AN INNOVATIVE FRAMEWORK FOR ONLINE EXAMINATION IN A HIGHER EDUCATION SETTING: A RESPONSE TO THE COVID-19 CRISIS

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ABSTRACT

Adopting modern methods for delivering teaching has been a great topic area of research in Higher education (HE). With the advancement of information and communication technologies towards accomplishing various contemporary demands such as Industry 4.0, online-based education has been explored to a greater extent, however, they are still limited. More recently, due to the coronavirus disease (COVID-19) pandemic, online teaching and assessment have become unprecedentedly mandatory in many HE settings. However, with online technologies, there arise new issues and concerns that impact educational quality. In this paper, we focus on the challenges associated with electronic examinations or online exams in HE and the strategies to address them. Using a design-based research approach we design, implement, and evaluate an innovative framework for online exams within a context of an Australian HE mixed-sector. We conduct an exploratory study on the quality of the process flow of the proposed Online Exam for Bachelor of Information Technology (OEBIT) framework. A triangulation of both qualitative data from focus groups and quantitative data from student outcomes provides the validity of data and confirms the completeness of the results. The successful deployment of our generalized framework with a smooth transition from pen-paper-based examination to online exam during the COVID-19 pandemic demonstrates its real-life application.

Keywords: Online examination, design-based research, DBR, Higher Education, Focus Group, Moodle

Introduction

In Australia, tertiary education has been evolving with high-quality participation and unique structural transformations within both the higher education (HE) and vocational education training (VET) sectors since the Dawkins reforms during the 1980s (Richard, Sarah, and Paula 2017). Over the past decades, the HE sector predominantly formed by universities has established high international rankings (Norton and Cherastidtham 2018). Australia is a strong global competitor for onshore international students (Norton and Cherastidtham 2018). Following the 2008 Review of Australian Higher Education, HE and VET providers overlap with universities becoming dual sectors and many TAFE (technical and further education) institutes are becoming mixed-sectors offering a complementary range of both HE and VET programs (Bradley, et al. 2008) (Wheelahan Leesa, et al. 2012). Today, non-university higher education providers (NUHEPs) have become a significant part of Australian higher education (TEQSA 2019). However, all these NUHEPs need to comply with the same requirements of the TEQSA Threshold Standard regulated by the National Tertiary Education Quality and Standards Agency (TEQSA) since 2012 (TEQSA, Application Guide for Registration in any University Category: new providers, registered Higher Education Providers 2020). National universities in Australia are self-accredited, which means their Higher Education degrees are internally regulated. TEQSA only accredits the institutes. On the other hand, NUHEPs must comply with the requirements of the TEQSA Threshold standard regulated by TEQSA (TEQSA 2020), leaving them with several challenges in meeting the quality standards for HE (Harvey, et al. 2016) (Birmingham 2017). COVID-19 pandemic imposed further constraints and raised issues, requiring a rapid shift to online teaching and assessments. We focus on how the rapid shift from pen-and-paper-based exams to online examinations was successfully implemented in such a NUHEP context by adopting a design-based research (DBR) approach in proposing a practical framework.

In general, COVID-19 had posed additional challenges as the students were deprived of on-campus facilities for teaching and personalized academic support, and were the remote-online alternatives were constrained. The impact of remote-online delivery and student learning in HE programs can be further intensified with online assessments where cheating could be more feasible (Khitam 2019) (Bretag, et al. 2019). Students had become anxious about their final examination where online exams had replaced the more familiar and typical pen-and-paper-based exams. In this study, we first explore the challenges and strategies of building and delivering an online exam during the evolving COVID-19 pandemic faced by a NUHEP institute in Australia. We adopt a combination of qualitative and quantitative methods to study a NUHEP institute delivering both HE and VET programs where one of their challenges for online exams was the inability to access private proctor services that several universities took advantage of (Bradley, et al. 2008, Wheelahan Leesa, et al. 2012). This had led the institute to explore and implement remotely invigilated online exams. While several studies on online exams have been conducted in different countries for many years, they were not directly applicable due to the varying socio-economic, cultural, and structural HE

contexts in Australia. This formed the main motivation in this research work to propose and evaluate a framework for the design and development of online exams for a HE program such as Bachelor of Information Technology (BIT) in the NUHEP institute under this study. The focus of proposing a generalized framework is to preserve academic integrity and to evaluate using a triangulation of qualitative data of focus groups and quantitative data of student outcomes for the continuous improvement and validation of the online exam process.

The key contributions of the paper are threefold: i) firstly, we have explored the challenges faced by a mixed-sector higher education institution (NUHEP institute) during the COVID-19 crisis that is not yet commonly studied, ii) secondly, we have taken a systematic DBR approach in proposing and implementing an innovative Online Exam for the BIT, so we refer the framework as OEBIT framework and iii) thirdly, we have evaluated the outcomes of the OEBIT framework developed and applied within the NUHEP institute while it was going through a mid-semester complete shift to online delivery rapidly. Further, the generic and practical nature of the proposed OEBIT framework is of academic interest due to its generalisability and straightforward adaptability to other similar institutes.

The rest of the paper is organized as follows. Section 2 provides an overview of our research approach that adopts the DBR methodology for the development of the proposed OEBIT framework and the research questions. In Section 3, we describe the OEBIT framework in detail within the context of the NUHEP institute under study. Section 4 presents the evaluation of the OEBIT framework using the outcomes achieved by administering the research questions with a focus group. Finally, Section 5 provides conclusions of the study and future work. All abbreviations are listed in alphabetical order.

Literature Review

Summative assessments are a significant part of academic studies on all levels to evaluate student learning at the end of the instructional unit. Traditional summative assessments are predominantly pen and paper-based, closed-book, invigilated, and strictly time-constrained exams (Williams and Wong 2009).

