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The Dynamics of Learning Management System Assessment: A Case of Undergraduate Mathematics

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ABSTRACT

The purpose of this study was to elaborate on the different dimensions to conduct an online assessment in undergraduate mathematics. Mathematics assessment using digital technologies is unique because it has special symbols and multi-step solutions. The sudden shift to full online learning necessitated Learning Management System-based online assessment as part of learning and for certification. The research design for this study was a qualitative case study. The case considered for this study was a calculus course and the 180 students registered for the course in 2021 at a South African university. The researcher was the instructor for this course. After explaining the details of conducting the online assessment of mathematics, data was collected on students' experiences in online assessment using questionnaires and interviews. A conveniently chosen sample of 13 students completed the online questionnaire. A further ten students took part in the telephonic interviews and these were selected conveniently again. Data was composed of written responses to the questionnaires and the transcriptions of the interview audio recordings. After sitting both quizzes and assignments on Blackboard, students preferred the assignment format. This was also suitable for mathematics where there is a need to show steps and proofs in the solution process for both formative and summative assessment. Course instructors hence can effectively administer appropriate formative online assessments on the Learning Management System that has the potential to propel the teaching and learning of mathematics.

Keywords: *Learning Management System; undergraduate mathematics; online assessment; quizzes; assignments; Blackboard; formative assessment*

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INTRODUCTION

With the advent of Covid-19 restrictions in early 2020, higher education institutions shifted to full remote teaching and learning using digital technologies. Resources were scrambled and basic training for both students and lecturers was rendered to the extent that the 2020 academic year was successfully completed. Microsoft Teams was used in teaching and learning at Walter Sisulu University in South Africa. Assessment for and of learning naturally followed online learning, making assessment an integral part of teaching and learning.[1] Assessment for learning is formative and assessment of learning is summative. By its nature, formative assessment is part of learning and hence requires the course

[1] Nicole A., Buzzetto-More, and Ayodele Julius N. Alade, "Best Practices in E-Assessment." *Journal of Information Technology Education*, 5, (2006): 251-269.

instructor to design, create and deploy tasks in sync with content coverage. Learning Management Systems (LMSs) which have been part of higher education for decades allows course instructors to conduct an online assessment.[2] Blackboard Learn was used then at Walter Sisulu University for assessment.

Unlike eLearning, online assessment has high stakes in education and commands greater accountability.[3] More so, synchronous and timed tests ought to be part of the formative assessment to provide good preparation for the online examination that was due at the end of the study period. Moreover, some disciplines like mathematics thrive on supervised individual tests to measure students' understanding. Unlike take-home assignments that are common in some disciplines, controlled tests help to condition and familiarise students with final online examinations. Examinations have been online and remote in a time-restricted environment since the outbreak of the Covid-19 pandemic. In that regard, all formative assessment tasks in mathematics were remote too and written in restricted time.

Mathematics, which dominated the undergraduate mathematics courses to the Bachelor of Education programme at Walter Sisulu University, formed an anchor to demonstrate the dynamics and intricacies of LMS-based online assessment. Mathematics is concerned with limits, differentiation and integration of functions of one or more variables. The computational nature of mathematics makes it compatible with assessment on digital technologies platforms. To compute is what a computer does.

The purpose of this study was to demonstrate online assessment in mathematics and determine its best practices through the students' perceptions of both formative and summative assessments. In mathematics, the focus is not on the final answer and there are specialised symbols and formulae used in solutions. According to Soares and Lopes, an online assessment of complete arguments, including proofs is more difficult than an assessment of the final answer.[4] The study thus adopted a descriptive qualitative research methodology. The research question was: To what extent do lecturers and undergraduate students make sense of online assessment in mathematics? Students are the end-users of the assessment system hence their perceptions and experiences are key determinants for the continuance and flourishment of the online assessment.[5]

LITERATURE REVIEW

The LMS offers two types of assessments, which are quizzes and assignments. Quizzes comprise multiple-choice, fill-in, matching, and true/false questions. In the quiz settings, it can be attempted multiple times, the questions can be shuffled and a time limit is set. Quizzes are done in real-time and graded automatically by the LMS following laid down commands. Secondly, the assignment activity enables the instructor to assess long questions offline and for extended periods. Students can type text directly into the text-box as in essay questions or they can submit completed assignments as a digital file. Assignments are not Internet dependent and hence can be done offline and submitted before the due date. Assignments can be graded by a human assisted by digital tools using a point scale or a rubric. All the final grades are recorded in the grade book for both quizzes and assignments. Herein, the LMS is used to create the assessments and deploy them according to set specifications. Course

[2] Bopelo Boitshwarelo, Alison K., Reedy, and Trevor Billany, "Envisioning the use of online tests in assessing twenty-first century learning: a literature review." *Research and Practice in Technology Enhanced Learning, 12(*16) (2017). https://doi.org/10.1186/s41039-017-0055-7

[3] Kelum A.A Gamage, Erandika K. de Silva, and Nanda Gunawardhana, "Online Delivery and Assessment during COVID-19: Safeguarding Academic Integrity." *Education Sciences, 10*, (2020): 301-314. https://doi.org/10.3390/educsci10110301

[4] Filomena Soares, and Ana Paula Lopes, "Online assessment through Moodle platform." *Proceedings of ICERI2018 Conference 12th-14th November* 2018, Seville, Spain (2018).

