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A Reflection on the Effectiveness of E-Assessments in Mathematically Intensive Engineering Courses Post COVID

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ABSTRACT

CONTEXT

Driven by the pedagogical transition to online delivery and assessment due to the COVID-19 pandemic, we have developed and implemented various online assignments and mastery quizzes using a versatile maths e-assessment tool called Numbas, for three mathematically intensive engineering courses (Mechanics of Materials 1 (2nd year), Structural Analysis (3rd year) and Control Systems (3rd year)). Issues in these courses included limited problem sets and student rote learning without understanding, assessments which had poor correlation to overall learning, and academic integrity concerns. We therefore aimed to use Numbas to improve the evaluation of students' true understanding of the concepts, analysis procedures and problem-solving skills, thereby enhancing their independent learning experience and outcomes whilst minimising plagiarism.

PURPOSE OR GOAL

This study is to reflect on our three-year practice, evaluating the following: (1) How the online assessment using Numbas helped the students to consolidate their understanding in an effective way. (2) How breaking down large questions into consecutive and interconnected sub-questions helped the students to learn in a step-by-step manner. (3) How these online assessment helps to improve students reflective learning experience.

APPROACH OR METHODOLOGY/METHODS

Different methodologies were adopted for different courses, based on the course type and assessment type using Numbas. For structural and mechanics courses, comparative studies were performed on the correlation between the assignment and final exam performances between years with traditional paper-based versus e-assignments. For the control course, final exam performance was evaluated. Surveys were also conducted to provide evidence of how the online assessment has helped the students to learn.

ACTUAL OR ANTICIPATED OUTCOMES

Online assessments developed based on Numbas have demonstrated their effectiveness in enhancing the student learning experience and performance through well-structured formative e-assessment throughout the trimester. Featuring a large question bank with randomised questions, these e-assessments have served intended purpose of fostering independent learning, minimising plagiarism, and providing ongoing feedback to improve academic teaching and student learning.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

Purposefully designed and well-structured online assessments using Numbas have been developed and implemented for three mathematically intensive engineering courses at Griffith University. Findings suggest that such a development has resulted in positive impact to students learning experience and outcomes, while facing the unprecedented challenges of COVID-19.

KEYWORDS
Online assessment, independent learning, academic integrity

Introduction

In response to the COVID-19 outbreak in 2021, various restrictive measures such as work-from-home policy, lockdowns, and university closures were implemented worldwide. These measures necessitated a rapid and significant shift in the mode of university teaching from traditional in-person to online delivery (Evans, 2020; Queensland Government Department of Health, 2020; World Health Organization, 2020). To facilitate this transition, Blackboard Collaborate Ultra, Microsoft Teams or similar online software were selected at Griffith University as the primary online platforms for lectures and tutorial sessions. The adoption of these platforms required a comprehensive reassessment of all teaching activities to ensure their suitability for online delivery. For instance, previously conducted workshops which were designed to enhance understanding through hands-on experimentation, had to be adapted for online teaching using recorded workshops and explanation of concepts in online lectures. While students were unable to physically operate experiments, they still had the opportunity to gain a fundamental understanding through the pre-recorded sessions, thus still fostering an active learning process. Although online lectures and tutorials can work effectively (Lapitan Jr, Tiangco, Sumalinog, Sabarillo, and Diaz, 2021; Manea, Macavei and Pribeanu, 2021) and is well evaluated in the literature, online assessments have been shown to provide unique challenges in terms of purposeful development, practicality of implementation, and reliability of measured outcomes (Cook and Jenkins, 2010; Kuikka, Kitola and Laakso, 2014).

