

Online Teaching and Learning Post-Covid: An Analysis of LMS Usage and Student Outcomes Following the Pandemic

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Abstract: In 2020, the global higher education sector plunged into online teaching and learning within a very short timeframe with the onset of the Covid-19 pandemic. The Sri Lankan state higher education system was no exception. While the initial readiness of both students and teachers for this switch varied or, in many cases, was low, online instruction was the predominant form of teaching and learning for most of the subsequent two years. The Sri Lankan university sector resumed face-to-face teaching for undergraduates in mid-2022 but aspects of online teaching and learning remain, providing a valuable opportunity to take stock of the experiences gathered during the pandemic. This study aims to use data on undergraduate courses offered both during and after the pandemic period at the Faculty of Business in the University of Moratuwa in order to identify online teaching practices that persisted beyond the COVID-19 period and relate student interactions with these activities with academic outcomes. The dataset spans 473 students in five cohorts across six undergraduate courses and includes Moodle (the LMS used by the university) logs, data on academic outcomes, and features of the online course pages. The student level data for the selected courses are augmented with interviews with the corresponding lecturers to gain further insights into why certain learning activities were considered successful and others not. By doing so, the paper aims to identify effective learning tools and best practices that arose during the unplanned transition to online teaching from both lecturer and student perspectives. The results show that there is a continuity in the tools between the online mode during the pandemic and the post-pandemic return to face-to-face teaching with tools such as quizzes, assignment submissions, and videos/lecture recordings used noticeably more than in the pre-Covid period. The use of interactive tools increase the student engagement with the course Moodle pages, which in turn are positively associated with learning outcomes. The paper thus highlights some positive consequences of the pandemic period on education in terms of enhancing the adoption of digital tools for learning among both staff and students.

Keywords: e-Learning interactions, Online course design, Covid-19, Undergraduate education

1. Introduction

The Covid-19 pandemic in 2020 led to large-scale disruptions to schools and universities globally, as face-to-face instructions were suspended to prevent spread of the virus (Sophie Lu et al. 2021). This resulted in a very rapid shift to online learning as a response to minimising the impact of these disruptions. While online learning and massive open online courses (MOOCs) were not a novelty at this time, the transition of courses primarily intended to be delivered face-to-face into an online delivery mode within a short period of time was not without challenges. Key among these was the difficulty of replicating physical classroom learning using distance learning infrastructure in contexts where institutions, teachers and students had limited exposure to online teaching and learning (Turnbull et al. 2021; Chiu et al. 2021; Adedoyin and Soykan, 2020).

In Sri Lanka, the first nation-wide Covid-19 lockdown was declared in March 2020. However, it is estimated that within three months, almost all universities had switched to online modes of learning (Hayashi et al. 2020). This is particularly commendable given that both teachers and students faced considerable barriers to accessing suitable devices and internet connectivity and, for the most part, lacked exposure to online instruction (World Bank, 2020). The transition to online learning in the state university sector (where undergraduate degrees are offered tuition-free) was facilitated by several measures taken at the time. Notably, the provision of free access to university web servers by internet service providers which allowed date-free access to video-conferencing tools via these servers. Accordingly, teaching in state universities took place online for the better part of two years, only resuming physical teaching towards mid-2022.

Maintaining student engagement and ensuring the achievement of student learning outcomes is not easy in an online environment, as evinced by the literature on MOOCs (Pilli and Admiraal, 2017; Moreno-Marcos et al. 2018; Deng et al. 2019; Israel, 2019). The online teaching and learning that occurred in the university system during the pandemic was different in key aspects such as the qualifications being offered and the courses being offered within defined time intervals (semesters), which means that the student motivation and independence over learning was different to that seen in MOOCs (Brooker et al. 2018; Tsang et al. 2021). However, given that

these courses were not originally meant for online delivery and were often delivered to simply replicate physical classrooms (Brancaccio-Taras et al, 2021; Pagoto et al, 2021), the questions of student engagement and learning remain valid, further compounded by the issues of infrastructure constraints on the side of the students. Even after the pandemic, online teaching and learning are still being used by state universities in Sri Lanka in the face of subsequent disruptions to on-site teaching such as the economic crisis and resulting fuel shortages in the second half of 2022 and during trade union actions carried out by academic and non-academic staff in the university system.