[5] Arnab Kundu, and Tripti Bej, E*xperiencing e-assessment during COVID-19: an analysis of Indian students' perception.* (Higher Education Evaluation and Development, Emerald Publishing Limited, 2021). https://doi.org/10.1108/HEED-03-2021-0032; Someah Alangari, Gary Wills, and Mike Wald, "A framework for acceptance of e-assessment by students in Saudi Arabian universities." *Proceedings of INTCESS 2017 4th International Conference on Education and Social Sciences 6-8 February 2017 Istanbul, Turkey* (2017).

instructors are at the helm of online assessment, which they do with content coverage considerations. The introduction of LMSs allowed tests and assignments to be developed by lecturers themselves using simplified authoring tools and test-builders.[6]

To manage the administration of online assessments, basic instructor knowledge and skills in information technology are important.[7] Instructors must decide on the mode of assessment commensurate with the discipline so that the outcomes reflect true students' understanding of the course content and are credible. Quizzes are more rigorous to design relative to assignments. There are many considerations to be done to design quizzes if they have to capture all the possible correct answers that students would come up with.[8] However, grading quizzes is easy and feedback is instant once all the credible answering options have been captured. On the other hand, assignments are more involving to grade since it is done manually. Basic training of academics and students was done in response to the shift to full online because of Covid-19; however, this might not have been enough for effective teaching, learning and assessment. With online examinations imminent at the end of every semester/year, instructors do not have much choice in the administration of online assessment that is in line with the mode of the final examination. Furthermore, remote online assessment is a novel experience for many university instructors and students, which in itself presents many challenges, particularly when guaranteeing students' understanding of content. In most higher education institutions, the assessment policies have not been adjusted to explicitly address remote online assessment.[9] The lack of such clear policies undermines universities' efforts to credible formative and summative assessments as academics then perceive online as discretionary.

General online assessment in higher education before and after the pandemic has been well-documented in literature. However, studies on actual deliberations in online assessment using the LMS in content-specific disciplines are rare. Some studies focused on the evaluation of online assessment in mathematics but not on what actually took place in the process of assessment of specific content domains. A practical concern about online assessment is whether it provides a true reflection of students' understanding of higher education. Brown and Lally conducted an evaluation research on first-entering engineering students' perceptions of online assessment in mathematics.[10] After conducting interviews and completing questionnaires, the engineering students lacked confidence and the necessary technical expertise in the assessment process and were confronted with many hindrances to online assessment.

Literature reveals that among the studies conducted on online assessment in mathematics, none focused on assessment involving long questions on the LMS. A study by Caspari-Sadeghi et al. focused on developing mathematics competency through multiple-choice questions (MCQs) which were formulated by students as a way of fostering self-learning. Even though the study enhanced self-regulated strategies in learning mathematics, it did not lead to higher achievement, mainly because of the sole use of MCQs.[11] If not properly constructed, MCQs and other short questions assess low-order knowledge.[12]

Sometimes prompt feedback from computer scoring helps to quickly identify students' misconceptions. This led to the usage of machine-scored short questions in a study on engineering

[6] Sue Timmis, Patricia Broadfoot, Rosamund Sutherland, and Alison Oldfield, "Rethinking assessment in a digital age: opportunities, challenges and risks." *British Educational Research Journal, 42*(3), (2016): 454-476. https://doi.org/10.1002/berj.3215

[7] Fernando Ferri, Patrizia Grifoni, and Tziana Guzzo, "Online Learning and Emergency Remote Teaching: Opportunities and Challenges in Emergency Situations." *Societies, 10*(86) (2020). https://doi.org/10.3390/soc10040086

[8] Sima Caspari-Sadeghi, B. Forster-Heinlein, Jutta Maegdefrau, and Lena Bachl, "Student-generated Questions: Developing Mathematical Competence through Online-Assessment." *International Journal for the Scholarship of Teaching and Learning, 15*(1) (2021).

[9] Martin Appiah, and Fanus van Tonder, "E-Assessment in Higher Education: A Review." *International Journal of Business Management and Economic Research, 9*(6), (2018): 1454-1460.

[10] Brown, and Lally, "Rhetorical relationships with students," 7–26.

[11] Caspari-Sadeghi, Forster-Heinlein, Maegdefrau, and Bachl, "Student-generated Questions."

[12] Caspari-Sadeghi, Forster-Heinlein, Maegdefrau, and Bachl, "Student-generated Questions."

mathematics.[13] In contrast to the LMS assessment, the assessment items were MCQ housed in Dewis, a home-grown web-based assessment application. Together with detailed feedback, it was discovered that students' misconceptions were tackled timeously with online assessment. Another formative assessment software tool iTest was used in a study by Prieto et al. to study the integration of alternative assessment and self-assessment online tools in mathematics courses in higher education. [14] As is common with all test software, the questions were MCQ in order to enable auto-scoring as part of the self-assessment strategy. A survey of students and academics involved in that study revealed positive attitudes towards the tool and that iTest offers a worthwhile assessment tool for content that focuses on skills and procedural development. The use of test software tools is much appreciated to promote autonomous learning; however, these are unavailable to developing countries.

METHODOLOGY

This study was a qualitative case research design, an inquiry that was conducted in a natural setting. An inquiry into the ways of presenting remote online assessments in a single mathematics course was conducted by the researcher in 2021. The course was offered fully online due to the pandemic restrictions. The researcher taught the course and administered assessments, making this study a scholarship of teaching and learning. The participants were 180 Level 3 undergraduate students at UWS. After conducting the formative assessment, an evaluation of students' experiences with online assessment was done by means of open-ended questionnaires and semi-structured interviews. A conveniently chosen sample of 13 students completed the online questionnaire. A further ten students took part in the telephonic interviews and these were selected conveniently again. Data were composed of written responses to the questionnaires and transcriptions of the interview recordings. The participants' narratives were read repeatedly and meaning was attached to the stories concerning students' experiences in online assessment. The participants were assigned names P1, P2, and so on up to P23 for confidentiality. The ordering carries no significance.

