance learning outcomes and support students' academic success. Sun and Yang (2023) call for research into the teaching, learning, and assessment methods during the pandemic to improve student learning outcomes. To date, few studies have explored student utilization of online learning resources during the pandemic. Furthermore, few studies have examined the relationship between student performance and the use of various LMS utilities during the pandemic's enforced and exclusive reliance on online learning.

This study seeks to bridge this knowledge gap by analyzing how disruptive times such as the pandemic have reshaped the use of online learning resources, with a focus on the implications for students' academic outcomes. In particular, we aim to answer the research question: How does the pattern of LMS resource utilization vary among students of different academic performance levels? We delve into the intricate dynamics of LMS resource utilization among students with varied academic performances. Distinct from previous works, our investigation probes into the students' engagement patterns in exclusive reliance on online learning platforms due to COVID-19 restrictions. Our findings illuminate the pathways through which online learning can bolster academic success. Furthermore, our study navigates the complexities of online learning and offers a timely exploration of the online learning landscape reshaped by the pandemic. Moreover, our analysis merges empirical data with theoretical insights to enhance educational strategies in the face of future challenges.

Relevant Literature and Theoretical Foundation

Online Learning

An LMS is a web-based information system pivotal for managing learning materials and assessment instruments, as well as tracking and reporting on student course activities, learning progress, and academic performances (Avcı & Ergün, 2022). An LMS includes a range of solutions for content management, course delivery, online learning, and student management, such as enrollment and activity management (Kasim & Khalid, 2016; Veluvali & Suriseti, 2022). Accordingly, the LMSs have increasingly become attractive for analyzing how student engagement with online resources correlates with academic performance (Avcı & Ergün, 2022).

An LMS also enhances collaborative learning by facilitating interactions among students and educators, thereby cultivating a comprehensive and dynamic educational experience (Bradley, 2021). Digital tools on an LMS empower students to actively read and engage with learning resources and interact with peers and instructors using web browsers on a wide range of operating systems and devices (Haleem et al., 2022; Marachi & Quill, 2020). The versatility of LMS tools is essential in modern educational paradigms, where adaptive learning and personalized education paths are becoming increasingly prevalent.

Various LMSs are currently accessible for educational purposes across the world. According to Gartner (2023)'s rating of higher education, Canvas, Moodle, and Blackboard have been the highest-ranked learning systems and have seen a significant user growth. Moodle's user base increased from 78 million in 2015 to approximately 328 million in 2022 (Moodle Project, 2022). Consequently, the predominant use of LMSs such as Moodle during the pandemic calls for a deeper investigation into their adoption and adaptation across diverse learning environments (Altinpulluk & Kesim, 2021; Moodle Project, 2022).

The evolution of LMS functionality has accommodated the extensive shift to online education (Mushtaha et al., 2022; Ozdamli & Karagozlu, 2022). During the pandemic, students were compelled to rely on online education as part of the formal curriculum (Ali, 2020; Potra et al., 2021). Students extensively used the LMS to access course files, upload assignments, and view marks online (Ortiz-López et al., 2023). In addition, students increasingly utilized the LMS to interact with lecturers, other students, and learning tools (e.g., taking online assessments such as quizzes and exams) (Goldie et al., 2023; Sumardi et al., 2021). The utilization of various LMS tools has become increasingly critical in fostering academic success during the pandemic (Junus

et al., 2021; Xing et al., 2023). In addition, the utilization has featured disparities in access and engagement, revealing a research gap in our understanding of how students of varying performance navigate and utilize LMS features, particularly within the constraints of continuous and exclusive online learning necessitated by COVID-19.

Connectivism in Online Learning

Connectivism theory is a learning theory for the digital age, often associated with the use of technology in education (Dziubaniuk et al., 2023). Connectivism theory posits that technology is a major component of the learning process (Downes, 2019). It promotes technology-enabled collaboration, discussion, and learning activities that extend beyond the individual level, facilitated by online learning tools, blogs, or social media (Goldie, 2016). Connectivism theory was introduced as a learning theory for the digital age and provides a theoretical framework for instructional design and helps educators construct effective learning environments (Gogus, 2023; Goldie, 2016).

Connectivism underscores the notion that individual learning is a networked process, where knowledge is disseminated and constructed through the interplay of digital technologies and the collaborative involvement of educational participants, such as learners and educators (Chang et al., 2022). In online learning, individuals feed information to a learning community and connect to an LMS (Madge et al., 2019). The LMS provides digital functions that facilitate the connections between various entities in the online learning network, such as individuals, digital tools, or resources, that can be interconnected to facilitate learning (Dang et al., 2019). On an LMS such as Moodle, learning occurs when instructors, peers, and digital innovations collaboratively interact (Dahal, 2022; Kumar & Sharma, 2016).