Four years down the road, we are now well-placed to look back on the online learning experience and draw lessons from this period. This paper, therefore, aims to use data on courses offered at a state university in Sri Lanka obtained from the learning management system (LMS), to identify changes in teaching practices that arose due to the onset of the pandemic and have since persisted. The paper has the specific objectives of identifying changes to course design and delivery because of the switch to online teaching and learning, identifying the online activities that increased student interactions and engagement, and finally, studying the relationship between student academic outcomes and interactions with the different types of activities. In doing so, the study links together improvements from the use of online learning tools as perceived by lecturers and manifested in changes to the design of the LMS course pages and the impact of these changes on student learning outcomes.

The literature on online learning highlights student characteristics, course design and course interactions as being the main categories that influence learning outcomes (Moreno-Marcos et al. 2018). While student characteristics are exogenous factors that the instructor should consider, the design of the course is within their control. Comparisons of face-to-face teaching with online settings suggest that the provision of interactive content, continued educator feedback with provision of formative feedback, and structured online discussions are key to fostering learning in online settings (Castro and Tumibay, 2019). Specific examples arising during the pandemic period of effective tools for online delivery include the use of quizzes and questionnaires to reinforce take-home messages (Rossi et al. 2021), provision of opportunities to interact with the instructor as well as other students through, for example, group work (Tsang et al, 2021), and the provision of recorded lectures to facilitate learning at a time that works best for the student (Hollister et al, 2022). Moreover, whereas the instructor may not achieve the same level of interaction with students in an online environment, the availability of massive amounts of data generated within the LMS can be used to increase what is known about the learner (Nguyen, 2015).

This paper adds to the growing body of knowledge that studies the effectiveness of online teaching and learning triggered by the pandemic, focusing on the Sri Lankan experience. Specifically, the study provides some insights on what worked and continues to work in terms of optimising the use of educational technology in higher education in a developing country context where the use of educational technology was limited prior to the pandemic. At the time of writing, Sri Lankan universities are facing disruptions to on-site learning as a result of trade union action but the impact of this is minimised due to the availability and experience with online teaching and learning. Taking stock of the lessons learnt during Covid-19 are therefore useful in a context where switches back to online learning, even sporadically, may continue to occur. More generally, the paper provides some reassuring findings on the adoption and evolution of online learning in a developing country setting.

2. Data and Methods

This paper aims to study changes to teaching practices and student interactions that arose during the period of online teaching and learning that was triggered by the Covid-19 pandemic. It does so in two parts. The first considers changes to course design that arose during this period and persisted thereafter to obtain insights on the activities and course design perceived by lecturers to be effective for use even after the switch to on-site teaching. Then, student interactions with the course page are used to study the levels of engagement generated by different types of activities and relate these interactions to student learning outcomes to identify the most effective activities from the student perspective.

2.1 Selected Courses

To achieve these objectives, this paper uses data from six different courses offered to undergraduate students at the Faculty of Business of the University of Moratuwa. We use information on course page design for each of the selected courses from before, during and after the onset of the pandemic. Note that the learning management system, Moodle, was already in use from well before the pandemic, though used to varying degrees by different lecturers. We select subjects that were taught by the same lecturer in all three periods to

ensure comparability over time. The subjects used for this analysis are Principles of Programming (Semester 2), Probability and Statistics II (Semester 3), Introduction to Econometrics (Semester 4), Data Structure and Algorithms (Semester 5), Business Application Development (Semester 6) and Financial Econometrics (Semester 7).