The research procedure involved designing and deploying assessment tasks in the form of quizzes and assignments on Blackboard. The scripts were graded and scores were recorded. More practical and research-based evidence is needed to inform instruction with regard to mathematics thinking in the digital age of humanity.[15] The goal was to ascertain that the shift to online assessment is backed by evidence that is gathered and presented by instructors themselves.[16] Thus, the following section presents evidence of what took place in the online assessment in mathematics, starting with the quiz.

Quizzes

In quizzes, MCQs are the most common, according to Boitshwarelo et al.[17] In mathematics, students have to do calculations on paper or mentally and then choose the correct answer among the given options. Figure 1 illustrates a typical MCQ in mathematics.

[13] Indunil Sikurajapathi, Karen Henderson, and Rhys Gwynllyw, "Using e-Assessment to Address Mathematical Misconceptions in Engineering Students." *International Journal of Information and Education Technology, 10*(5) (2020).
[14] Nuria Joglar, Diego Martín, J. Manuel Colmenar, Iván Martínez, J. Ignacio Hidalgo "iTest: Online assessment and self-assessment in mathematics." *Interactive Technology and Smart Education.* (2012) https://doi.org/10.1108/17415651011071622
[15] Peter Akayuure, Michael Johnson Nabie, and K. Raheem, "Learning Mathematics in the Digital Age: Challenges Caused by Covid-19 Pandemic Arrangement". *Mathematics letters* (2022).
[16] Caspari-Sadeghi, Forster-Heinlein, Maegdefrau, and Bachl, "Student-generated Questions."
[17] Boitshwarelo, Reedy and Billany, "Envisioning the use of online tests in assessing twenty-first century learning."

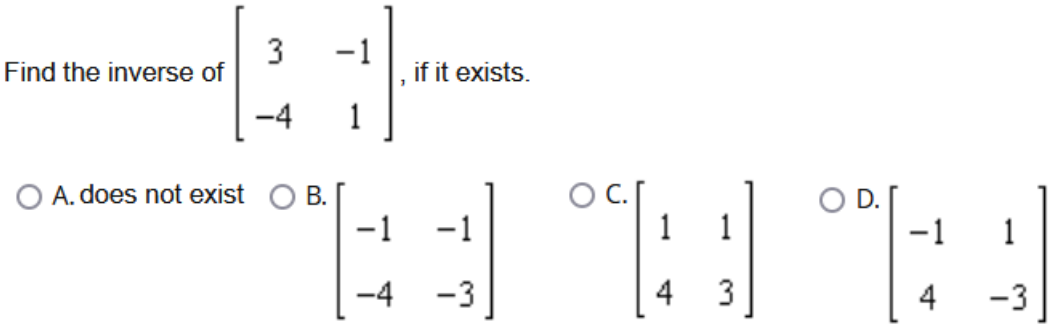

Figure 1. A typical MCQ in a quiz

The questions and the options were shuffled to minimise students' copying. In quizzes, fill-in questions are also popular, which can be single or multiple fill-ins. However, fill-in questions require students to have a clue about the manner of writing the answer. In any case, students should get full marks whether they write their answers as a digit or in words with or without units. Figure 2 depicts a fill-in type of question.

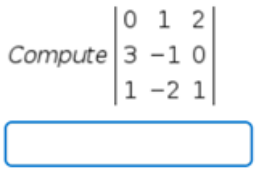

Figure 2. A typical fill-in question

Multiple fill-in questions with partial crediting are also possible in Blackboard. The researcher designed multiple fill-in questions in an attempt to allocate marks for steps in the solution process. The partial crediting was activated to allocate part marks to incomplete solutions. Figure 3 illustrates a sample of multiple questions.

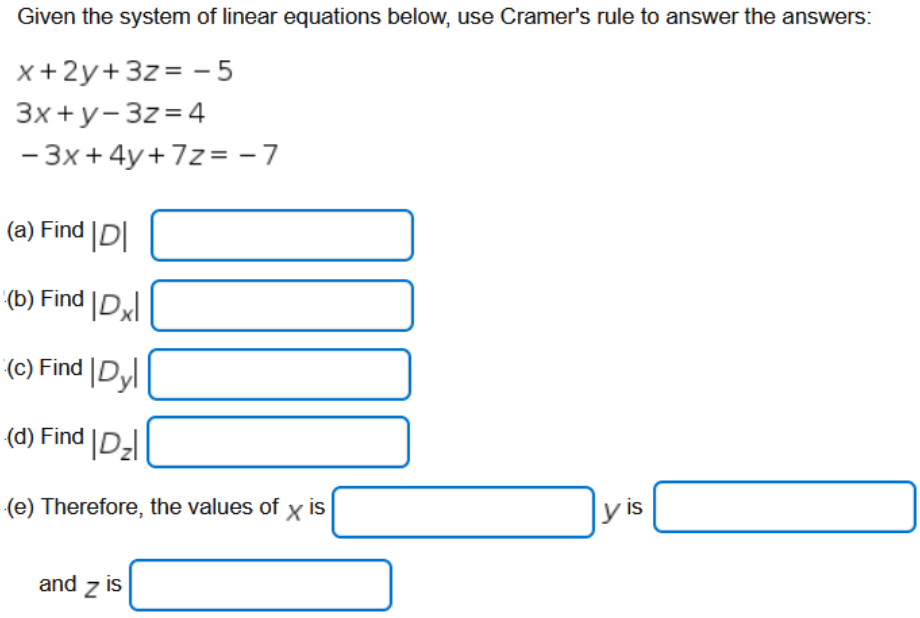

Figure 3. An example of a multiple fill-in question

In Figure 3, each of the blank spaces has a mark allocation which is scored independently. Interestingly, parts (b), (c), and (d) are directly connected to the answer in (a) such that failure to get correct answers for part (a) excludes any possibility of earning full credits for the subsequent parts. To come up with an algorithm that will credit part (b) to (d) even though part (a) is incorrect was beyond the capability of the researcher. Finally, True/False questions were also included in the assessment as illustrated in Figure 4.