Ana and Paul have developed an online examination system based on multiple-choice questions (Ana and Bukie 2013). In addition to the shortfalls of the multiple-choice questions as a strategy for summative evaluation, it does not work well for at-home un-proctored online exams. Therefore, there is a need to work on the design of the exam questions, in particular measuring the desired learning outcomes achieved by each student. Bengtsson (Bengtsson 2019) promoted take-home exams as an alternative to traditional exams. However, take-home exams are not recommended due to the huge risk of unethical student behavior. Multiple studies have investigated the use of Moodle quizzes as the formative assessment to improve the instructional design in higher education (Cohen and Sasson 2016). Researchers have studied user authentication as one element of online exams

like biometric techniques (Salameh and Shukur 2015) or artificial intelligence approaches to thwart online exam cheating (Alrubaish, et al. 2019) or automatic question bank generation to effectively assess the students (Awat and Ballera 2018). However, there is a lack of studies that have investigated and proposed all the elements of a comprehensive online examination framework i.e. question design, accessibility, communication, security, scalability, and invigilation.

DBR approach is similar to the action research approach and focuses on practical knowledge and solutions. It offers a collaborative approach that engages academics, researchers, administrators, and subject matter experts in the applied educational environment (McKenney and Reeves 2014). The approach provides a systematic evaluation of the effectiveness of educational artifacts. In the existing literature, most evaluations of educational artifacts are not strictly based on DBR and focus on IT techniques involved in online and mobile technology rather than on the evaluation of processes within a HE setting (Anderson and Shattuck 2012). DBR approach is used to design and develop interventions like learning environment design for productively engaging students (Chandan 2019), secondary school workshops on Artificial Intelligence (Estevez, Garate and Manuel Grana 2019), student feedback system (Chavan and Mitra 2019), or evaluation framework for an online training course for online instructors (Shattuck and Anderson 2013). Using DBR in the educational field is not a novel concept. However, it has not been applied as uniquely in this research work where the focus is to design and develop a process-based framework for online exams for summative assessments within an Australian HE mixed-sector context.

Recently, different digital platforms and online technologies are being used competitively to provide education reaching broader and wider geographical locations through blended learning. These advancements support educational institutes to expand and innovate their teaching activities to offer programs to students beyond the barriers and limitations of physical classrooms. In this context, enforcing educational quality by enforcing the integrity of student assessments is of paramount importance. Different system modeling and research studies to review the student learning and assessment activities have resulted in frameworks for educational decision support systems. In an online exam environment, authentication and managing security during conducting exams are of major concern. Thus, different types of challenges and prospects are been reviewed in (Raman, B, G, Vachharajani, & Nedungadi, 2021; Gamage, Silva, & Gunawardhana, 2020) and multiple discussions have been carried out focusing on the student adoption experience not only at a small scale but also at a large, multi-campus higher educational institution (Raman, B, G, Vachharajani, & Nedungadi, 2021). Different solutions are been proposed to make the online exam procedure secure and authentic. New technologies including blockchain-based online examination schemes and authentication have been proposed and implemented to promote academic integrity and to reduce academically dishonest behaviors (Gamage, Silva, & Gunawardhana, 2020; Zhu & Cao, 2021; Holden, Norris, & Kuhlmeier, 2021). Such approaches are of enormous benefit to the online education environment including our previous proposals for online exam adoption techniques (Fahd, Miah, Ahmed, Venkatraman, & Miao, 2021; Ngqondi, Maoneke, & Mauwa,

2021; Fahd, Venkatraman, Miah, & Ahmed, 2021). This paper advances the research in this direction further in proposing the OEBIT framework.

Methodology

We adopt the DBR approach for our research that focuses on developing, evaluating, and reflecting the OEBIT framework for the design and delivery of online exams. In educational research, there is often a gap between the educational research theory and the practice of teaching. DBR approach, an emerging methodology in the educational sector, addresses the gap by aligning the educational pedagogy with the education practice. DBR allows continuous improvement of the educational assessment framework by comparing practices and outcomes through the iterative process of design, evaluation, and redesign. DBR approach focuses on understating and detailing how and why the designed artifact works practically instead of only examining the working of the artifact (Research Collective Design-Based 2003), which was required in this study.

From various literature, we find that DBR is also known as design experiments, design research, and educational design research (Brown 1992) (Collins, Joseph and Bielaczyc 2004) (Mckenney and Reeves 2013). DBR has become increasingly popular in research in the field of education as it is considered as a research methodology designed 'by and for' educators. DBR is defined as "a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings and leading to contextually-sensitive design principles and theories". (Wang and Hannafin 2005)

DBR focuses on purpose-built design experiments to enhance educational practices and resolve educational problems by bridging the gap between theory and practice (Cobb, et al. 2003). In practice, researchers work together with academics to identify educational context problems and solve that real problem using the DBR research approach. DBR approach uses the term 'artifact' to denote the object, activity, or process that is an outcome of the research as a potential solution to address the identified problem.

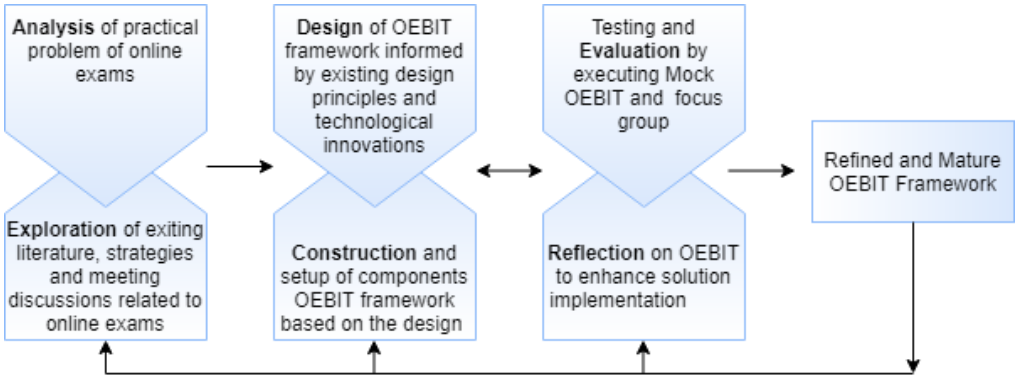


Figure 1: GMDR 3-phased model of DBR Approach for the OEBIT Framework

DBR approach emphasizes the iterative phases of the study analysis, design and development, implementation, and evaluation. To clearly show how this study was positioned within the phases of the DBR approach, it is beneficial to use the 3-phase DBR model the Generic Model for Design Research (GMDR) (Mckenney & Reeves, 2013).