2.2 Changes in Course Design

For each subject, we study changes to course design from before to after the Covid-19 pandemic by computing counts of the different types of activities employed by the lecturer in each of the three periods considered. We break the activities down into quizzes, assignments and online submissions, content-related files that have audio or video elements and content-related files that do not, and other activities. The other activities category includes Moodle tools such as forum posts, glossaries, H5P interactive lessons, virtual programming labs, etc.). Given that these counts will not capture the nuances of course design, which is a much more qualitative concept, we obtain additional insights directly from the lecturers whose courses are included. It should be noted our measures of course design are limited to what is observable on the Moodle course pages – activities conducted in real-time during lectures or Zoom sessions are excluded from this analysis.

2.3 Student Interactions and Outcomes

The student perspective is incorporated into the analysis by considering the level of student interaction generated by different types of activities and the relationship with student learning outcomes. This analysis focuses only on courses offered during and after the pandemic: this provides a sample of 12 courses (2 offerings each of the selected 6 subjects) and 473 students, some of whom are covered in multiple subjects.

Learning outcomes are measured by the continuous assessment (CA) marks (based on assessments carried out during the semester) that make up 40-60% of the final grade for a course. CA marks usually capture a wider array of learning outcomes (e.g. use of software, writing skills, and practical applications) than the written examination held at the end of the Semester. Students' interactions with the course pages are measured using Moodle activity reports and course logs, which allow us to construct total clicks by type of activity, time spent on quizzes and number of submissions completed.

2.4 Analysis

The identification of changes in course design and levels of student interaction generated on the course page are based on a descriptive analysis.

For the study of how student interactions affect student outcomes, we use correlation analysis and multiple linear regression which are carried out on the entire dataset of 1055 student-course LMS interactions and learning outcomes. While the correlation matrix provides a bivariate analysis, the regression allows for a more nuanced analysis. For instance, together with the identified course interaction variables, we are also able to control for subject and cohort specific differences given that we are comparing subjects that may vary in levels of difficulty and cohorts which were exposed to varying amounts of online instruction. Specifically, we estimate the following regression model:

$$y_{ist} = \beta X_{ist} + \gamma Z_{st} + \alpha_s + \theta_t + u_{ist} \quad (1)$$

where y_{ist} are the CA marks obtained by student i on subject s offered to cohort t , X_{ist} is the vector of course page interactions for the same, Z_{st} are the characteristics of the course page, and α_s and θ_t refer to the subject and cohort fixed effects, respectively.

3. Results

3.1 Changes in Course Design - Lecturer Perspectives

Figure 1 visualises the changes in course design observed across the selected courses using the number of different types of activities and learning materials used before, during and after the pandemic. The categories analysed are quizzes and assignment submissions (both formative and summative), other activities (including discussion forums, H5P interactive lessons, virtual programming labs, questionnaires, etc.), learning materials with an audio/video element (e.g. video recordings and voice-embedded PowerPoints) and learning materials without the audio/video element (e.g. lecture notes and slides). It should be noted that of the six subjects considered, there were two that were offered for the first time during the Covid-19 period.