The application of connectivism has proven effective in evaluating the influence of online learning platforms on learner behavior (Downes, 2019). For example, Mpungose and Khoza (2022), whose research is underpinned by connectivism theory, investigated postgraduate students' experiences with using Moodle and Canvas. They found that students used Moodle and Canvas primarily for downloading readings and participating in discussion forums. In online learning structures facilitated by an LMS, students are encouraged to seek the opinions, suggestions, and ideas of others, as there is no longer a single source of knowledge (Kompen et al., 2019). Such findings underscore the importance of LMS features in student academic engagement, which our study seeks to further elaborate by examining the differences in resource utilization among students of varying academic achievements.

Self-Regulated Learning

Self-regulated learning (SRL) plays a pivotal role in digital education, highlighting the individual's capacity to autonomously oversee and direct their learning processes toward achieving goals within an online setting (Chang et al., 2023; Wong et al., 2019). It emphasizes learning steered by metacognition and strategic action, which includes planning, monitoring, and evaluating personal progress (Wirth et al., 2020). Self-regulated learners are cognizant of their strengths and weaknesses and employ a range of strategies to navigate the daily challenges of academic tasks (Teng & Huang, 2019). Embodying a proactive approach, these learners emphasize the value of their learning objectives. They are skilled at self-monitoring their progress and adjusting their learning strategies as needed (Teng & Huang, 2019).

The significance of SRL was further accentuated during the pandemic, with students encountering heightened challenges in time and workload management due to increased isolation and diminished peer engagement (Hensley et al., 2022). Consequently, the competency to self-direct one's learning journey has been increasingly essential, enabling students to effectively navigate the unique challenges posed by the shift to online education (Martin, 2020). Students who perform at a high level are more likely to be self-regulated learners (Broadbent et al., 2021; Hadwin et al., 2022). This regular and strategic use of the LMS likely contributes to their high academic performance. For instance, students who excel in online courses often actively access course announcements, engage with lecturers, and communicate attentively with peers (You, 2016). Conversely, unsuccessful learners struggle to allocate an appropriate amount of time and effort to complete such tasks (Pereira et al., 2020; You & Kang, 2014). In online environments, students less able to self-regulate struggle with virtual interaction and reduced in-person support from teachers (Longhurst et al., 2020).

SRL emphasizes an individual's autonomy and control over their learning trajectory, while connectivism underscores the importance of digital connections and interactions. The LMS, acting as a technological nexus, not only fosters the connections and interactions central to connectivism but also provides learners with the tools and resources they need to navigate their learning journey, in line with SRL principles. Consequently, this study aims to investigate the LMS landscape, integrate SRL with connectivism, and provide profound insights into optimizing online learning outcomes.

Hypothesis Development

A student is motivated to use an online learning platform by its learning contents and features (Aikina & Bolsunovskaya, 2020). Specifically, an LMS enhances the online learning experience by providing a repository for course materials and by facilitating interactions through features like discussion forums, quizzes, and feedback mechanisms. These tools are not only essential for the dissemination of information but also for fostering a collaborative and interactive learning environment. However, the literature suggests that the utilization of these online resources is not uniform among students.

Research indicates that high achieving students tend to access online course files with greater frequency, suggesting a relationship between course file utilization and academic success (Soffer & Cohen, 2019). In a study of online education, Crampton et al. (2012) find that fail-grade students access fewer lecture slides when compared to students who achieve a pass grade or above. This discrepancy in resource utilization may highlight a gap in learning strategies between different groups of students. High-performing students may demonstrate more proactive and strategic use of these resources, reflecting their self-regulated learning skills (Nnadozie & Khumalo, 2023). On the other hand, students who perform less well may need additional support in effectively accessing and utilizing such online learning resources as course files to improve their academic outcomes. Therefore, we propose:

Hypothesis 1: Students at various academic performance levels view course files at different frequencies.