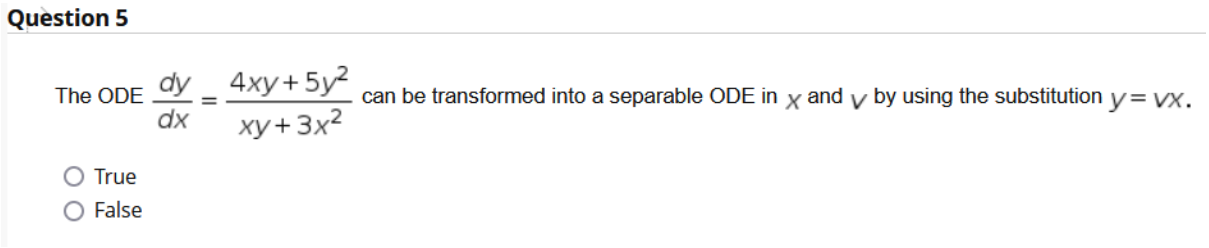

Figure 4: A True/False item in the assessment

The problem in Figure 4 is long and involves many steps but these cannot be credited. The only attempt was to allocate high marks for questions like these. But these high-mark allocations were only earned or lost by considering the final answer. The researcher did not include matching-type questions as these do not really add value to mathematics. In fact, all the question types under quizzes are hardly used in textbooks or lecture notes in mathematics; hence, on what basis do these find themselves in online assessments in mathematics? Assessment is part of learning so the examples and activities in textbooks should be reflected in the formative and summative assessments. Mathematics textbooks do not give questions that focus on the final answer only in general. Based on this, the researcher was under pressure to shift to the assignment type of assessment on the LMS, which is explained in the next section.

Moreover, it is cumbersome to moderate a quiz and the students' scripts by an independent person outside the organisation. The assessment task and scripts only exist on the system electronically. The moderator would have to log in to the course on the LMS to access the quiz and the test options which include the allocation of marks and the student's responses. The instructor and moderator are assumed to possess moderate IT skills and be able to find the underlying cause of quizzes especially. However, lack of experience dissuades the use of novel assessment tools by course instructors.[18] This is not the case with assignments where the question paper and students' scripts are stand-alone as in contact examinations.

Assignments

Questions under assignment are natural and reflect the way mathematics concepts are developed. The issue may be instructors and students not knowing how to administer and write them online respectively. Firstly, the instructor use a word processor to create the test and items as usual. It is at this stage that the test or examination can be sent for moderation following the normal way as in contact assessment. This is followed by creating the assignment on Blackboard where the question paper is uploaded and the test specifications are instituted. For controlled tests, the duration is set to two or more hours. The assessment task is set to display and close at specified times to stop students from submitting after the test has closed.

To sit for the assessment, students click to download the question paper and then respond to the questions with a pen on paper. Those who choose to typeset may do so, but with multiple steps and special mathematics symbols, this is cumbersome. They are supposed to scan to *pdf* and submit the file to the LMS before the assessment closes. Figure 5 depicts a sample of a student's script.

[18] Joglar, et.al. "iTest: Online assessment and self-assessment in mathematics."

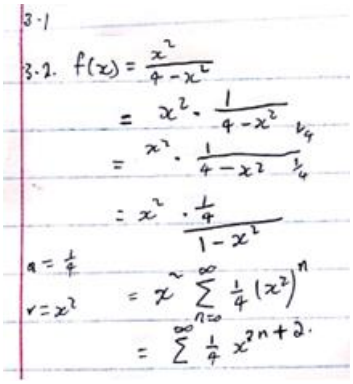

Figure 5: Sample of a student's work

The course instructors can start marking immediately after the test closes by clicking the name of the test to be marked. They can see the number of submissions that needs grading. To grade, the instructor clicks the Grade button as shown in Figure 6.