A number of different e-assessment systems are available including Numbas (Numbas, 2021), Tutor-web (Lentin, Jonsdottir, Stern, Mokua, and Stefansson, 2014) and assessment tools built into Blackboard Collaborate Ultra and Canvas. Numbas is a free and open-source system that was developed by UK's Newcastle University for mathematical subjects (Numbas, 2021). Using Numbas, assignment and project problems can be created in such a way that questions with random variables can be written and students can practise the one sort of problem (with different variables) until they are confident on a particular type of problem (Allan, Campbell and Crough, 2019). Numbas is a tool that performs automatic marking of a variety of types of answer, including mathematical expressions, numbers, short text, and multiple-choice (Numbas, 2021). While Numbas has all these advantages, it has a steep learning curve, requires initial training and substantial development time, as well as careful thought and planning to design questions. However, its advantages outweigh the many challenges, and therefore, Numbas has been used to develop online assessments for a range of mathematically intensive engineering courses including Mechanics of Materials 1 (2nd year), Structural Analysis (3rd year) and Control Systems (3rd year) at Griffith University.

Before the COVID-19 pandemic, assessments were predominantly designed in a paper-based format. All students received the same set of problems. Upon completion they were required to submit their work either to the library or through an online submission system. Hosseini and Ferguson (2022) highlighted that such practises led to concerns about academic integrity, as students could easily access solutions from websites or rely on materials from their peers either within their cohort or having taken the course in previous years. One significant consequence of this type of assessment was the difficulty in addressing academic integrity violations effectively, as investigating and proving such instances were challenging tasks. Additionally, students had a lack of timely feedback on their assignments, as it typically took up to two weeks to receive feedback after the submission deadline due to marking being done manually. It has been well recognised that the feedback is a useful tool to improve students learning skills and engagement (Bonham, Deardorff and Beichner, 2003; Carroll, Casey, Crowley, Mulchrone, and Shé, 2017; Hosseini and Ferguson, 2022). For lecturers and tutors, on the other hand, grading paper-based assessments posed consistency and efficiency challenges. Also, providing personalised feedback to each student was a laborious task, and in most cases, only general feedback could be given to the entire cohort (Gok, 2011; Pearson and Penna, 2022). Another disadvantage of this approach was that only limited problem sets are available for students to practice. With only a finite number of practice problems, students often found themselves lacking sufficient opportunities to fully grasp the course content and adequately prepare for their final examinations (Karpicke and Blunt, 2011; Krzic and

Brown, 2022), often leading to rote learning of problem solutions rather than understanding of the process and decision making involved.

By introducing the use of Numbas, the benefits are manifold. Firstly, each student receives a unique set of randomised parameters for their assessment, randomly generated within a range predefined by the lecturer. This individualisation ensures that students must approach their assignments independently, reducing the likelihood of accessing answers from external sources such as websites or peers. Although students may share the methodology and collaborate with their peers, they are still required to solve their unique set of problems based on their own understanding, thereby promoting academic integrity and personal mastery of the subject matter (Pearson and Penna, 2022). Secondly, the platform enables students to receive detailed feedback immediately after submitting their assignments. This timely feedback has been shown to enhance student motivation and active participation in the learning process (Carini, Kuh and Klein, 2006). Thirdly, Numbas allows students to attempt the assessments multiple times. This iterative approach empowers learners to revisit specific topics, reinforcing their understanding and mastery, which can be especially beneficial in preparing for final examinations.

The correlation between the student performance of final exams and assignments have been investigated over the years (Gok, 2011; Magalhães, Ferreira, Cunha, and Rosário, 2020). Some studies have investigated the effect of online- versus paper-based assignments on final exam performance. For instance, Hosseini and Koohi-Fayegh (2021); Mestre, Hart, Rath, and Dufresne (2002) have reported mixed findings on the students' exam performance being either improved or similar regardless of the assignment types. However, these studies are limited and few have considered the differences in student performance, before and after the COVID-19 outbreak, associated with the transition from paper-based to online-based assignments (Boardman, Vargas, Cotler, and Burshteyn, 2021; Hosseini and Koohi-Fayegh, 2021; Klein, Ivanjek, Dahlkemper, Jeličić, Geyer, Küchemann, and Susac, 2021). To provide further insights into the challenges and benefits of online assessments, this study presents a reflection on the effectiveness of e-assessments in mathematically intensive engineering courses offered at Griffith University post COVID-19.