GMDR consists of three main phases adopted for the study as follows:

1. Analysis and exploration – Analysis of problem, explore the options, and set the goal
2. Design and construction – an iterative cycle of design and solution development to reflect the evaluation process.
3. Evaluation and reflection – an iterative cycle of testing, evaluating, refining the solution and reflection by focus group

In this study, the first analysis and exploration phase of GMDR is achieved by: conducting a preliminary literature review; combining findings iteratively to facilitate decision making by key personnel from the teaching team; and collecting other strategies used by other higher education institutions as options to consider. The second phase of GMDR is adopted for the design and construction of the OEBIT framework for the development of an online practice exam using Moodle quiz facility that served as a prototype. The third phase of GMDR is employed to critically review the results of the online practice exam to refine the procedure of the OEBIT framework towards developing and administering the actual online exam for BIT students in the NUHEP institute of the study. Table 1 briefly outlines how the OEBIT framework is developed by mapping with the iterations of the three phases of the GMDR**.** We also give importance to the final reflection of the OEBIT framework using the single focus group. The participants of the focus group, experts in their fields, are selected based on their extensive research expertise in the field of teaching and learning and real-life experience with different educational systems. The participants of the focus group formed the discussion panel and are also the co-authors of the article. The responses to research questions were administrated by email and online focus group meetings with a clear explanation of the research goal.

The quantitative evaluation is performed on data based on student outcomes i.e. final exams results and attendance. This study has used the probability sampling method where it has given 100% eligible individuals samples as the chance of being chosen for the sample. This study used a heuristic research approach of relying on experts' responses to the research questions which allow achieving a certain degree of reliability and validity as mentioned by (Rapanta, Botturi, Goodyear, Guàrdia, & Koole, 2020). The findings of the study were shared with the focus group participants to validate the findings, called respondent validation adopted from (Nyumba, Wilson, Derrick, & Mukherjee, 2018). Compliance with the policies and procedures ensures the validity and reliability of data across the institute. The reliability and validity of the quantitative data are demonstrated by using the same parameters while comparing the data from different semesters in 2020. Furthermore,

qualitative and quantitative methods triangulation removes the bias and confirms the validity of the results.

The main aim of this research study is to develop, implement and evaluate an innovative OEBIT framework at a NUHEP institute during the COVID-19 crisis. The OEBIT framework is developed to be sufficiently generic that it is adaptable within other contexts of mixed-sector higher education institutions. The research questions considered for this study are:

1. Does the OEBIT framework meet the lecturer and student expectations?
2. Are the OEBIT framework processes sufficient to maintain academic integrity?
3. Does the OEBIT framework impact the design of an exam paper?

Table 1: Mapping of GMDR Phases in Developing the OEBIT framework

Analysis and exploration	Design and construction	Evaluation and reflection
1. Literature review on online exams and challenges. 2. Analyse online exam strategies used by other higher education institutions. 3. Feedback through iterative meetings with key personnel from the administration, management, and teaching teams.	1. Develop a checklist to assure quality and consistency across all online exams 2. Design and setup the online practice exam process 3. Develop and design online practice exams for BIT subjects 4. Apply the OEBIT framework for online practice exams. 5. Use evaluation feedback to make iterative improvements to the design of the final exam. 6. Develop a final online exam following the quality checklist. 7. Design and setup the final online exam process attributes. 8. Develop online exams audited by moderators 9. Apply the OEBIT framework for the final online exam processes.	1. Evaluate the OEBIT framework by adopting it for the online practice exam processes. 2. Conduct statistical analysis of student attendance and performance of the online exam 3. Reflections on the OEBIT framework by the focus group to make ongoing improvement for future online exams

Proposed OEBIT Framework

A traditional pen-paper examination is a summative assessment that is time-constrained and considered as a key determinant of assessing student knowledge and achievement of key learning outcomes of the subject (Venkatraman, 2007). The OEBIT framework is aimed at replacing the traditional pen-and-paper examination process. The OEBIT framework prescribes the management of the remote online examinations to ensure that the quality of the summative assessment adheres to academic policies and standards. The OEBIT is a generalized framework that can be used by other academic institutes for conducting remote online exams.

We describe the methods adopted to develop our proposed generalized OEBIT framework in a NUHEP institute's educational setting for implementing remote online exams. Firstly, the factors considered for developing the framework are listed below:

- Using a familiar Learning Management System (LMS) environment to provide the required security for students and lecturers
- Flexibility in catering to the needs of each subject uniquely
- Enforcing control procedures and quality standards
- Adhering to audit checks
- Enhancing robustness via process flow communications among key components of the framework

The critical components of the OEBIT framework include platform selection, exam structure, exam generation, communication, and proctoring as shown in Figure 2. Some notable features of these components include: making use of Moodle LMS facilities for delivering random question variations, shuffling questions, facilitating students for file uploads, and providing Zoom integration; generating exams that minimize plagiarism by assessing "why" rather than "what"; running practice exams to create familiarity of the online environment for students, provide students an opportunity to check their computer/camera configuration requirements; provide teachers with a test run and an opportunity to improve from any unforeseen pitfalls; running a focus group for sharing ideas and responsibilities; and the setting of proctoring rules such as the creation of small Zoom invigilation groups.

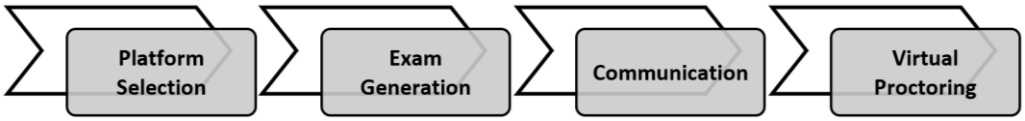


Figure 2: Critical Components of Proposed OEBIT framework

Alruwais et al (Alruwais, Wills, & Wald, 2018) identified the benefits and detriments of having an online assessment from the point of view of educational aims and of different stakeholder entities, including lecturer, student, and institution. In our OEBIT framework, we have not only identified the challenges but also their respective solutions to include the point of view of 5 key stakeholder entities much more comprehensively: lecturer, LMS, student, auditor, and invigilator. Their roles and responsibilities in the OEBIT framework are summarised in Figure 3.