In addition to viewing course files, engagement in online forums differs among student groups. In an online learning environment, it is likely that students at different academic performance levels interact with forum posts at different frequencies for several reasons

(Galikyan & Admiraal, 2019). For instance, students who are performing well, as Chiu and Hew (2018) find, tend to be more motivated and confident, leading them to engage more with peers in online discussions. In addition, these students may view forum posts more frequently to stay more engaged and to learn and grow. On the other hand, students who are academically struggling may view forum posts less frequently when they are not as interested in the learning materials or lack the confidence to engage with their peers (Saqr & López-Pernas, 2021). Furthermore, Hromalik and Koszalka (2018) suggest that high performing students typically exhibit better self-regulation and employ effective learning strategies, including frequent use of course discussion forums to support their learning. Lower-performing students may lack these strategies and thus not prioritize forum engagement. Hung and Zhang (2008) posit students with a higher “number of messages posted, number of messages read, and frequency of synchronous discussions attended” are better academic performers. Crampton et al. (2012) discover students who pass the subject post more messages on the discussion forums than students who fail. Therefore, we have the following hypotheses:

Hypothesis 2: Students at various academic performance levels view forum posts at different frequencies.

Hypothesis 3: Students at various academic performance levels create forum posts at different frequencies.

The course gradebook is another useful resource for students, facilitating self-regulation and academic monitoring (Kuznekoff & Munz, 2022). Empirical evidence reveals that students at different academic performance levels view their course gradebooks at different frequencies. (Liu (2023) suggests that the gradebook acts as a mechanism for students to manage their educational progress proactively. Geddes (2009) observes that business school students who excel academically tend to check their gradebook more often, suggesting an association between grade monitoring and academic success. High achieving students are typically more motivated and may utilize the gradebook strategically to ensure they remain on course to achieve their goals, hence their more frequent engagement with it. In contrast, students who are struggling in the course may be discouraged by their current performance, thereby not seeing the value in regularly checking their grades. Therefore, we propose the following:

Hypothesis 4: Students at various academic performance levels view course gradebooks at different frequencies.

Online quizzes are an integral component of online learning, facilitating course assessment and reinforcing learning (Raes et al., 2020). For instance, Dobbins and Denton (2017) reveal that students unanimously agree incorporating quizzes in online learning is an effective method for enhancing their engagement and interaction during lectures. Self-regulated learning theory posits that students with high academic achievement are often adept at managing their learning processes, which includes utilizing online quizzes as a means of self-assessment. Parte and Mellado (2022) extend this understanding by unveiling that students leverage quizzes to identify areas needing improvement, thereby optimizing their study approaches and performance.

High achieving students possess potent metacognitive abilities, facilitating their use of online quizzes to scrutinize their comprehension and fine-tune their study methodologies as required. Conversely, students with lower academic performance may be predominantly

extrinsically motivated, engaging with quizzes chiefly as they bear a direct impact on their grades. Their metacognitive skills may also be less mature, potentially curtailing their efficacious use of quizzes for self-assessment and modification of learning strategies. Consequently, they may not resort to online quizzes as regularly to assess their progress. Hence, we put forth the following proposition:

Hypothesis 5: Students at various academic performance levels view online quizzes differently.

Methodology

Participants

The study's participants consisted of 313 undergraduate students enrolled in two sessions of an information technology course at an Australian public research university. The course was fully delivered online via Moodle 3.7, a platform that became increasingly instrumental in the shift to online learning during the pandemic. The students relied on the LMS to access the course contents and functions remotely. The demographic breakdown was 53.04% male and 46.96% female students (Table 1). Students were categorized into three groups based on their academic performance: above-credit, credit, and below-credit, aligning with the university's grading standards (Table 2). These classifications provided a diverse cohort for examining LMS utility use across different academic performance levels.

Table 1

Students' Demographics

Demographics	Percent (%)	N
Gender		
Female	46.96%	147
Male	53.04%	166
Total	100%	313
Academic Performance		
Above-credit	36.74%	115
Credit	41.85%	131
Below-credit	21.41%	67
Total	100%	313

Table 2

Academic Performance Definition Used in Grading

Student Performance Groups	United States Equivalent	Description
Above-credit (Distinction and High Distinction)	A and B	A superior or outstanding performance, indicating that the student has demonstrated superior or above superior ability across the entire content of the course.
Credit	C	An acceptable performance, indicating that the student has demonstrated the ability to think analytically and contextually across the entire content of the course.
Below-credit	D and F	A performance below-credit.

(Pass and Fail)		
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Instruments

The primary data source was the log data from Moodle 3.7, which served as the virtual learning environment where all course-related activities were conducted. Several key variables were the focus of our study: Course File Views tracked students' access to learning materials such as lecture slides, readings, and recordings; Forum Views and Posts captured students' engagement in asynchronous discussions; Gradebook Views captured students' access to their academic records; and Online Quiz Views traced students' access to formative assessments which were used to evaluate students' learning outcome. These aspects were integral to online learning, providing insights into student engagement, content delivery, and course assessment. The data was systematically logged by the Moodle server. The demographics such as students' gender and academic performance categories were also collected.