Methodologies for Developing E-Assessment

Although being designed for maths testing, Numbas can also be applied to many different subjects that are heavily mathematical based (Carroll et al., 2017; Hadjerrouit and Nnagbo, 2022; Hosseini and Ferguson, 2022). The platform is suitable for both summative and formative assessment, with advanced marking and question design features not available through most quiz tools, including its ability to assess answers provided as mathematical expressions (or symbols). In developing our e-assessment for the different courses evaluated within this study, different methodologies were adopted and are discussed according to the type of assessment they were applied to.

On-going Assignments

For structural and mechanics courses (3101ENG and 2101ENG), on-going assignments are one of the major assessment activities and are used to develop problem solving skills as well as summative assessment. Assessment in *Structural Analysis* (3101ENG) includes five problem-solving assignments each having 3-4 major questions (due fortnightly, totalling 25% weighting) and a computer-based analysis-optimisation project (15%), contributing to the complex learning tasks of this course, plus a career building skills task (10%) and final exam (50%). For *Mechanics of Materials 1* (2101ENG), assessment includes mastery quizzes (4 quizzes worth 20%), 4 assignments (due every 2-3 weeks, totalling 20%), and final exam (60% weighting).

Previously, these assignments in each course were traditionally run, with each student receiving the same assignment question, and marking was completed over a two-week period before returning to students for feedback. To facilitate easier marking of assessments and provide prompt feedback in large classes (100-200 students), authors changed to Numbas implemented e-assignments with randomly generated questions and electronic entry of answers by students at

incremental stages of the solution process, allowing for automated marking and immediate feedback to students upon submission.

Strategies used for the development of online assignments using Numbas include: (1) Creation of large question pools with a wider range of structural variables (dimensions, member sizes, material properties, location and magnitude of loading, location and type of supports), to thoroughly assess students' understanding and problem-solving skills whilst minimising plagiarism. (2) Breaking large questions down into consecutive and interconnected sub-questions and give legitimate part marks to not unduly penalise students for carrying through the calculation mistakes. (3) Provide multiple-choice graphical solutions to assist better understanding of the structural behaviour under load (e.g., deformed shape, shear force and bending moment diagrams), truly reflecting the sophisticated analysis process required by this course.

To evaluate the effectiveness of e-assessments in the structural and mechanics courses (3101ENG and 2101ENG), comparative studies were performed on the correlation between the assignment and final exam performances between years with traditional paper-based versus e-assignments.

Mastery Quizzes

Control systems (3304ENG) is a core course for both Mechanical and Electrical engineering students. The course involves both theoretical knowledge requiring a strong mathematical foundation, as well as practical skills to apply this knowledge to achieve system requirements. Problems are complex, involving lengthy often non-intuitive problem-solving strategies. Previously, assignments were used to assess student understanding of these skills, but these were very time consuming to mark resulting in delayed feedback to students, and plagiarism was a real issue. Final examination answers indicated that the lower tail cohort had not well mastered these problem-solving skills, and misconceptions which could have been addressed earlier in the course were not rectified, and there was a high exam failure rate. In response to these observations, mastery quizzes were introduced to the course. These were used as formative assessment, worth only 10% of the total course marks.

Online mastery quizzes were created for each topic (5 in total), focusing on the key types of problems and required skills for solving them. Problems were non-trivial, and had a large range of parameters to ensure a very large question pool. Solutions entered included steps in the solution process, and interpretation questions, providing both scaffolding to the student as well as fair breakdown of solution marks for partial progress. After completing the quiz, the system provides an overview of the students' overall performance on each question, including the time taken to answer, and the difficulty level of each question. It provides valuable feedback to both students and the lecturer. Upon submission, they receive a report detailing questions, correct and incorrect answers, as well as feedback. This provides an opportunity for students to identify and learn from their mistakes. Multiple attempts (with new parameter values) enabled students to correct misunderstandings and reinforce learning (Marsh, Roediger, Bjork, and Bjork, 2007). Knowing that they can have multiple quiz attempts can also motivate students to engage in the course content, and allows student to try-fail-try again helping them seek a better understanding of the subject matter (Ross, Chase, Robbie, Oates, and Absalom, 2018).