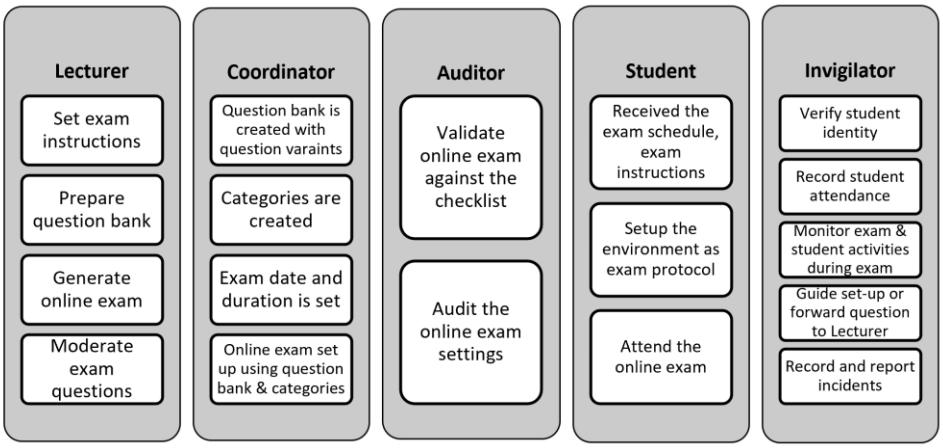


Figure 3: Stakeholder Roles and Responsibilities in OEBIT framework

The Moodle LMS is an existing learning environment familiar to all educators and students of the NUHEP institute and its Quiz facility is employed for developing online exams using the OEBIT framework. Each BIT subject's online exam is embedded in each subject's Moodle shell so only enrolled students of the subject could have access to that exam. To undergo their online exams, the students are required to log in to Moodle with their username and password. After logging in, the students are required to select the scheduled Moodle shell to open the exam link. Students would then proceed to answer the questions one by one in a sequence. Alternately, they could select the question number to answer a particular question directly. When students finish answering the questions, they would click on a submit button to complete their online exam. Invigilators validate the exam submission of the student by verifying through the live student participation link of each exam. Based on the NUHEP context, we considered six out of the eight standards commonly used Online Exam Control Procedures (OECPs) from (Cluskey, Ehlen, & Raiborn, 2011) and these are presented in Figure 4.

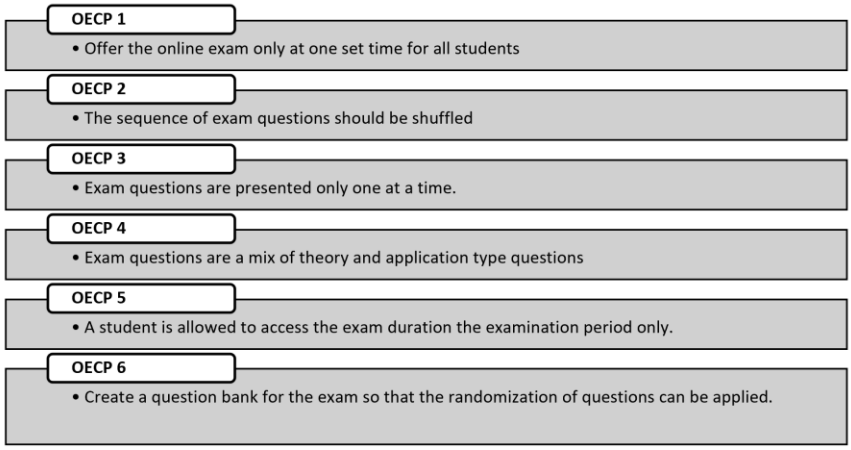


Figure 4: Essential OECPs of the OEBIT framework (adapted from *(Cluskey, Ehlen, & Raiborn, 2011)*)

Each online exam based on the OEBIT framework is designed as essay-style Moodle questions that could be attempted only once and completed within a limited period of typically between 2-3 hours as prescribed in the respective Subject Outline. In certain subjects that require students to upload documents as a part of their answer, the exam length would include an additional 30 minutes for uploading their documents during which the students are not allowed to answer questions. All exams are also provided with additional fifteen minutes of reading time. For example, for a 2.5 hour (150 minutes) exam with no documents to upload and that had a start time of 9:15, Moodle timer settings would be set to open at 9:00 am and close at 11:45 am (165 minutes). If that exam required document uploads, the closing time would be set to 12:15 pm (195-minute duration). Students are prohibited from working on their answers during reading time and uploading time which is monitored by the invigilator.

The configuration of each exam setup in Moodle open is flexible to cater to different requirements of the BIT subjects and the "Time Limit" setting determines how long the student is allowed to interact with the exam. This helps the students to be conscious of the time remaining as Moodle displays a countdown clock. Figure 5 illustrates the different configuration setting parameters of a Moodle Quiz based on different BIT subjects' online exam requirements.

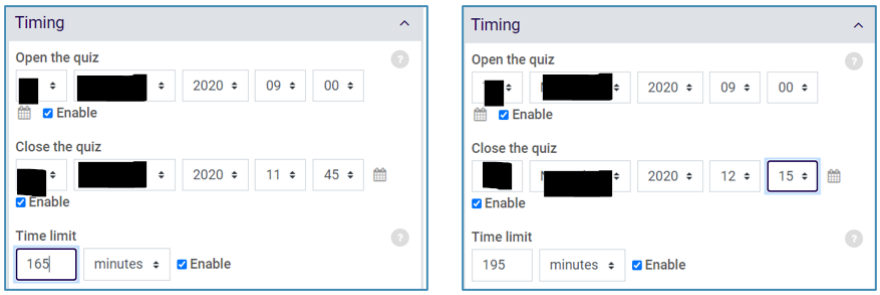


Figure 5: Examples of different Moodle exam configuration settings

As required by the NUHEP institute, the OEBIT framework could cater to unrestricted open book online exams. The framework has processes to check if the design of questions mitigates the ability to answer questions from internet sources. Moodle's configuration to shuffle questions from a minimum of four variants to each question is useful to minimize collusion as each student would get a different exam paper. The design of questions within a question bank is audited and moderated for quality and accuracy.