The reliability and validity of our study's data instruments rely on the robust features of Moodle 3.7, which systematically tracks and records user interactions within the LMS. The variables of interest—course file views, forum views, forum posts, gradebook views, and online quiz views—are direct measures of student engagement with the course content, discussions, and assessment tools. The reliability of these measures is underpinned by the automated logging processes of the Moodle server, which ensures a consistent and error-free recording of student activities. These logs offer a reliable temporal footprint of student engagement, with each action timestamped to ensure accurate tracking over the course period.

The validity of these measures is substantiated by their established use in educational research as indicators of student engagement and academic behavior. Furthermore, the granularity of the Moodle log data allows for a detailed analysis of student behavior patterns, which aligns with the study's aim to dissect the nuances of LMS resource utilization among students of varied academic performances. By relying on objective server data, the study avoids common pitfalls associated with self-reporting methods. In summary, the direct counting of Moodle use frequency from log files stands as a reliable and valid approach to measuring student engagement in online learning environments.

Data Collection Procedure

We collected the data over the course of an entire academic term from May 31 to August 26, 2020, which included ten weeks of lectures and two weeks of exams. This period was selected as it represented a time when all teaching and learning activities transitioned to a fully online format due to pandemic-related restrictions. Upon receiving ethics committee approval, which ensured adherence to privacy and ethical research standards, the research team utilized Moodle server logs to capture students' interactions with the LMS. These logs included a timestamp for each student's activities, providing a granular view of engagement with the platform's tools. Personal identifiers were stripped from the data to maintain student confidentiality, and all information was secured to limit access exclusively to the research team for the purposes of this study.

The focus was on five primary LMS utilities: course file views, forum views, forum posts, gradebook views, and online quiz views. These utilities were selected for their relevance in assessing the patterns of student engagement and their potential impact on academic

performance. The usage data collected totaled 129,567 records from the student cohort. We present the statistics describing students' use of these utilities in Table 3.

Table 3

Descriptive Statistics of Logs

LMS Utility	Count	Individual Records			
		Minimum	Maximum	Mean	Std. Dev
Course File Views	96063	65	1067	306.911	145.755
Forum Views	12035	0	273	38.450	41.746
Forum Posts	139	0	16	0.444	1.438
Gradebook Views	2214	0	86	7.073	9.035
Online Quiz Views	19116	0	142	61.073	25.266

Informed by the statistics of the five LMS utilities (Table 3), course file views have a high mean of 306.911 and a large standard deviation of 145.755, indicating frequent but variable usage among students. In other words, course files are a critical resource for students, but their usage may depend on individual learning styles. Forum views have a mean of 38.450 and a standard deviation of 41.746, indicating that students often view forums but not as frequently as course files. The high standard deviation suggests that while some students find forums useful for their learning, others may not engage with them as much. Forum Posts have a low mean of 0.444 and a standard deviation of 1.438, suggesting that students do not post in forums often. This indicates that students are more comfortable consuming information from forums than actively participating in discussions. Gradebook views have a mean of 7.073 and a standard deviation of 9.035, indicating that students check their grades occasionally. The relatively high standard deviation suggests that some students check their grades more frequently than others, possibly reflecting different levels of concern about academic performance. Online quiz views have a mean of 61.073 and a standard deviation of 25.266, suggesting that students are frequently accessing online quizzes. The lower standard deviation compared to course file views and forum views indicates less variability in quiz usage among students.

Analysis Method

We employed the Kruskal-Wallis H Test as our primary analytical method. This non-parametric test was selected due to its suitability for the ordinal nature of our data and its robustness against non-normal distributions (Liu & Weistroffer, 2022; Mishra et al., 2019). Before conducting the test, we verified its assumptions, such as the independence of observations and the scale of measurement of the data. The Kruskal-Wallis H Test aimed to analyze statistically significant differences in the frequency of use of LMS utilities between the performance groups (i.e., above-credit group, below-credit group, and credit group).

Results

The statistics illuminate that the utilization of LMS utilities varies considerably across different academic performance groups (Table 4). Testing the significance of these utilization patterns via the Kruskal-Wallis H Test is crucial in answering our research question.