To evaluate the effectiveness of the mastery quizzes, a comparison of final exam performance before and after implementation of Numbas mastery quizzes was evaluated. Qualitative feedback from students was also reviewed.

Analysis and Discussion

On-going Assignments

Correlations between uncontrolled (assignments) and controlled (final exam) summative assessment are presented herein, using data collected from the Gold Coast campus cohorts undertaking 3101ENG.

Prior to COVID (2018 and 2019), the negative correlation shows that the majority of students performed far better in assignments (clustered to the higher end), whereas their final exam marks were not as strong and very scattered (Figure 1 (a)). For paper-based assignments with a single set of variables for all students, academic integrity issues were of concern as no effective method is available for controlling plagiarism. As a result, the students' true understanding and ability in problem solving could not be accurately assessed.

During and post COVID (2020 to 2023) when online assignments were developed and implemented with Numbas, the correlation demonstrates a high level of disparity (Figure 1 (b)), implying that e-assessment is effective in reflecting the students' true performance with improved academic integrity control. Greater spread of data distribution reflects more separated ability and diversity of students, demonstrating better and more factual representation of performance. Again, negative correlation suggests that overall, the assignment marks were better than the final exam marks. This pattern can be attributed to several factors including but not limited to: (1) given the volume of content covered in this course, anxiety and a lack of confidence may decline students' ability to perform under time-constrained and stressful final exam conditions, (2) assignments typically are more interesting to students, given the time and resources available to achieve high marks.

In addition, assignment non-submission rate is also significantly decreased when e-assessment was introduced, from 8.5% in 2019 to below 5.7% in 2023.

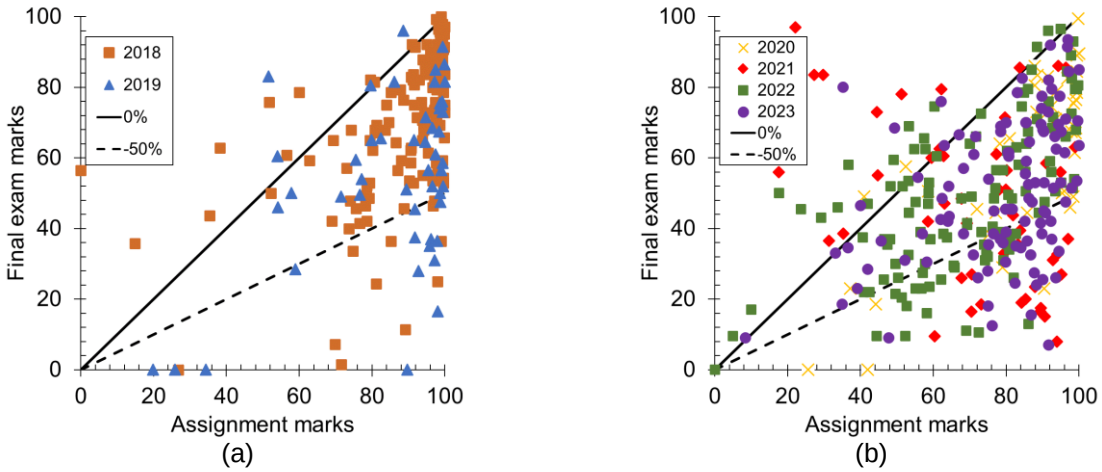
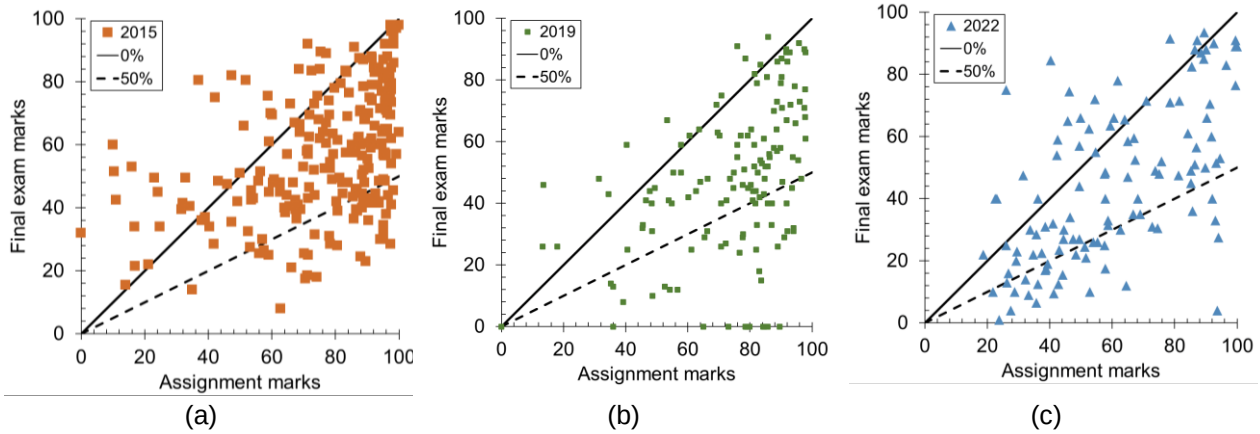