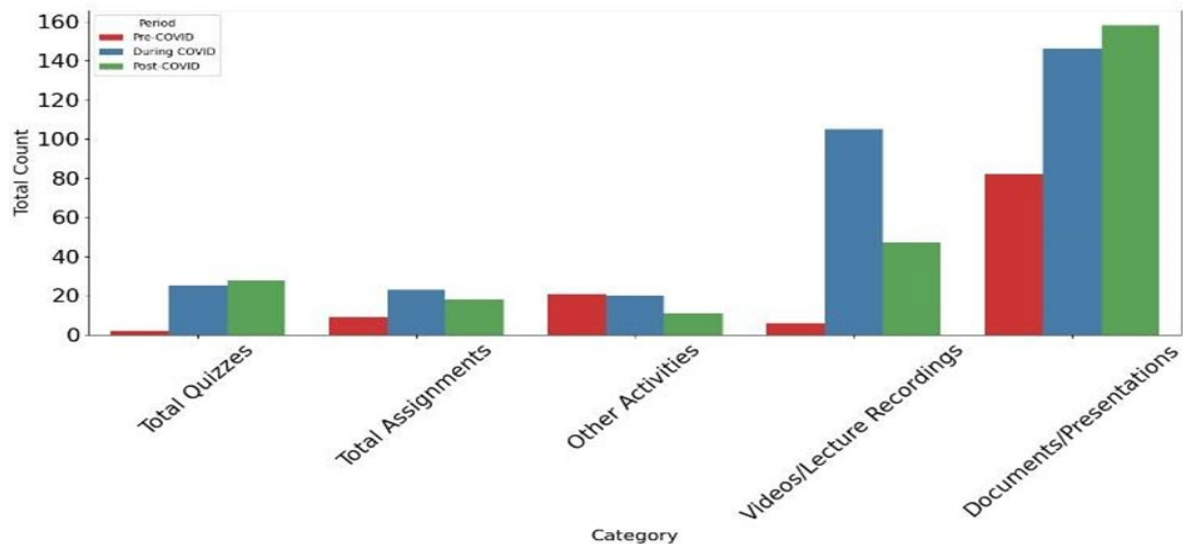


Figure 1: Features of selected course pages before, during and after the Covid-19 pandemic

Figure 1 clearly shows the increased usage of most tools during the Covid-19 period as compared to pre-Covid. When comparing the during and after Covid-19 periods, we see a mixed pattern though in most cases, the activities were still used more than in the pre-Covid-19 period, highlighting the increased adoption of Moodle tools following the pandemic period. There is a much greater use of quizzes, with a continued increase even from the during-Covid to post-Covid period, though the biggest increase is from pre- to during-Covid. There is a similar increase in the number of assignments from pre- to post-online learning. This is intuitive given that assessments had to be conducted online rather than through pen-and-paper tests or physical submissions.

The most dramatic change is seen in the provision of videos and lecture recordings, highlighting the transition to asynchronous learning during the pandemic period with a sharp decline following the return to face-to-face lectures. The number of non-video/audio learning materials provided also continues to rise during the duration of the period studied. The only type of activity to show a decline from before to after the pandemic is the “other category” - the decline from pre- to during Covid is driven by the removal of virtual programming labs in Principles of Programming while the decline from during to post-Covid is driven by the removal of H5P interactive lessons from Introduction to Econometrics.

3.1.1 Reasons for the changes

Discussions with the lecturers in charge revealed that the use of Moodle quizzes is perceived by the lecturers as a more efficient way of assessing certain outcomes, given the automatic grading options, while also ensuring that students remained on track with the content over the course of the semester. Once the lecturers gained familiarity with the wide array of question types and the possibility of randomising questions and enabling sequential navigation, concerns about cheating were also minimized. Accordingly, Moodle quizzes have become the main format of in-class tests during the Semester even after returning to on-site delivery. However, when it came to the submission of tutorials, this kind of randomization was less feasible, resulting in a return to hard copy submissions to at least ensure students wrote out their own solutions.

The steep increase in lecture recordings during the pandemic was driven by issues of internet connectivity faced by many students. Given the difficulties faced in remaining connected to video-conference sessions for prolonged periods, lecturers were encouraged by the institution to make recordings available so as not to penalise students facing this issue. However, following the return to on-site lectures, lecturers could decide whether to provide previous recordings and if so, which recordings to make available. Most of the recordings provided post-Covid period were of lectures carried out for the previous cohort - recordings of tutorials or Q&A sessions from previous cohorts were not posted, resulting in the post-Covid decline.

The only category to show a decline from the pre- to post-Covid period was “other” activities. Discussion with lecturers revealed an interesting reason for this. While H5P lessons provide an interactive way of presenting learning material given the combinations of audio, video and quiz content, it was revealed that students had a preference for voice-embedded PPT or video recordings as these could be downloaded to their devices and viewed without an active internet connection whereas the H5P lessons required continuous internet

connectivity. Given that many students were not using these lessons, they were subsequently discontinued, with selected lessons being provided as additional learning material. The discontinuation of the virtual programming labs was explained by the availability of questions of the type “Coderunner” in Moodle quizzes, which provided the same level of functionality.