Table 4

Descriptive Statistics of Logs of Three Student Groups

LMS Utility	Group	N	Minimum	Maximum	Mean	Std. Dev
Course File Views	Above Credit	115	132	1067	337.809	163.200
	Credit	131	105	959	307.550	140.725
	Below Credit	67	65	565	252.627	103.741
Forum Views	Above Credit	115	0	273	48.878	49.220
	Credit	131	0	257	36.947	39.345
	Below Credit	67	0	111	23.493	24.156
Forum Posts	Above Credit	115	0	16	0.765	2.112
	Credit	131	0	5	0.344	0.918
	Below Credit	67	0	1	0.090	0.288
Gradebook Views	Above Credit	115	0	41	7.530	8.324
	Credit	131	0	86	7.405	10.146
	Below Credit	67	0	51	5.642	7.798
Online Quiz Views	Above Credit	115	34	140	68.870	23.688
	Credit	131	0	136	59.939	24.643
	Below Credit	67	0	142	49.910	24.847

The results of the Kruskal-Wallis H Test (See Table 5) indicate that students of various academic performances behave differently when viewing online course files, forum posts, and online quizzes. The results also reveal that students of various academic performances behave differently when posting on forums. However, students do not behave differently when viewing the gradebook.

Table 5

Statistics of the Kruskal-Wallis H Test

LMS Utility	Comparison Group	N1	N2	Kruskal-Wallis Statistic	<i>p</i> -Value
Course File Views	Above Credit—Below Credit	115	67	5078	0.000 ***
	Above Credit—Credit	115	131	8398.5	0.120 (ns)
	Below Credit—Credit	67	131	3461	0.015 **
Forum Views	Above Credit—Below Credit	115	67	5287.5	0.000 ***
	Above Credit—Credit	115	131	8663	0.042 *
	Below Credit—Credit	67	131	3338.5	0.006 **
Forum Posts	Above Credit—Below Credit	115	67	4393	0.016 *
	Above Credit—Credit	115	131	7981.5	0.240 (ns)
	Below Credit—Credit	67	131	4011.5	0.103 (ns)
Gradebook Views	Above Credit—Below Credit	115	67	4420.5	0.095 (ns)
	Above Credit—Credit	115	131	7765.5	0.674 (ns)
	Below Credit—Credit	67	131	3871.5	0.172 (ns)
Online Quiz Views	Above Credit—Below Credit	115	67	5755	0.000 ***
	Above Credit—Credit	115	131	9370.5	0.001 **
	Below Credit—Credit	67	131	3194.5	0.002 **

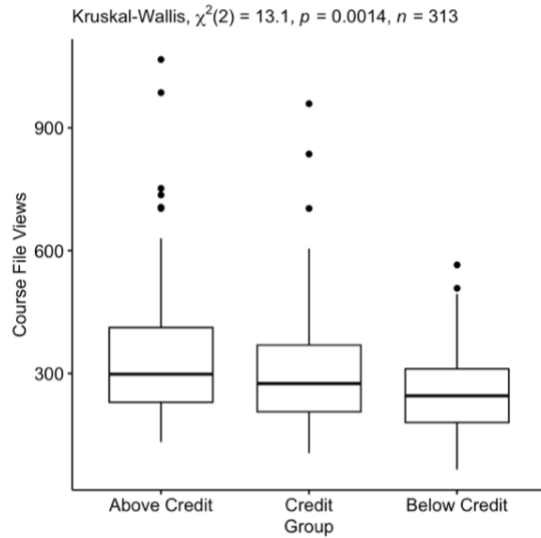
Viewing Course Files

The Kruskal-Wallis H Test reveals that students at various academic performance levels view course files at significantly different frequencies ($p = 0.001$), rejecting the null hypothesis (Figure 1). The mean view frequency of above-credit students is 337.809, while the mean

frequency values of credit students and below-credit students are 307.55 and 252.627, respectively. The test reveals that the mean view frequency of above-credit students is significantly greater than that of the below-credit students. In addition, the mean view frequency of credit students is significantly greater than that of the below-credit students at 252.627. Noticeably, the mean view frequency of above-credit students is not significantly greater than that of the credit students. Thus, H1 is partially supported.

Figure 1

Course File Views



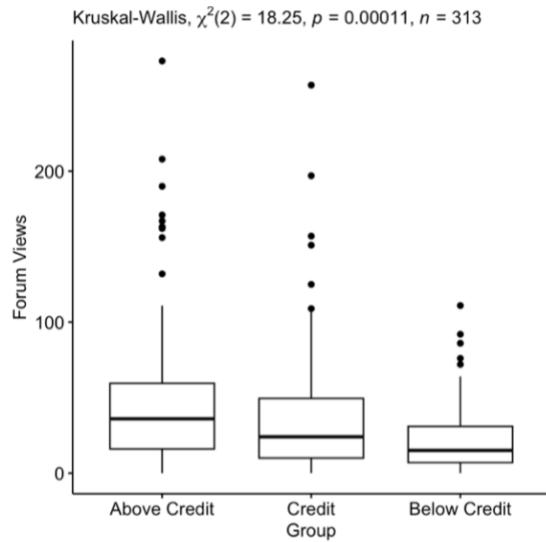
The test results indicate students who frequently engage with course files perform better academically. In comparison, students in the below-credit group have the lowest mean frequency. Our results suggest a relationship between engagement with course files and academic performance.