Figure 1: Disparity of uncontrolled-controlled assessment correlation: (a) prior to COVID, (b) during and post COVID in 3101ENG

Correlations between uncontrolled (assignments) and controlled (final exam) summative assessments for 2101ENG are presented in Figure 2, using data collected from the students undertaking the course in 2015 with paper-based assignments (Figure 2 (a)), in 2019 with the first-time introduction of Numbas (Figure 2 (b)), and in 2022 (Figure 2 (c)).

Figure 2 (a) shows the relationship between assignment marks and final exam marks using traditional paper-based assignments. The concentration of points towards the right-hand side indicates considerable inflation of assignment marks, relative to their performance on the final exam. This may indicate potential issues with plagiarism and consequently, accurate assessment of students' true understanding and problem-solving abilities was compromised.

With the introduction of Numbas assignments in 2019, there was a more even distribution and improved correlation between the final exam and assignments. This is particularly evident in the wider spread of marks, indicating a more aligned and coherent set of results in 2022.
Therefore, providing online problem-solving assignments with prompt feedback to students and controlling plagiarism becomes more feasible and valuable due to the enhanced correlation between their performance on assignments and the final exam.



(a) (b) (c)

Figure 2: Correlations between assignments and controlled final exam marks in 2101ENG: (a) 2015, (b) 2019, (c) 2022

Mastery Quizzes

To evaluate the effectiveness of introducing the mastery quizzes in the course 3304ENG, final examination marks were evaluated before and after the introduction of the quizzes. This final examination is held under controlled conditions, in-person, and assesses all theoretical topics addressed in the course. For fair comparison, 2020 and 2021 marks were not included, as these COVID-affected years had differently structured on-line exams.

Table 1 shows the in-person final examination marks for indicated years. In 2016, the course was opened to both mechanical and electrical disciplines, resulting in much high failure rates, due to the difference in background mathematical expertise of students taking the course. In 2019, master quizzes were introduced to address concerns over these high failure rates. When marking examination papers, it was observed that the answers to questions showed improved problem solving skills than had been seen in previous years.

Table 1: Final examination marks grouped by indicated percentage range

Year	≥85%	75-85%	65-75%	50-65%	45-50%	25-45%	<25%
2015	11.11%	14.14%	23.23%	22.22%	7.07%	19.19%	3.03%
2016	5.43%	11.96%	15.22%	27.17%	11.96%	25%	3.26%
2017	0.99%	3.96%	13.86%	41.58%	11.88%	22.77%	4.95%
2018	9.68%	13.98%	23.66%	18.28%	11.83%	19.35%	3.22%
Mastery quizzes introduced 2019							
2019	20.24%	21.43%	26.19%	20.24%	5.95%	2.38%	3.57%
2022	10.34%	22.41%	20.69%	17.24%	10.34%	15.52%	3.45%
2023	19.74%	17.11%	17.11%	28.95%	3.95%	10.53%	2.63%

Note: 2020 and 2021 did not have in-person final examination, and therefore have not been included due to the very different nature of the assessment item.