3.2 Interactions with Different Types of Activities

Next, we use the LMS logs and activity reports for the selected courses during and after Covid to measure the level of interactivity generated by different types of Moodle activities. Specifically, we consider clicks in total and per unit for the broad categories of course page, static learning materials (including lecture notes and slides, recordings and voice embedded PowerPoint files), assessments (quizzes and assignment submissions, both formative and summative), and other (which includes items such as forums, questionnaires, interactive lessons, etc.). We also compute the time spent on untimed quizzes (where students decide the time they spend), the percentage of the permitted duration used for timed quizzes, and the share of submissions made early/on time or late. The mean values of these measures are provided in Table 1.

Table 1: Interactions across activity types

	During Covid	After Covid
Total clicks		
1.1 Total clicks (average per student per course)	450 (std dev 242)	453 (std dev 236)
1.2 Clicks on learning materials (% of total)	18.65	24.30
1.3 Clicks on assessments (quizzes, submissions) (% of total)	34.93	25.80
1.4 Clicks on other activities (% of total)	6.78	7.75
1.5 Clicks on course page (% of total)	39.64	42.15
Clicks per unit		
2.1 Average clicks per item of learning material	2	3
2.2 Average clicks per assessment	16	17
2.3 Average clicks per “other” activity	10	22
Time spent on quizzes		
3.1 Time spent on quizzes with no time limit (minutes per subject)	1121 (std dev 6208)	1068 (std dev 281)
3.3 Time spent on timed quizzes (% of allowed duration)	87%	88%
Assignment submission		
4.1 % assignments/submissions submitted on time	80%	64%
4.2 % assignments/submissions submitted late	7%	21%

The time spent on quizzes further highlights the role assessments play in increasing student interactions during online learning. The average time spent on untimed quizzes (which are formative rather than summative assessments) is more than 19 hours per course per semester during Covid and 18 hours post-Covid, though the standard deviations are large suggesting considerable variation. In the case of untimed quizzes, it is possible that students open the quiz and keep it open on their browser while engaging in other activities, which means that the computed time is a noisy measure of the time actually spent completing the quiz. Timed quizzes do not have this issue and on average, students use close to 90% of the assigned time when completing quizzes with a time limit (which are mostly, but not exclusively summative). Assignments are also mostly submitted within the deadline by most students (80% during Covid and 64% after). The late or non-submissions can be explained by submissions here include both summative and formative assessments.

3.3 Relationship Between Course Interactions, Course Design and Learning Outcomes

While the previous results link student interactions with the course page with the design of the course page, the more important connection is that between student learning outcomes and course design, which facilitates interaction. As such, in this section, we relate continuous assessment marks with the course design and student interaction measures, starting with the correlation matrix provided in Figure 2.