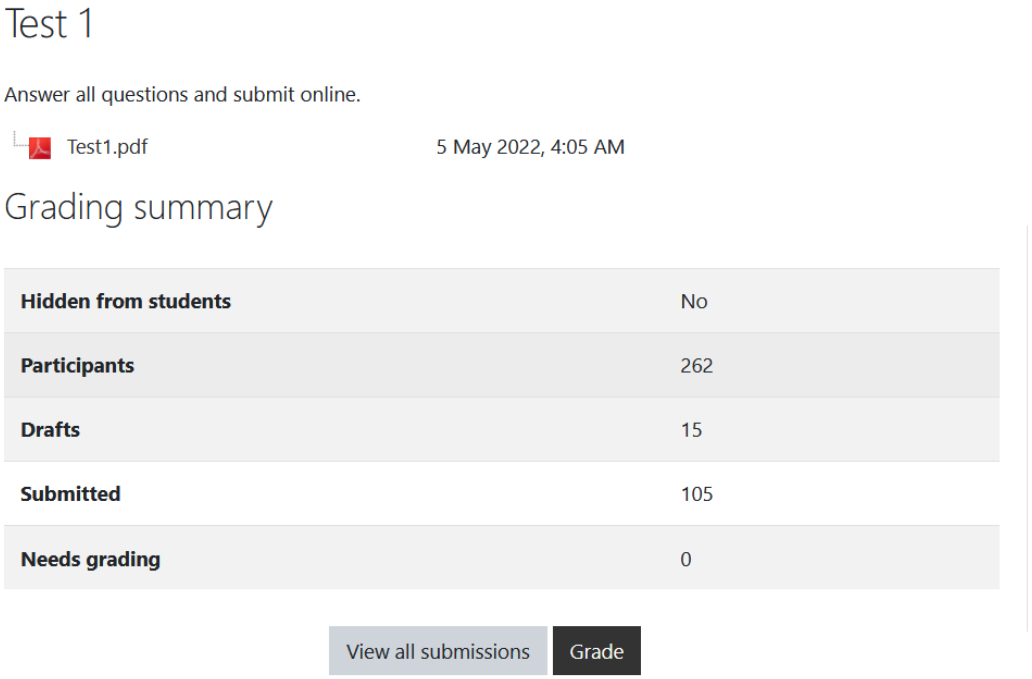

Figure 6. The first step is to access students' scripts for marking purposes.

Figure 6 highlights the fact that some students still encounter difficulties in submitting their work; not all students succeeded. With the necessary encouragement and practice, most students managed to improve their submission skills. Some disciplines can do with take-home assignments but mathematics is different. In mathematics, controlled tests dominate and the pandemic did not change that. The duration for formative and summative assessment tasks is controlled. Students who could not finish on time were blocked by the system, as shown in Figure 7.

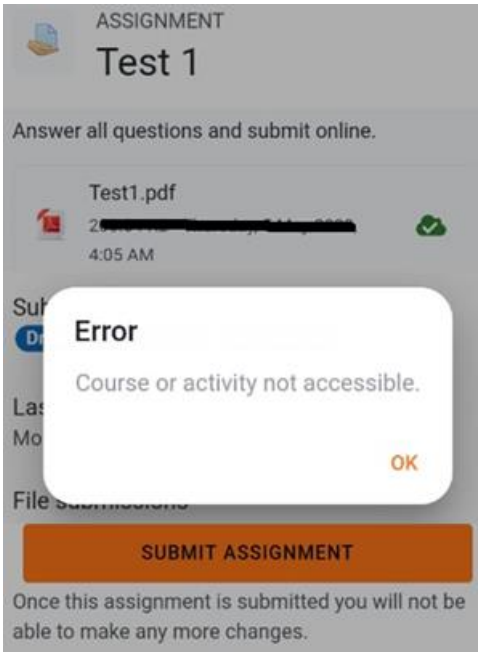

Figure 7: Students denied to submit chance to submit after the assessment closes

Some students tried to coerce the instructor to accept WhatsApp or email submissions. However, it was not possible because these platforms cannot be controlled effectively.

The grading process is simplified by the in-line grading facility on the LMS (see Figure 8). With the right settings, as soon as the instructor enters the score and clicks Save Changes, the student receives feedback on the other end.

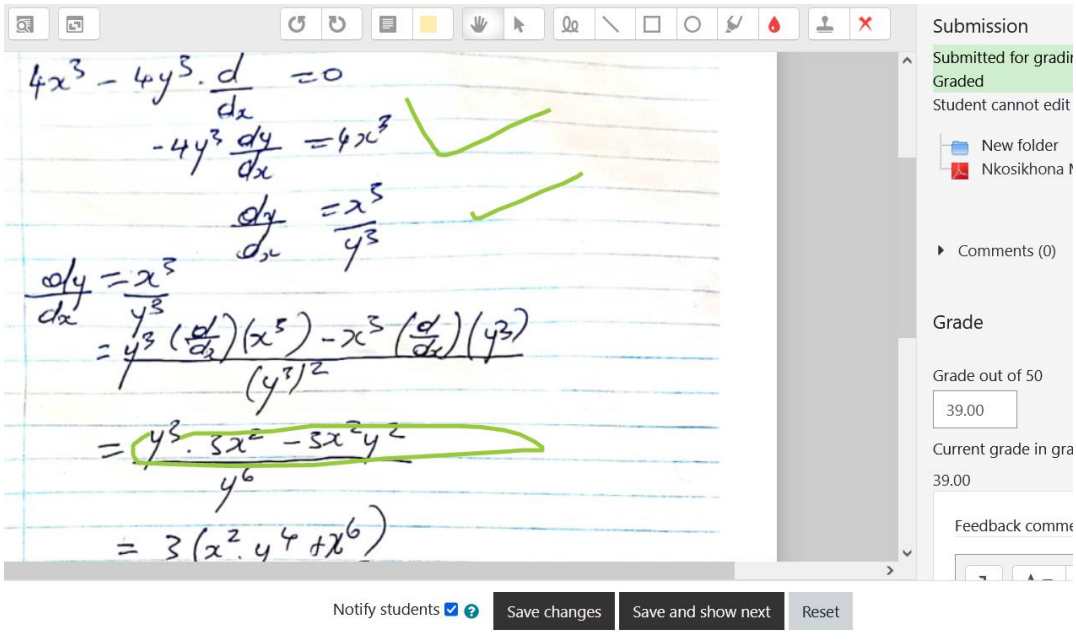

Figure 8: In-line grading of students' work

The feedback is in the form of a score and the Annotated pdf, as shown in Figure 9. It can be noted that, unlike quizzes which render instant feedback, assignments are not. However, feedback is immediate as soon as the script has been marked.

Figure 9: Feedback received by a student

When students open the Annotated PDF, they get to see the marked script. Figure 10 shows part of the marked script.