Figure 3 (a) shows the percentage of students who attempted the final examination and received less than 50% of that assessment item. In all years, the percentage of students with less than 25%, often representing those disengaged from learning, is quite similar. However, there is a considerable improvement in the failure rates of students achieving between 25 and 50% on the final examination from 2019 compared to 2016-2018 failure rates. It is noted that the 2022 cohort was the most affected by remote learning due to COVID with previous two years of study being largely on-line. As a result, a higher failure rate was seen in 2022 than in 2019 and 2023.

Figure 3 (b) shows the effect of the introduction of mastery quizzes on students with passing marks. Here we see a higher rate of students achieving greater than 75%, while similar numbers with 50-75%, indicating an improvement in the performance of passing students also.

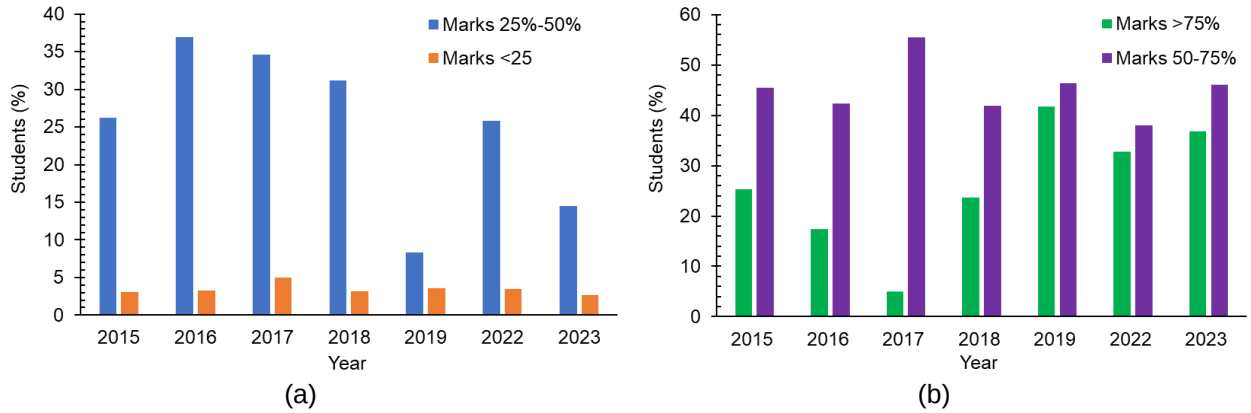


Figure 3: Percentage of students attempting final exam with failing and passing marks: (a) students achieving < 50% on the final examination; (b) students achieving ≥ 50% on the final examination.

Quantitative and Qualitative Evaluations

E-assessment was developed and introduced to 2101ENG in 2019, to 3101ENG in 2021, and to 3304ENG in 2019. An additional Student Evaluation of Course (SEC) survey question "*The course effectively used online assessment (e.g., quizzes) to help me learn*" was added to the quantitative summary to seek students' feedback (Table 2). The SEC scores for each course are shown to be consistently high, indicating that online assessments have positively assisted students in their learning. This is further backed by the qualitative responses from students, as given in Table 3.

Table 2: Quantitative Summary

	3101ENG (2022)	3101ENG (2023)	2101ENG (2023)	3304ENG (2023)
No. Response	10	13	39	26
Score	8 SA 80.0% 1 A 10.0% 0 N 0.0% 1 D 10.0% 0 SD 0.0%	7 SA 53.8% 3 A 23.1% 1 N 7.7% 1 D 7.7% 1 SD 7.7%	21 SA 53.8% 12 A 30.8% 4 N 10.3% 1 D 2.6% 1 SD 2.6%	14 SA 53.8% 8 A 30.8% 3 N 11.5% 0 D 0.0% 1 SD 3.8%
Mean	4.6	4.1	4.3	4.3