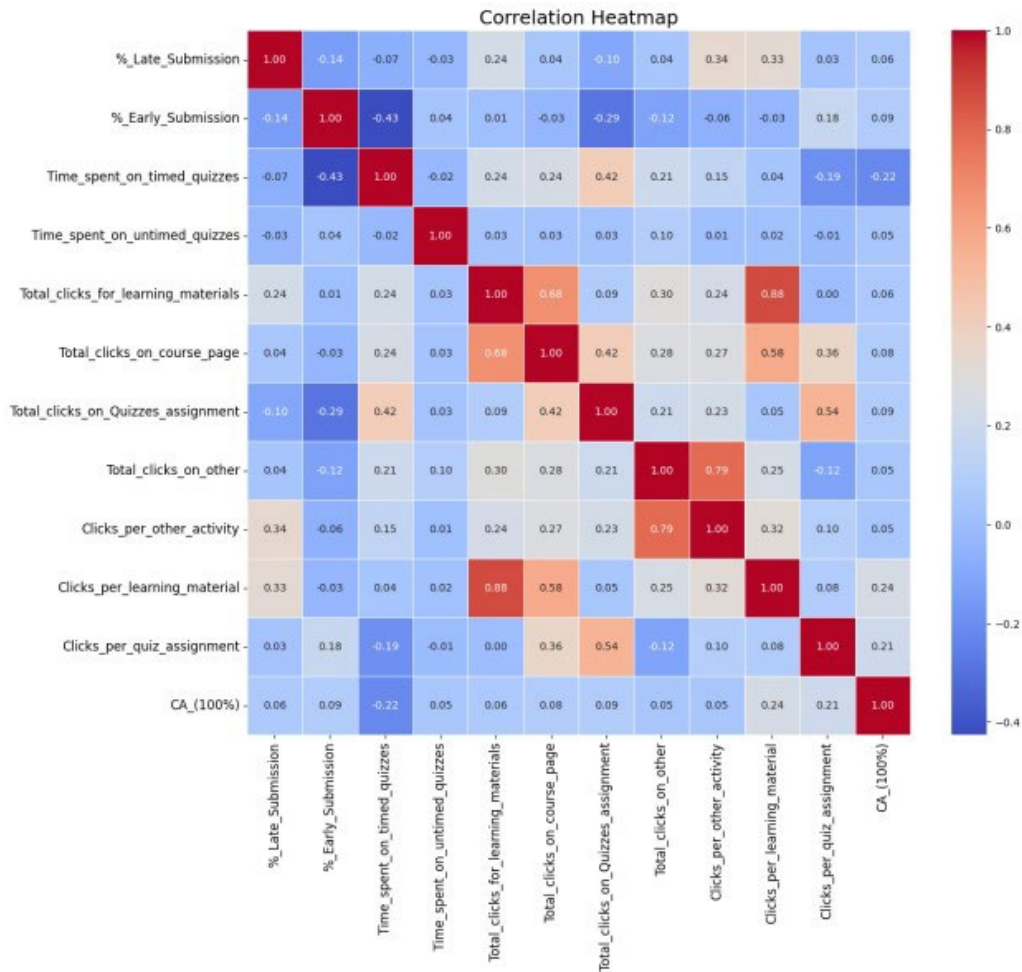


Figure 2: Correlation heatmap of interaction with course page metrics

The correlation matrix (Figure 2) provides some interesting insights. Among the student interaction variables considered, most are positively correlated with CA marks, though the correlations are not strong. So, for example, the total number of clicks or the percentage of assignment submissions or clicks per assessment or learning material are positively associated with CA marks. The only exception is the percentage of allowed time used for timed quizzes, which is negatively correlated with marks - students who spend more of the allowed quiz time tend to get lower marks. These students spending more of the assigned time are also less likely to submit their assignments on time (correlation of -0.43), potentially due to poor time management.

These bivariate correlations hide variations in subject difficulty, differences in student cohorts and course design. Accordingly, the final set of results are based on the estimation of Equation (1) using a multiple linear regression model. The results are presented in Table 2.

Table 2: Estimated effects of course design and course page interactions on CA marks

Covariate	Coefficient	p-value
Course design		
Number of quizzes	1.7990	0.000
Number of submissions	9.6300	0.000
Number of other activities	4.5632	0.000
Number of content related files (videos/lecture recordings)	-0.4232	0.000
Number of content related files (lecture notes/slides)	-1.0113	0.000
Interactions with course page		

Covariate	Coefficient	p-value
% assignments submitted late	0.1582	0.000
% assignments submitted early/on time	0.2671	0.000
% allowed duration used in timed quizzes	0.0803	0.004
Time spent on untimed quizzes	2.582e-05	0.220
Total clicks on learning materials	-0.0182	0.477
Total clicks of assessments	0.0024	0.852
Total clicks on other activities	0.0330	0.049
Total clicks on course page	0.0073	0.231
Clicks per learning material	0.6407	0.532
Clicks per assessment	0.1863	0.047
Clicks per other activity	-0.0197	0.655
Fixed effects (reference categories: Cohort 2022 and Subject: Probability and Statistics II)		
Cohort 2017	-33.4191	0.000
Cohort 2018	-34.0604	0.000
Cohort 2019	-24.5115	0.000
Cohort 2020	-7.9419	0.002
Subject: Business Application Development	33.2756	0.000
Subject: Data structures and algorithms	28.2435	0.000
Subject: Financial econometrics	13.2363	0.085
Subject: Introduction to econometrics	-25.1790	0.000
Subject: Principles of Programming	47.5210	0.000

Note: The table reports the coefficient and p-values from estimating Equation (1) using data on 1055 student-subject observations. The regression model has a R-square value of 0.415.