Viewing Forum Posts

The Kruskal-Wallis H Test shows that students at various academic performance levels view forum posts at significantly different frequencies ($p = 0.001$), rejecting the null hypothesis (Figure 2). We observe a significant difference in the behavior of viewing forum posts among students of different academic performances. The mean view frequency of above-credit students is 48.878, significantly higher than the frequency of credit students at 36.947 and the frequency of below-credit students at 23.493. In addition, the mean view frequency of credit students is significantly higher than that of the below-credit students. Thus, H2 is fully supported.

Figure 2

Forum Views



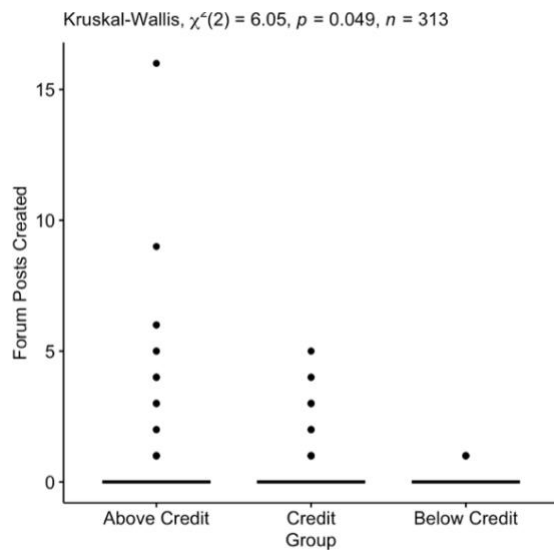
In other words, students who frequently view course forums perform better academically. In comparison, students in the below-credit group view course forums only half as frequently as above-credit students. This difference suggests a positive relationship between the frequency of viewing forum posts and academic performance.

Posting on Course Forums

The Kruskal-Wallis H Test result indicates a significance of 0.049, rejecting the null hypothesis (Figure 3). Specifically, the mean view frequency of above-credit students is 0.765, significantly greater than that of the below-credit students at 0.090. Accordingly, H3 is partially supported.

Figure 3

Forum Posts Created



Viewing Gradebook

The test indicates a significance of 0.230, failing to reject the null hypothesis (Figure 4). This finding suggests no significant differences in gradebook views among students of different academic performances. Therefore, H4 is not supported.

Figure 4

Gradebook Views

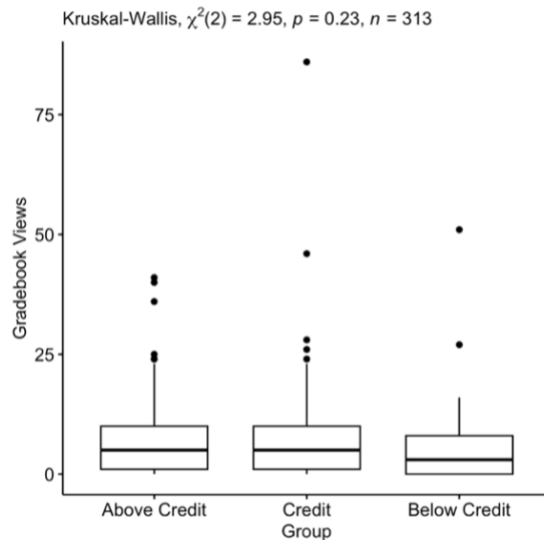
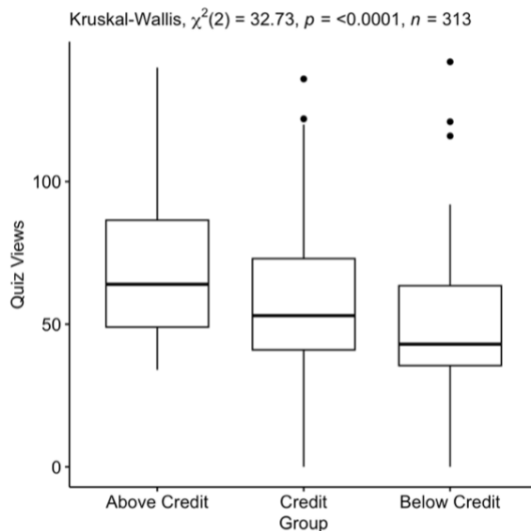