The OEBIT framework included the preparation of online examination and subject matter with a practice remote-online exam. It is crucial to communicate the format of the examination and details with the students in advance to allow students to clarify any doubts about the exam process. Practice exams are considered a valuable revision strategy by familiarising students with the examination online environment and timing requirements. It is intended that the practice examination boosts confidence and reduces exam anxiety. The preparation and delivery of practice exams also helped in testing and refining the OEBIT framework. The OEBIT framework caters to various communication processes with students via email and SMS related to the exam schedule, exam instructions, online exam protocol, and a detailed set of instructions on how to set up and participate in online exams.

The authors (Prince, Fulton, & Garsombke, 2009) recommended proctoring as the best practice for online exams and the non-accessibility of such professional proctoring tools forms one of the greatest challenges for the OEBIT framework in the NUHEP institute. Though invigilated examinations are generally preferred for course accreditation committees and regulatory bodies, in the Australian context there is no such mandatory requirement for online invigilated exams (Bearman, Dawson, O'Donnell, Tai, & Jorre de St Jorre, 2020; Butler-Henderson & Crawford, 2020; Dawson, 2021). However, adhering to quality assurance and to mitigate academic integrity breaches, the OEBIT framework recommends a separate invigilated Zoom session for every 15-20 students undergoing an online exam. An invigilator was responsible for just one Zoom session to properly manage student authentication and monitoring of the camera view of the student. The invigilation process steps designed in the OEBIT framework are shown in Figure 6.

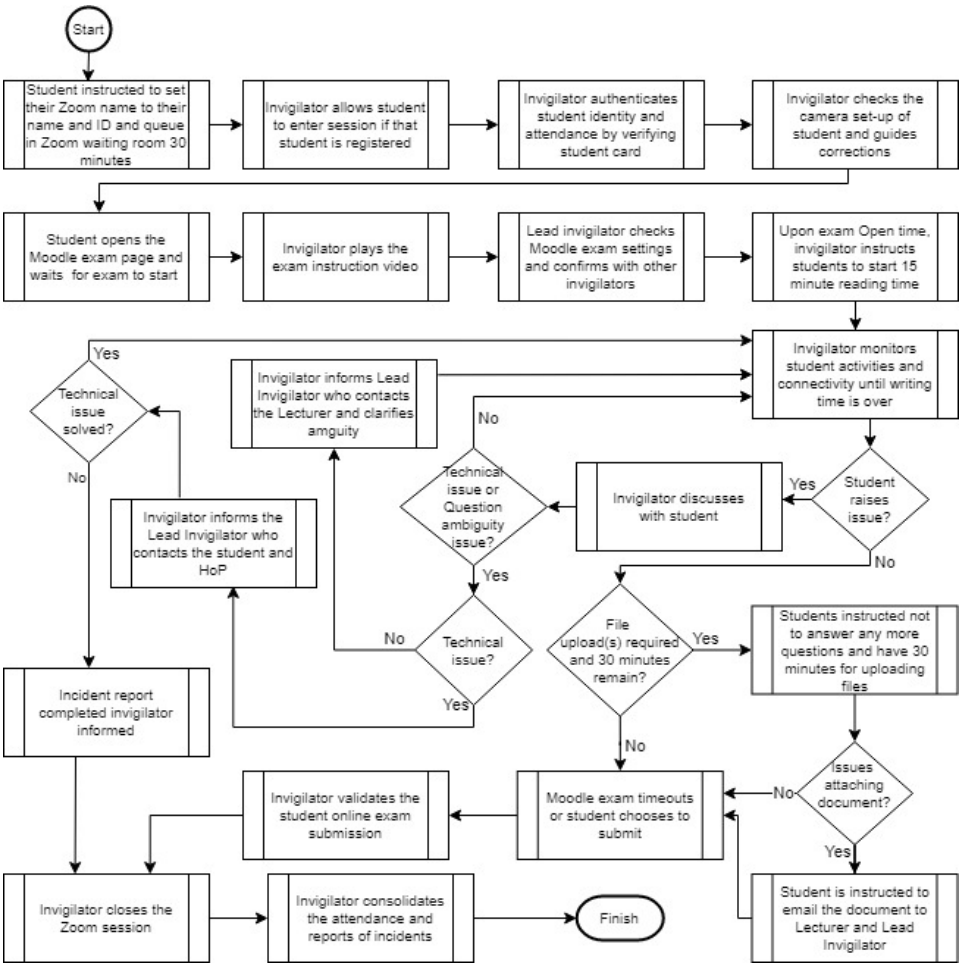


Figure 6: Online exam Invigilation process workflow

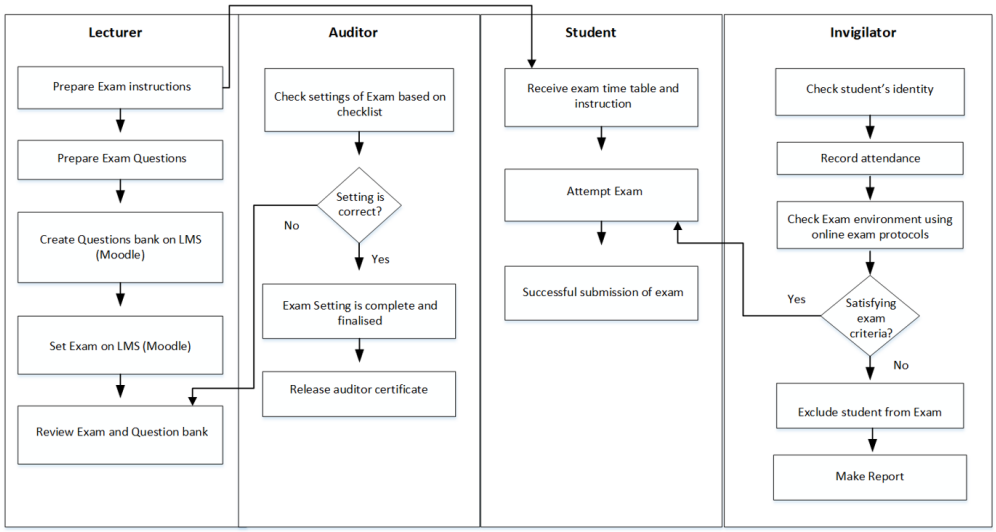


Figure 7: The OEBIT framework workflow

The invigilator performs an identity-check of the student to ensure that the right student is attempting the exam. Students are required to set up their camera to show a side-view that captured themselves and their computer monitor, keyboard, and mouse. Students could inform invigilators about technical issues and could ask invigilators to seek clarification on exam questions from their Lecturers. Students could attend the online exam at home or, if they do not have access to reliable internet at home, from the campus exam venue under the supervision of an on-campus invigilator. Figure 7 shows the interactions between each workflow process of the OEBIT framework for each stakeholder.