Table 2 shows the associations of different interaction measures and aspects of course design with learning outcomes. Starting with the course design variables, the number of quizzes, assignments and other activities are positively and significantly associated with CA marks. On the other hand, the number of content related files are negatively associated with marks, suggesting that it is the activities that generate more student engagement that have a stronger bearing on the continuous assessment marks, after controlling for differences in average marks between subjects and cohorts (which themselves are also statistically significant).

There are again many course interaction variables significantly correlated with marks. For instance, submission of a larger share of assignments on time or even late has a positive impact on marks relative to non-submission. Specifically, increasing the share of assignments submitted on time by 1 percentage point is associated with a 0.27 increase in the CA mark compared to non-submission. Interestingly, the multiple regression results in a reversal of the negative correlation seen between % of permitted time spent on timed quizzes and CA marks because of controlling for differences in mean marks across courses and cohorts. We now see a significant and positive relationship between the two variables. Among the variables measured by clicks, the only variables that appear statistically significant are the clicks on other activities (including forum discussions, questionnaires, H5P interactive content, etc.) and the number of clicks per assessment. Taken together these results suggest that students who engage more with the interactive components of the course are obtaining higher marks in the continuous assessments.

4. Discussion and Conclusion

This paper makes use of data on courses offered to undergraduates before, during and after the Covid-19 pandemic period to identify changes to the teaching practices, as reflected on the Moodle course pages, over this period and relate the Moodle activities used since the online learning period to student interactions with the LMS and their final learning outcomes. The study finds that there are substantial changes in the use of

Moodle activities during the online learning period with many of the changes persisting even after the return to onsite delivery. For instance, tools such as quizzes and assignments, video recorded lectures were used more frequently after the online learning period. When considering the interactions generated by the different types of activities, quizzes and submissions generated a large portion of clicks on the LMS, followed by learning material, though the per item number of clicks is higher for interactive content than for learning materials. The story is completed by linking student interactions with learning outcomes and the results from the bivariate and multivariate analysis suggests that course design and student interactions are indeed significantly linked to marks, where courses with more interactive content or students engaging more with interactive content are positively associated with better performance in the continuous assessment. By and large, this exercise suggests that the Moodle course pages were used for a wider range of functionalities during and after the pandemic than before Covid when the pages were used primarily to share lecture slides or tutorials. Moreover, the continuous increase in learning materials and activities used on Moodle suggests ongoing efforts to provide a broader range of learning resources to enhance students' learning. This confirms the technological disruption aspect of the Covid-19 pandemic on education with both staff and students compelled to adopt digital technology for learning (Adedoyin and Soykan, 2020). Given the continued use of online learning tools sporadically or in a blended learning mode, these results provide some heartening evidence of positive changes arising from a challenging time.

The analysis in this paper is subject to several limitations, starting with the relatively small sample of courses under study. It would be instructive to expand to a broad range of subjects for more generalizable conclusions. This will be carried out in future work. We are also constrained in terms of data available for some of our selected measures. For instance, our analysis of student interactions and course design are limited to those taking place through the LMS - activities that were carried out in the lecture hall or during Zoom meetings as well as interactions taking place via email or social media are not observed. Similarly, measures such as clicks and time spent on quizzes may not capture the true level of interaction the course page generates. However, to the extent that these measures are easily monitored through the LMS, they have the advantage of being useful for early warning systems or flagging of students who may be falling behind. As such, we believe that it is not wrong to conclude a heightened use of digital technology in education, which can be beneficial for both students and teachers, as a positive consequence of the Covid-19 pandemic period of online teaching and learning.

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