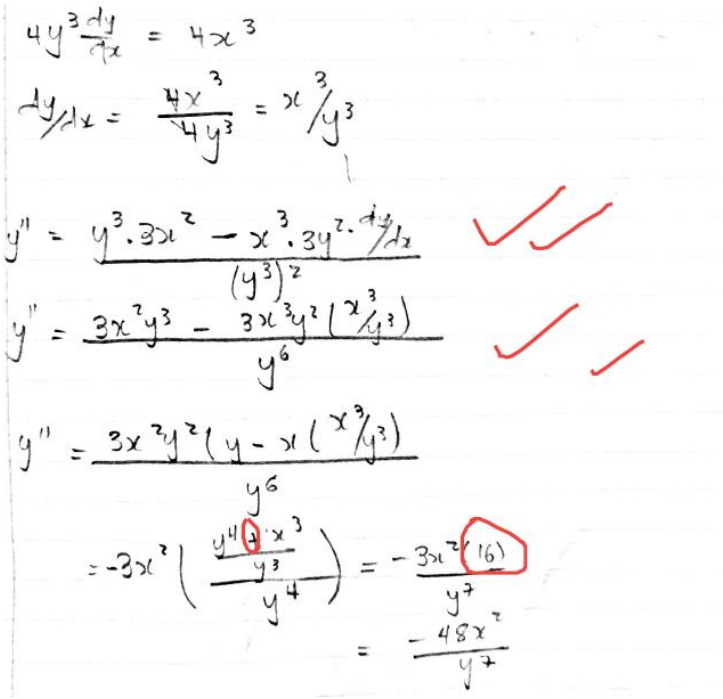

Figure 10: Evidence of marked work in the Annotated PDF

All the Annotated PDFs can be downloaded and forwarded to the external examiner or moderator with ease. Finally, the only thing left is for the course instructor to download the mark-sheet already populated with all the marks for both the quiz and the assignment. The LMS keeps perfect records for all the processes of test design, submissions, grading and records of marks for all assessment tasks. That also makes the process of re-marking much easier should there be a need for that. For the examination, it was simple to command the system to bar students from accessing any kind of feedback soon after grading.

FINDINGS AND DISCUSSION

At the start of the assessment period, it was not clear which modes of online assessment exist in Blackboard and which one is most suitable for assessment in mathematics. Thus, the instructor started with the quizzes. After both the instructor and students developed dissatisfaction with quizzes, a decision was taken to start experimenting with assignments. It was a time of learning and discovery for both students and the instructor. After the favourable experiences in assignment, students made their choice on their preferred format of assessment. The dialogue with P6 below describes this:

Researcher: Which one do you prefer, an assignment or a quiz?
P6: I prefer an assignment.
Researcher: Can you motivate why you prefer an assignment?
P6: Because we are going to write down and it is useful for proofs. Sir, it's not easy to write those proofs when you are writing those quizzes. That's why I personally I prefer a quiz.

Indeed proofs, verifications, and other long solutions common in mathematics can be best done on the assignment platform. P19 also pointed out that in mathematics*, "it's not easy to do calculations on a computer*". Instead, students preferred the assignment format where they write responses manually and upload them to the LMS, to which the instructor uses inline grading to mark. By this, students can demonstrate their skills in solving problems step-by-step, which is something they are used to in contact learning anyway. The assignment format, therefore, provides a transition from contact to online assessment. It is important to make a choice because not all LMSs mix objective and subjective items in the same assessment task. It is one or the other.

When students sat for quizzes, some complained about losing marks when they were correct. Auto-scoring by the system is oftentimes rigid so that any deviation from the expected response deprives students of credits due to them. In the interview, P7 said:

P7: Blackboard sometimes marks us wrongly.
Researcher: How so? A computer does not favour or hate. It simply follows instructions.
P7: It happens. There was a quiz that we wrote online. There were marking errors there. I confirmed with you on WhatsApp and I sent my rough work to you. Then you said it was correct and then adjusted the marks. So Blackboard sometimes marks wrongly.
Researcher: I get you. It has to do with the person who designed the task.

Faced with unanticipated or ill-posed students' responses, a computer cannot be flexible like a human marker.[19] Moreover, P3 admitted that even though computers dominate modern life, she had reservations when it comes to mathematics assessment.

Researcher: We have lived with computers so much for you to doubt them.
P3: For mathematics, a computer no. Sometimes it's the way you write your answer. I remember my answer was correct but the way I wrote it was incorrect according to the computer. The final answer was incorrect.
Researcher: Can you be specific?
P3: It's like when the answer is x=13 but then the only thing I wrote was 13. Then I get it incorrect by just leaving x.
Researcher: Yes I agree with you. The way you write your answer may cause you to lose marks.
P3: Look, only the way you write but the answer itself is correct.
Researcher: As a lecturer, I have to accommodate all the possible answers.

Having gone through these experiences, the majority of students preferred a human marker and that was only possible in assignment format. The algorithms for mathematics objective questions in

[19] Sikurajapathi, Henderson, and Gwynllyw, "Using e-Assessment to Address Mathematical Misconceptions in Engineering Students."

the quiz is the domain of expert programmers because the permutations for all possible correct and partially correct answers are huge. A course instructor with basic tools and knowledge cannot have the ingenuity to accomplish such a feat. Hence, the institutions that rely on objective computer-based tests use proprietary software with huge question banks for mathematics. On the other hand, non-computational computational disciplines like Accounting and Business Studies find MCQ very useful and popular.[20] These online tests obviously are not LMS-based in contrast to the focus of this study. Hence, for credible LMS-based assessments for mathematics, in particular, the use of assignments was popular with students.

For fill-in questions, some symbols are not available on the computer keyboard. P4 elucidated herein in the interviews:

> *Researcher: Are all topics suitable for quizzes?*
> *P4: Most of them are good, except when it comes to inequalities where we have to write greater than or equal to.*

To accommodate special symbols in mathematics, assignments are appropriate. P11 corroborates this in the questionnaire by saying, "*there are symbols or signs that are not there in the computer when we write online; they need to be written down*". In addition, even when assignments are used, typesetting mathematics text is clumsy, especially for a time-controlled assessment. In that regard, handwritten solutions are the best, which is also the very way students have been used to since the pre-Covid-19 times.