Note: 5pt Likert scale: SD - Strongly Disagree, D - Disagree, N - Neutral, A - Agree, SA - Strongly Agree

Table 3: Qualitative Response

The course effectively used online assessment (e.g., quizzes) to help me learn?
2101ENG*: "The quizzes and assignments were very helpful."; "Weekly quizzes and assignments engaged me in my learning and ensured that I did not fall behind on learning the content."; "The pacing of the quizzes and assignments really help you learn a lot of content in a nice formal way."; "The weekly quizzes and assignment to stay on top of the content."; "I think the way the online assessment was set out was smart and well spaced. It allowed up to rack up marks slowly and practice the subject matter regularly."; "The quizzes and assignments were very helpful.".*
3101ENG*: "Loved the assignments on Numbas, they were great practice and helped me develop my understanding the different topics."; "We received feedback on my online assignment every time. When we handed in our assignments, we immediately knew the mistakes in the assignment, which was very helpful for my review and examination."; "I enjoyed the Numbas set up as it was easy to follow and learn at the same time.".*
3304ENG*: "The fortnightly quizzes really helped consolidate my knowledge.", "I liked the layout of online quizzes to keep me engaged in current topics, I firmly believe this helped me more than I initially realised and I think they are a core part of learning in this course."; "Quizzes were a good way to make sure you are keeping up."; "The weekly quizzes helped me to better understand each topic with the use of multiple attempts.".*

Conclusion

Purposefully designed and well-structured online assessments (on-going assignments and/or mastery quizzes) using Numbas have been developed and implemented for three mathematically intensive engineering courses at Griffith University. Analysis results confirm that such a development has resulted in positive impact to students learning experience and outcomes, while facing the unprecedented challenges of COVID-19. The adoption of e-assessment has been effective in reflecting the students' true performance with improved academic integrity control. For structural and mechanics courses, correlations between online assignments and final exams demonstrate better and more factual representation of performance. For the control course, improved problem solving skills and improved performance of passing students have been achieved. In summary, e-assessment has led to improved learning, faster marking, immediate and timely feedback to students. Importantly, assessment for learning rather than just of learning (Boud, 2007) has been made possible. Further validation of these findings will be conducted using pre- and post-testing methods (Hake, 1998) as a matter of future work.

It should be recognised that although the Numbas platform has benefits for both lecturers and students in terms of auto marking and timely feedback, initial training and development of assessments are still a labour-intensive process. It not only needs carefully design and check the questions and answers based on a wide range of parameters which designed by lecturers, but also needs financial and technical support to assist the academic team (Hosseini and Koohi-Fayegh, 2021; Magalhães et al., 2020).

References

Allan, C. N., Campbell, C., & Crough, J. (Eds.). (2019). *Blended Learning Designs in STEM Higher Education*. Singapore: Springer.

Boardman, K. L., Vargas, S. A., Cotler, J. L., & Burshteyn, D. (2021). Effects of Emergency Online Learning during COVID-19 Pandemic on Student Performance and Connectedness. *Information Systems Education Journal, 19*(4), 23-36.

Bonham, S. W., Deardorff, D. L., & Beichner, R. J. (2003). Comparison of student performance using web and paper-based homework in college-level physics. *Journal of Research in Science Teaching, 40*(10), 1050-1071.

Boud, D. (2007). Reframing assessment as if learning were important. In D. Boud & N. Falchikov (Eds.), *Rethinking assessment in higher education* (pp. 24-36). London, UK: Routledge.

Carini, R. M., Kuh, G. D., & Klein, S. P. (2006). Student engagement and student learning: Testing the linkages. *Research in higher education, 47*, 1-32.

Carroll, T., Casey, D., Crowley, J., Mulchrone, K., & Shé, Á. N. (2017). Numbas as an engagement tool for first-year Business Studies students. *MSOR Connections, 15*(2), 42-50.

Cook, J., & Jenkins, V. (2010). Getting started with e-assessment. *University of Bath, Bath*.