Figure 5

Online Quiz Views



Viewing Online Quizzes

The result of the Kruskal-Wallis H Test indicates a significance < 0.001 , rejecting the null hypothesis (Figure 5). The mean view frequency of above-credit students is 68.870, significantly higher than the frequency of credit students at 59.939 and the frequency of below-credit students at 49.910. In addition, the mean view frequency of credit students is significantly

higher than that of the below-credit students. This finding indicates significant differences in online quiz view frequency among students of different academic performances. Therefore, H5 is fully supported.

The results of the Kruskal-Wallis H Test are synthesized in Table 6. These results underscore the importance of certain LMS features (H1, H2, H3, and H5) in relation to academic performance.

Table 6

Summary of Hypothesis Testing Results

Hypotheses	Engagement with LMS	χ^2	<i>p</i> -Value	Result
H1	Viewing Course Files	13.10	0.001**	Partially Supported
H2	Viewing Forum Posts	18.25	0.000***	Supported
H3	Posting on Course Forums	6.05	0.049*	Partially Supported
H4	Viewing Gradebook	2.95	0.230	Not Supported
H5	Viewing Online Quizzes	32.73	0.000***	Supported

Discussion

The adoption of online LMSs has been well documented, yet research into the differentiated use of LMS tools during the pandemic remains scarce. Addressing this research void, our study delves into the relationship between students' academic achievements and their interaction with Moodle's online learning tools, such as course files, discussion forums, gradebook, and online quizzes. Our findings contribute to the body of literature by demonstrating nuanced patterns of online resource utilization during a period of widespread disruption in higher education. Students' differential engagement with LMS resources aligns with self-regulated learning theories, suggesting that proactive and strategic use of online learning tools is associated with higher academic performance. Higher academic performance is linked to more frequent engagement with course files and online quizzes and active participation in forums, reinforcing the pedagogical principle that student interaction with learning content and peers is pivotal to the learning process.

Implications for Research

Our findings reveal that students with superior academic performance tend to frequently interact with course files and review online assessments, as well as being actively involved in forum discussions. These patterns demonstrate the pivotal role of such resources in reinforcing the learning process. Despite these insights, the comparable frequency of accessing course files between the highest-performing (above-credit) and moderately performing (credit) students suggests the influence of other factors on superior academic outcomes. Additionally, the varying frequency of forum interactions—both in viewing and posting—across different levels of academic achievement implies that such proactive participation may enhance academic success. Yet, the absence of notable differences in posting frequency across specific academic groups hints that mere participation in forums is not the sole factor for academic enhancement. In contrast, the regularity of gradebook monitoring did not show marked differences across academic levels, implying that the act of grade monitoring alone may not be closely tied to academic performance. Thus, while it is vital to stay informed of academic standings, it does not emerge as a decisive factor in academic triumph. These insights emphasize the crucial role of

active engagement with digital learning tools in achieving academic excellence and offer valuable considerations for the structuring of online academic programs and pedagogical strategies.

The analysis reveals distinctive patterns in the usage (e.g., use frequency) of Moodle functionalities across different academic performance tiers. This underscores the importance of considering the distinct value each feature offers, as they are not uniformly embraced by all student demographics. Through the research lens of connectivism, we examine the connection magnitude, in terms of use frequency, between peers and a variety of LMS features. In particular, we see strong connections between peers and such features as course files, forums, and online quizzes through the peer activities of “view.” These strong connections are likely to powerfully impact the learners using the LMS. Those weaker connections (with lower frequency) suggest that the activities of viewing gradebook and posting on forums are not as common to the learners as those main activities to maintain connectedness. By examining the connections between students and various digital features, we gain a better understanding of which features are most instrumental in supporting online learning.

The view course file and view course forum features of Moodle support predominantly one-way communication, which may suit students who prefer to process learning material individually. However, the feature for posting on forums, which enables interactive two-way communication, is not utilized to the same extent. This discrepancy might hint at a preference among certain students for more direct, perhaps less public, forms of communication with instructors, such as emails or personal meetings, which this study’s data collection methods may not capture. Educators, recognizing these patterns, could enhance support for passive learners by offering alternative engagement options like personalized feedback or one-on-one sessions to encourage more active involvement. In addition, educational strategies might incorporate reflective prompts or collaborative tasks that validate passive engagement while nudging towards active participation. Future research is needed to understand the relationship between passive engagement and academic performance, as well as to develop interventions that can help transform passive online interactions into more active and meaningful learning experiences.