Online assessment is not watertight on cheating and other unfair practices. Measures to stop cheating may not be attainable, but instructors should strive to minimise the chances of doing so. Absolute test security is not yet possible in a remote environment.[21] Mathematics is not spared either. The stance taken in this study was to lean towards open-book tests in terms of the questions set. Straightforward and low-order questions were avoided but this was only possible in assignment format. Since these were hand-written, any change in handwriting becomes suspicious. Contract cheating is avoided when third parties write for the students, since a change in handwriting may give out the perpetrators. A comparison of handwritings is possible since the LMS store all submissions for the current year and prior. P11 mentioned that he prefers online assessment in general because "*it is favourable to pass because you have chances to search aside what you don't know*". However, this could not work on problems like: *showing that the second derivative of the function* $x^4 - y^4 = 16$ *with respect to* x *is given by* $\frac{-48x^2}{y^7}$. Searching for the solution either on the Internet or in other texts is futile in problems like these. It requires a logical understanding of the concept and the problem in order to get the required answer. Students just have to know the concept of implicit differentiation and necessary substitution for $\frac{dy}{dx}$ at some stage in order to get the $\frac{d^2y}{dx^2}$ devoid of any differentials. Herein, students who would not have understood the concept obviously may not succeed.

This works very well for students who write singly, since those who write in a group setting may still gain an unfair advantage. P20 said that those students who are not smart pass because they are forced to be with those who understand better during the test. P19 emphasised collective work by saying all future tests may continue to be written online "*because we write very calmly and collectively*". One of the recommended measures to curb cheating is to limit the assessment duration. However, when the researcher adhered to this premise, some students were not comfortable. On being asked about the possible improvements that could be done by the lecturer to make online assessment better, P11 pointed out that "*give us enough time to write*". According to P11, more time allocation is needed, but that cannot be granted except when it is necessary. Setting tight time frames wherein to

[20] Sandra Einig, "Supporting students' learning: The use of formative online assessments." *Accounting Education: An International Journal, 22*(5), (2013): 425-444.
[21] Selma Senel, and Huseyin Can Senel, "Remote Assessment in Higher Education during COVID-19 Pandemic." *International Journal of Assessment Tools in Education, 8*(2), (2021): 181-199. https://doi.org/10.21449/ijate.820140

answer questions is one way to deter cheating.[22] In Figure 5, some questions were skipped altogether due to time curtailment. With extended timespans, students end up filling in skipped questions via consultations with peers or mathematics texts. It is for this reason that mathematics and other quantitative disciplines lecturers stay away from take-home assessments. In any case, even in those disciplines where take-home assignments are suitable and common, the final examination cannot be taken home under any circumstance at UWS and other institutions. Hence, online assessment in this regard serves to familiarise students with the rigour of summative assessment. In all, four formal tasks were administered and these were enough to prepare students for the final online examination. P6 concurred and said,

> *It does give us sufficient practice. It gives us the structure; what kind of questions to expect and how they are going to be asked. Sometimes you may know the content but it's how the question is posed that gives a problem. If I am familiar with the questions, there is not going to be a problem.*

Sometimes with sufficient resources, students can be directed to a venue and write online tests therefrom or students write from a computer laboratory under supervision. At the moment, UWS, a historically disadvantaged institution does not have computer laboratories which can accommodate large classes at once.

Some participants in this study lamented on the lack of crediting of steps if the assessment is confined to quizzes only. This applies to all types of questions under quizzes. MCQs have an added disadvantage in that test-takers can make random guesses, as posited by P6, "*sometimes we guess without understanding the question and get the answer right without knowing the content. Based on that, I don't think MCQs give us a true reflection of our understanding of mathematics*". P3 indicated that "*sometimes I may not calculate; I guess the answer*". Random guessing does not help students understand mathematics. Rather than guessing, P20 did the calculations first before choosing the answer, rather than guessing. P14 also said, "*Mathematics has got some steps when dealing with some calculations, so multiple-choice questions just give us a final answer. If I didn't get it correct, I won't get marks for steps ... it only shows the final answers*". P21 added by saying,

> *It would have been better to show the calculations than just clicking on the final answer as it might happen that the steps throughout the calculations were correct yet I arrived at the wrong final answer. Therefore, the short questions are contrary to our progress.*

Students did not find it easy to pass in assignments; it is either they knew or they did not score. In some cases, students skipped questions which they felt they did not know as is common in contact assessment. This endorses online assessment as credible. In quizzes, a good or poor mark cannot be linked to the students' mathematics concepts.

Indeed grading in mathematics starts with the initial steps which progress until the final answer. In this case, the final answer may not be correct but the student scores substantial credits in the workings. In fact, according to Ali and Al Dmour, lecturers should deviate from traditional types of questions like MCQs. [23] MCQs and their variants are not suitable for science, technology, engineering and mathematics.[24] On the contrary, some students like P20 had positive attitudes towards MCQs. P20 said, "*I don't just choose, I do calculate first. It really makes a difference because if I am wrong I can see and start again and rectify my mistake. Don't change that format please*". P20's response is an

[22] Boitshwarelo, Reedy, and Billany, "Envisioning the use of online tests in assessing twenty-first century learning: a literature review."