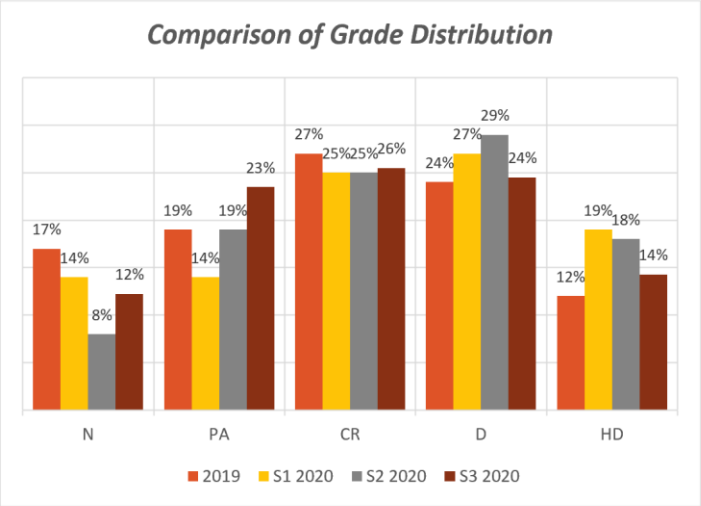
This study collected qualitative feedback from the BIT focus group to discuss the effectiveness of the OEBIT framework based on the research questions. The responses of the focus group were useful to analyze the OEBIT processes and to implement improvements subsequently.

Research Findings and Discussion

The application of our OEBIT framework in a NUHEP institute to design and deliver online exams in 2020 during the COVID-19 pandemic was evaluated. The institute had conducted pen-paper-based traditional exams until 2019. The effectiveness of the OEBIT framework was assessed by comparing the outcomes of the online exam versus the pen-paper-based traditional exam. The outcomes were measured based on three indicators: (i) Grade distribution, (ii) Student overall performance, and (iii) Student attendance. The findings of our comparative study are presented below.

Figure 8 shows an overall outcome achieved in 2020 online exams using the OEBIT framework as compared to paper-based exams held for the same subjects in 2019 without the introduction of the framework. Firstly, we observe a well-defined indication that there was a reduction in the failures

(N grade) by 3% with OEBIT adoption in Semester 1 2020, which was further reduced in Semester 2 2020 by 6%. The failure rate slightly increased by 4% in Semester 3 2020, however, more students were able to achieve higher grades in both semesters in 2020. In Semester 1 2020, HD-High Distinction improved by 7% and D-Distinction improved by 3%). The grade distribution displays a much more desired "bell curve" as demonstrated in Figure 8. In Semester 2 2020, the percentage of the higher grades was mostly maintained at par with levels achieved in Semester 1 2020. The major improvement is demonstrated by a good decrease in the failures (N grade) achieved from 17% in 2019 down to 14% in Semester 1 2020 and further reduced to 8% in Semester 2 2020. These results justify that the use of iterative development of the DBR approach in the continuous update of the framework processes has been effective.



HD	80–100
D	70–79
C	60–69
P	50–59
N	0–49

Figure 8: Comparison of Grade distribution

From these measures, there were clear indications that the OEBIT framework had helped to establish similar student outcomes, and comparing the results obtained in the online exam showed even better overall performance than the paper-based exams. The other distinct indication was that students' attendance in the online examination was higher in comparison to previous semesters by 2% in Semester 1 2020 and by 4% in Semester 2 2020 and S3 2020 as shown in Figure 9.