Evans, C. (2020). Coronavirus (COVID-19) - Important update [Press release]. Retrieved from www.griffith.edu.au/coronavirus

Gok, T. (2011). Comparison of student performance using web-and paper-based homework in large enrollment introductory physics courses. *International Journal of the Physical Sciences, 6*(15), 3740-3746.

Hadjerrouit, S., & Nnagbo, C. I. (2022). Affordances and Constraints of the E-Assessment System Numbas: A Case Study in Mathematics Teacher Education. *International Association for Development of the Information Society*.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American journal of Physics, 66*(1), 64-74.

Hosseini, A., & Ferguson, C. (2022). *Benefits of Transitioning from Paper-Based to Online Assignments in Problem Solving Courses*. Paper presented at the Canadian Engineering Education Association (CEEA), Toronto, Canada.

Hosseini, A., & Koohi-Fayegh, S. (2021). *Engineering education in Canada in the wake of COVID-19 pandemic*. Paper presented at the Canadian Engineering Education Association (CEEA), Charlottetown, Canada.

Karpicke, J. D., & Blunt, J. R. (2011). Retrieval practice produces more learning than elaborative studying with concept mapping. *Science, 331*(6018), 772-775.

Klein, P., Ivanjek, L., Dahlkemper, M. N., Jeličić, K., Geyer, M.-A., Küchemann, S., & Susac, A. (2021). Studying physics during the COVID-19 pandemic: Student assessments of learning achievement, perceived effectiveness of online recitations, and online laboratories. *Physical review physics education research, 17*(1), 010117.

Krzic, M., & Brown, S. (2022). Question banks for effective online assessments in introductory science courses. *Natural Sciences Education, 51*(2).

Kuikka, M., Kitola, M., & Laakso, M.-J. (2014). Challenges when introducing electronic exam. *Research in Learning Technology, 22*.

Lapitan Jr, L. D., Tiangco, C. E., Sumalinog, D. A. G., Sabarillo, N. S., & Diaz, J. M. (2021). An effective blended online teaching and learning strategy during the COVID-19 pandemic. *Education for Chemical Engineers, 35*, 116-131.

Lentin, J., Jonsdottir, A. H., Stern, D., Mokua, V., & Stefansson, G. (2014). A mobile web for enhancing statistics and mathematics education. *arXiv preprint arXiv:1406.5004*.

Magalhães, P., Ferreira, D., Cunha, J., & Rosário, P. (2020). Online vs traditional homework: A systematic review on the benefits to students' performance. *Computers & Education, 152*, 103869.

Manea, V. I., Macavei, T., & Pribeanu, C. (2021). Perceived benefits of online lectures during the pandemic: A case study in engineering education. *Pro Edu International Journal of Educational Sciences, 3*(1), 35-41.

Marsh, E. J., Roediger, H. L., 3rd, Bjork, R. A., & Bjork, E. L. (2007). The memorial consequences of multiple-choice testing. *Psychonomic Bulletin & Review, 14*(2), 194-199.

Mestre, J., Hart, D. M., Rath, K. A., & Dufresne, R. (2002). The effect of web-based homework on test performance in large enrollment introductory physics courses. *Journal of computers in mathematics and science teaching, 21*(3), 229-251.

Numbas. (2021). Numbas, really versatile maths e-assessment. Retrieved from www.numbas.org.uk

Pearson, C., & Penna, N. (2022). Automated marking of longer computational questions in engineering subjects. *Assessment & Evaluation in Higher Education*, 1-11.

Queensland Government Department of Health. (2020). Queensland novel coronavirus (COVID-19) update [Press release]. Retrieved from https://www.health.qld.gov.au/news-events/doh-media-releases/releases/

Ross, B., Chase, A. M., Robbie, D., Oates, G., & Absalom, Y. (2018). Adaptive quizzes to increase motivation, engagement and learning outcomes in a first year accounting unit. *International Journal of Educational Technology in Higher Education, 15*(1), 1-14.

World Health Organization. (2020). Coronavirus disease (COVID-19) pandemic. Retrieved from https://www.who.int/emergencies/diseases/novel-coronavirus-2019

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