[23] Liaqat Ali and Nidal Abidal Hamid Hmoud Al Dmour, "The Shift to Online Assessment Due to COVID-19: An Empirical Study of University Students, Behaviour and Performance, in the Region of UAE." *International Journal of Information and Education Technology, 11*(5) (2021). https://doi.org/10.18178/ijiet.2021.11.5.1515

[24] Pingkan Imelda Wuisan and Basuki Wibawa "Using Electronic Assessment System in Higher Education: Challenges and Solutions for Lectures, Students and Institutions." International Journal of Recent Technology and Engineering, 8(2S9) (2019). https://doi.org/10.35940/ijrte.B1141.0982S919

indication that indeed students perform the calculation first before selecting an answer-option in MCQs. However, there is no evidence of such as the calculations are not part of the solution. P20's response is an indication that indeed students perform the calculation first before selecting an answer-option in MCQs. However, there is no evidence of such as the calculations are not part of the solution. There is no distinction between a random guess and a prior calculation of a problem.

Experiences from and evaluation of formative assessment were incorporated into the design of summative assessment (final examination) much to the delight of the test-takers (students). Formative online assessment served to acquaint both instructors and test-takers with the online examination which was due at the end of the academic year. This in turn raises the validity and credibility of the final examination, which is used to demonstrate that a student has met programme or certification requirements of a course of study. As such, both quizzes and assignment modes of assessment were demonstrated in this study and the lecturer and students settled for the Blackboard assignment. It was also unanimously agreed to conduct the final examination as an assignment to enable students to write multi-step long questions which are common in mathematics. In assignments, the lecturer sets the normal question paper as in the traditional assessment approach. The examination is downloaded from the LMS and handwritten offline, which does not put immense pressure on the need for a robust network or specialised devices for the three-hour duration of the examination. This proved beneficial when considering that some institutions of higher learning are resource-constrained, which limits their capability to provide adequate resources for student use. Furthermore, the majority of students at these institutions originate from marginalized communities that barely afford a mobile phone. With assignments, many students used their smartphones to access the question paper, scan the solutions and submit the scripts to the LMS. Mobile multi-media devices pose to take a core position in the delivery of instruction and assessment.[25] The absorption of mobile phones by South African university students has been impressive recently.[26] On the contrary, online tests require an uninterrupted Internet connection for the entire duration of the assessment and exclusive devices like laptops and desktops. Non-standard devices distort some items and affect navigation within the test.

Unlike other disciplines which are non-computational, Mathematics poses unique challenges for online assessment. These challenges need to be taken into consideration when designing an assessment for it to be credible and valid. Mathematics has multi-step solutions which are characterized by special symbols. For example, students need the freedom to express their solutions without the limitations of the mode of assessment. Moreover, the grading of students' work should not be rigid, as in computer scoring. The two aforementioned facts necessitate moving away from short questions with pre-determined responses and the introduction of human marking. Students can tolerate the effects of poor teaching but they cannot escape the effects of poor assessment.[27] Nevertheless, the unanticipated and sudden move to fully online assessment in most institutions as a result of Covid-19 saw, in most cases, no adjustments to institutional assessment policies to incorporate the online mode of assessment. Consequently, students and lecturers used that as a loophole to circumvent online assessment practices.[28] To maintain quality and utility, the creation and deployment of online assessment tasks require the experience and commitment of the lecturers. With such huge responsibility, it is human nature to try to shun full online assessment in favour of traditional assessment of practices. The successful implementation of the LMS in teaching, learning and assessment depends heavily on

[25] Eliseo Perante Marpa, "Technology in the teaching of mathematics: An analysis of teachers' attitudes during the COVID-19 pandemic." *International Journal on Studies in Education, 3*(2), (2021): 92-102.
[26] Patient Rambe, and Chrispe Chipunza, "Using mobile devices to leverage student access to collaboratively-generated re-sources: A case of WhatsApp instant messaging at a South African University." *International Conference on Advanced Information and Communication Technology for Education* (ICAICTE 2013) (2013).
[27] Appiah, and van Tonder, "E-Assessment in Higher Education: A Review." 1454-1460.
[28] Appiah, and van Tonder, "E-Assessment in Higher Education: A Review." 1454-1460.

successful academic staff buy-in.[29] Making sure students learn is a pivotal role of lecturers. The Blackboard LMS handled well assessment of the specialised content areas like mathematics. More so, students' performance in the assessment was regular, a true reflection that the mode of assessment did not aid or diminish proof of students' understanding of mathematics.

CONCLUSION AND RECOMMENDATIONS

Assessment is central to teaching and learning hence must be done appropriately. The dynamics of LMS online assessment in mathematics were elaborated and students' perceptions of online assessment were examined. It is through such reflections that successful student learning remains the key focus. The practical significance of this study is that the researcher is currently teaching the same courses and engaging in LMS assessment for both Moodle and Blackboard LMS. As a scholarship of teaching and learning study, researching and publishing one's teaching helps to improve practice. The Blackboard assignment mode was widely used in formative and summative assessments for mathematics that brought the 2021 academic year to a successful end. The responsibility for online assessment remains the domain of the course instructors so that they can use it as part of learning. This study documented evidence of online assessment in mathematics which was analysed by taking students perceptions of it. Further research can be undertaken to demonstrate and analyse students' perceptions of online assessment in other disciplines. It is recommended that sometimes it may be necessary to offer specialized training to lecturers to equip them with the necessary skills on how to administer the formative online assessment in their disciplines. This makes teaching more effective. Generic training is common in most institutions but is not sufficient in some content-specific disciplines like mathematics. Once lecturers are skilled, they will in turn coach their students on sitting online assessments. This study also recommends upholding online assessment in courses like mathematics beyond the Covid-19 pandemic as it is a good opportunity to make learning relevant to students in this digital era. This gives rise to blended or digitally-infused learning which should be a common phenomenon in higher education institutions.

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