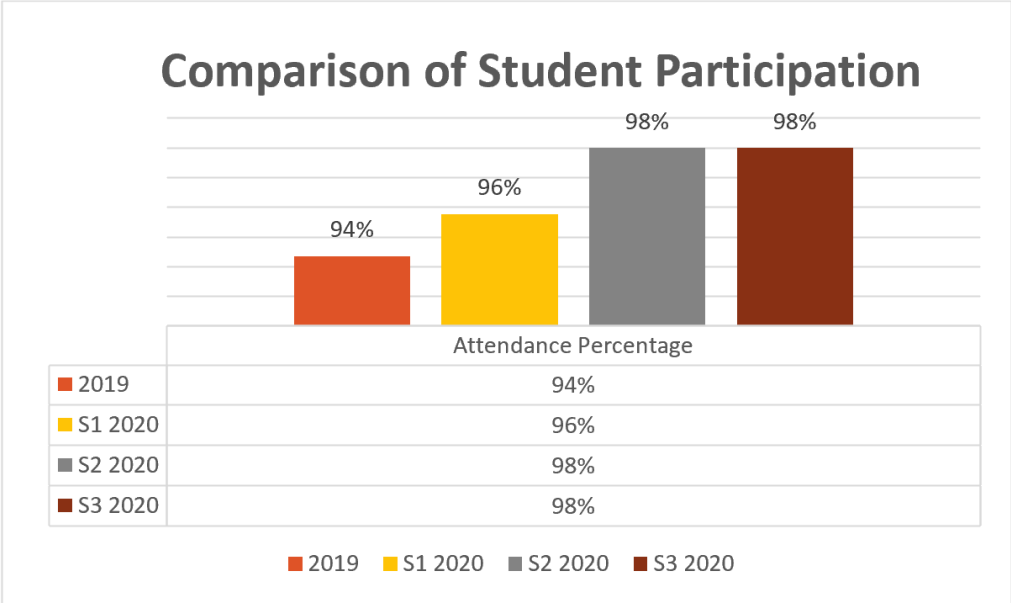


Figure 9: Comparison of student overall attendance

While the abovementioned quantitative indicators show promising improvements in student outcomes with the adoption of the OEBIT framework, we acknowledge that there are more quality factors to be explored to address the research questions. In particular, academic integrity has been reported in the literature as one of the inherent drawbacks of online exams without having professional proctor tools in place. This is also tied in with the design of the questions as they were modified in the OEBIT framework to cater to online unrestricted open book exams. The exam questions were modified to be case studies based on more of assessing higher-order learning skills demonstrated by students. This required to shift the lecturer and student expectations based on the practices that were followed in previous years in traditional exams without the OEBIT framework. Despite efforts taken by Lecturers to re-design exam questions, academic integrity issues that arise with the use of technologies such as smartphones and online search engines were not 100% avoidable in online exams. Lecturers were aware of this, and careful checks and penalties were imposed when there were some traces of answers with copy and paste from the internet or other sources, especially due to a poor question design in certain online exams. Another difficulty was that technical issues at the student end had created delays and some decisions to be made on the fly leading to some confusion among different invigilators on certain exam days. These problems were resolved immediately using the comprehensive invigilation process of our OEBIT framework. Overall, such hiccups during online exam invigilation had not created major issues, and certainly, they were not more than the several issues that were commonly faced during paper-based exams. In general, we observe that the OEBIT framework had helped various stakeholders to think through deeply their roles and responsibilities using the communication processes adopted.

In summary, it has been demonstrated that the proposed OEBIT framework provides an efficient method for online exam design, delivery, and student learning assessment. One of the major outcomes of this research study is the generalization of the majority of components of the OEBIT framework so it can be adopted by other educational providers to prepare and execute remote online exams with minor adaptation to their educational environment. We observe that student outcomes were comparable to the previous year and that students found the online exam experience a positive one. Most students benefited from no or limited traveling time on the examination day. The focus group felt students were appreciative that the mix of questions better tested deep learning of the subject matter with many focus group members able to recall conversations with positive comments from students received, including the enhanced preparation with the online practice examination. These observations were further verified with the focus group study outlined below.

Results of the Focus Group Study

The design, implementation, and execution of the remote-online exam by employing the OEBIT framework were enhanced through the review of the same processes that were adopted in the online practice exam iteratively according to the GMDR model of the DBR approach. The online practice exam served the purpose of the review and prototype stage of the Design-based research methodology. Focus group discussions on the online practice exam had also facilitated the refinement of our OEBIT framework. Finally, after the application of the OEBIT framework for the final online exam, feedback from the focus group was obtained relating to the three research questions asked. Table 2 gives a summary of common themes and findings that emerged from the set of responses obtained from the focus group that was aligned to the research questions.

Table 2: Summary of focus group responses aligned to the research questions

Research Question 1	*Does the OEBIT framework meet the lecturer and student expectations?*
The focus group provided informal qualitative feedback from other lecturers and students in the OEBIT framework meeting their expectations. From the viewpoint of lecturers, the OEBIT framework had well-defined processes and a comprehensive checklist for various audits performed during the entire online exam development. It was a shared opinion that the OEBIT framework established a uniform standard set of processes that had minimized any potential issues with online exam delivery. The group believed that with an OEBIT framework in place, the stakeholders had felt assured that a quick rescheduling of a remote-online exam was possible in any worst-case scenario. There were clear benefits shared concerning fewer resources required due to the non-requirement of certain traditional processes such as printing, securing, setting up the examination venue, and timetabling of rooms. Lecturers' expectations related to academic quality were also discussed and agreed to have been achieved by the OEBIT framework with the use of the plagiarism detection	

process and the moderation process. Some lectures argued that creating and marking online exams were slower than pen-and-paper exams, although it was quite a debated topic. However, during the development of the OEBIT framework using iterative development of the DBR approach, continuous updates to the framework processes required a champion to lead the process and the focus group agreed that there was a lack of clarity in this aspect.

Concerns were raised about students who could cheat that can get undetected during the online exam. Other common concerns were about the security of remote-online exams that could be subject to cyberattacks. Legitimate concerns were also raised about disadvantaging students who were subject to obstacles outside their control such as poor internet connections, technical computer issues (e.g., slow computer), taking the exam in their car due to lack of uninterrupted environment in their shared accommodation, or deprived family circumstances. However, it was also noted that the remote-online examination had higher participation than the traditional examination indicating that these concerns did not surface much during the exams.

Most students had the minimum devices with required specifications for smooth conduct of online exams such as two webcams, microphones, web browser, computer/laptop, and reliable internet connection. The students who could not demonstrate that they had the minimum devices in the practice exams were instructed to complete their actual examination in the institute's computer laboratories or library facilities. Furthermore, the online exams for many units required answering questions by typing text only. This minimized the technical requirements for students and the related online technical issues. However, five exams required hand-written answers such as drawing diagrams or the use of mathematical symbols. This required the students to take photos of their written work and upload them. We believe that this had resulted in additional stress on the student's ability to answer the question. However, it was mentioned by the focus group that the practice examinations helped to overcome this issue to a great extent as the students were quite well-prepared for this scenario.

Research Question 2	*Are the OEBIT framework processes sufficient to maintain academic integrity?*

It was a common understanding of the focus group that the risk of plagiarism and cheating could never be eliminated, whether the exam took place face-to-face or online. Using the OEBIT framework, several techniques were employed to minimize the risks including the preferred use of case study-based questions over theory-based questions so that answers could not be found on the internet. With the setting of four variations for each question which Moodle could deliver randomly, a unique exam paper was automatically generated for each student. Further, Invigilators were able to monitor every student during online exams through Zoom sessions, especially because it was limited to only 20 students allocated to each online Zoom room. With verified

student identification and two cameras to monitor both the students' online computer monitor and their hands/face, the academic integrity issue was well-managed using virtual proctoring and checks.	
Research Question 3	*Does the OEBIT framework impact the design of an exam paper?*
All remote-online questions were problem-solving questions that required applied knowledge, opinions, and insight. Theory-based descriptive and definition/recall-based questions were not considered to be appropriate for open-book remote-online examination. The design of each exam paper was discussed by the focus group and reached a common understanding that the best type of questions were those that were designed based on a scenario or case study. Questions in first-year subjects' exams were designed for students to demonstrate their understanding, insight, or appropriate application of fundamental theory. Questions for second-year subjects tested students' ability to analyze and demonstrate deeper insights on the topics and their applications. For third-year subjects, the questions were designed to test that students could analyze real-life situations leading to conclusions, as well as generate new ideas and opinions. However, lecturers expressed concerns that not all the learning outcomes would be appropriately tested if all questions were designed in this manner. For instance, mathematics-based topics required hand-written answers that were uploaded, and this could not be avoided to cater to the key learning outcomes of such subjects.	