Implication for Education Practice

The discrepancies in LMS feature utilization have tangible implications for educational practice. Educators and administrators should consider these findings when choosing and implementing online learning platforms, ensuring that the tools provided align with pedagogical objectives and student needs. Strategic use of these tools, as our findings suggest, can lead to enhanced academic outcomes. Therefore, it is crucial for educators to not only implement these tools but also to train students in their effective use, making them integral parts of the learning strategy.

Our findings reveal that high performing students view online course files more frequently—in other words, frequently viewing course learning files is related to better academic performance. Therefore, our study reassures the importance of learning materials in online learning. It is important for online course instructors to provide relevant, organized, and easily accessible course files to improve students’ online learning experience. Moreover, educators should focus on developing high-quality course files and promoting their use to engage more students. Moreover, we find that frequently viewing forum posts is related to better academic performance in online learning. This finding underscores the importance of fostering active

forum engagement among students inclusively. Accordingly, in online teaching, educators should design and develop engaging features to encourage students to view and participate in forum discussions.

Our findings suggest that the students did not use two-way communication features as frequently as using one-way communication features. In this regard, there exist good opportunities for system designers and developers to improve LMSs to encourage two-way communication, particularly for lower-performing students who may benefit from more interaction in a remote environment. For example, Moodle provides limited support for formatting scripts (e.g., Python) in a preferred manner and for creating forum posts with customizable privacy settings. Developers should compare student posts on various platforms (e.g., with and without advanced capabilities) to determine if they should provide students with more flexible options for posting in a forum.

Our study clearly shows that students' engagement with course files and forum posts varies with their academic performance, but such variance is not observed in how they view gradebooks. This indicates that active engagement with course files and discussions is more influential on academic success than frequent grade checks. Educators should, therefore, encourage students to prioritize active learning and interaction with course content over mere performance monitoring. Another implication is that educators can build early warning systems that analyze students' online behavior to identify those likely to be at risk of academic failure. For instance, if a student is not regularly accessing course files or participating in discussions, this could be a signal that they are struggling and may need additional support.

The rapid advancement of artificial intelligence (AI) and its pervasiveness in various facets of daily life heralds a transformative potential for online learning. Despite this, current integrations of AI functionalities within platforms like Moodle are scarce, particularly in personalizing the educational journey, automating progress tracking, and facilitating adaptive assessments. This study's findings, which highlight the differential engagement of students with online learning resources, underscore the need for such AI-driven personalization. By embedding AI features in the LMS, developers can tailor learning experiences to individual student profiles, thereby addressing the engagement challenges highlighted in this research. The ability of AI to provide real-time feedback and predictive analytics could be pivotal in enhancing learner engagement and academic outcomes. Therefore, future endeavors may explore the utilization of AI elements in online platforms to elevate the quality of learners and to overcome the barriers to engagement identified throughout our study.

Conclusion

The COVID-19 pandemic has profoundly influenced the educational landscape, prompting a swift transition to online learning platforms across higher education institutions. Our study investigates how students' engagement with online resources varies amidst such global challenges. The differential use of LMS features among student performance groups reveals that engagement levels with course files, discussion forums, and quizzes are nuanced, underscoring the complex nature of online learning and its implications for academic success. These insights underscore the multifaceted role of digital tools in learning processes and provide a foundation for educational stakeholders to refine remote learning practices. The study contributes to a deeper understanding of the interplay between technology use and academic performance, marking a theoretical advancement by contextualizing usage patterns within the frameworks of

self-regulated learning and connectivism, enriching the discourse on online learning adoption during unforeseen educational disruptions.

However, it is crucial to acknowledge the study's limitations. While our analysis of log data provides a quantitative measure of student engagement with LMS features, it lacks the qualitative depth to explain the motivations behind these behaviors. The insights gained are bound by the context of the pandemic, which presents an extraordinary situation that may not represent typical online learning conditions. Additionally, the study is limited to a single institution's data, potentially limiting the generalizability of the results. We encourage future research to delve into the underlying reasons for the observed behaviors by examining student perceptions, demographic variables, and motivational factors. Another limitation that future studies might address is the exclusive focus on the pandemic period; comparisons with pre- and post-pandemic online learning behaviors could provide a more holistic view of the evolution of students' engagement with online learning platforms. These limitations do not diminish the significance of the study's contributions but rather define the scope within which the findings should be interpreted. They also highlight the pathways for subsequent research to build on the groundwork laid by this study, contributing to a richer and more nuanced understanding of online learning in higher education.

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