Implication and Recommendations

Educators take utmost responsibility for continuous improvements based on lessons learned and knowledge sharing of best practices. Based on the feedback collected by the focus group, we have examined the strategies to improve and recommend the key processes of the OEBIT framework for a successful deployment of online exams in any other similar educational setting. Table 3 summarises the recommendations through lessons learned during certain key processes identified in the OEBIT framework.

Table 3: Recommendations of key processes in OEBIT Framework

OEBIT Processes	Recommendations through Lessons Learned
Designing Practice Exam	Create a practice exam that allows students to become familiar with the mandatory protocols they are required to comply with during the actual remote-online examination. The practice examination prepares the student for the structure of the exam, the nature of the exam questions, and the invigilation process and protocols.

Designing Final Exam	Additional support staff or professional development of existing staff will help the team to improve their skills in online exam design and process. Identifying each examination requirement much earlier would lead to better management/invigilation of remote-online exams It is beneficial to create an exam bank of case studies and practice-based questions to train students in demonstrating their ability to apply concepts, techniques, and skills. Avoid multipart questions in one question on a page to avoid the student from missing to answer sub-question(s). Avoid questions that refer to or flow from questions on the previous page. Group related questions into sections for students' better understanding. Randomizing questions minimizes the probability of students sharing answers
Exam Duration Setting	Reading time is a significant element of the online exam. It allows the student to settle in with the online exam environment and mentally get prepared and focus on answering the online exam. If the subject has special requirements such as document uploads of answers, they must be indicated in instructions, and where necessary additional time requires to be allocated in the exam duration for smooth invigilation of such online exams.
Security and Authenticity Checking	Moodle LMS-based exam provides secure and authentic user access and appropriate user access rights for audit checks and monitoring are essential. Invigilation through Zoom and cameras gives legitimacy to the online exam process.
Quality Checklist and Testing	An online exam quality checklist serves as a standard process that ensures consistency and enhanced accuracy. The practice exam supports the testing and evaluation to improve or fix any inaccuracies or inconsistencies in the online exam setup.
Communication	Communicating about the remote-online examination requirements and setup before the actual remote-online examination plays an important role. Communicating about the exam duration and structure to the invigilators and students just before their exams alleviates anxiety and stress during the actual exam. Communication to students about the alternative arrangements to replace situations due to any technical hitches of the remote-online exam is essential. Assign dedicated staff as the contact person for students prior, during, and after the remote-online examination as this will allow students to raise issues that can then be resolved quickly.

This study focused on the significance of online exams in the HE sector and how the process of design and administering online exams can be further improved using the DBR methodology. With the current COVID situation, when remote online exam writing by students became mandatory and HE was unprepared with the processes, not many HE providers followed a systemic methodology. When the COVID outbreak occurred, HE providers had scrambled in the middle of the semester to remote learning. Many faculties had to rethink their assessments including exams on the fly. Some HE providers could use exam proctoring services while other institutions explored non-proctored alternatives due to primary constraints of affordability and timely administration. In our study, we have designed, developed, and conducted exams using an innovative online exam framework by applying DBR along with our in-house learning management system based on good practices and assessment theories *(Dawson, 2021) (Bearman, Dawson, O'Donnell, Tai, & Jorre de St Jorre, 2020)*. An online exam is not a novel concept, however, it became an essential assessment method due to COVID lockdowns and distancing requirements without following a systematic analysis and review. Studies have already indicated that most students prefer online exams instead of traditional exams since online exams present a range of benefits for the students *(Butler-Henderson & Crawford, 2020)*. For example, students prefer to type their answers instead of handwriting them and to attempt exams from their familiar home environment without having to travel to the exam venue. However, our research is unique in focussing on the design and delivery processes of online exams that paves way for continuous improvement. Our proposed online exam framework is innovative and the first of its kind as it follows a DBR based iterative design and evaluation methodology. We studied the usefulness and impact of online exams from various stakeholder perspectives that have not been explored before. Furthermore, we claim that we promoted a new application of the DBR methodology that provides a well-fit approach in supporting the continuous improvement process to enhance quality due to its iterative nature of interventions. Further, the qualitative study using focus groups complemented the quantitative study of student outcomes providing completeness of the evaluation of our proposed OEBIT framework. Using such triangulations, we have addressed any threats to reliability, validity, and bias in results that can be associated with our methods, processes, and data collection. We demonstrated that the generalized framework was workable through this study. We have provided sufficient motivation for other HE programs and institutes to apply the framework in their settings effectively.

Conclusions and Future Work

This paper presented several challenges and constraints experienced while conducting a remote-online examination in a higher education institution's unique context during the COVID-19 crisis. With these constraints as inputs, we employed design-based research (DBR) approach to formulating an online exam for the Bachelor of Information Technology (OEBIT) framework. Our proposed framework underwent a holistic systemic approach to design, develop, and administer remote-online examinations in the institute successfully. We developed useful artifacts and

workflows for various processes that resulted in positive outcomes of the OEBIT framework through continuous improvements achieved in student attendance, classroom engagement, and overall results. These outcomes have demonstrated the effectiveness of the DBR approach in our proposed generalized OEBIT framework. Further, we evaluated the application of the OEBIT framework for its generic features in its adaptability to other similar contexts. We employed a focus group study using 3 key research questions and the findings have led to recommendations and best practice guidelines. The triangulation of quantitative and qualitative methods confirmed the validity and reliability of the results obtained.

Future work will consider improvements in the OEBIT framework based on the recommendations made and the best practices gained from other similar institution settings. We would also consider enhanced technologies such as screen lockdowns and software/hardware control that can be used through Moodle's exam browser. We believe the use of multiple cameras and specific software packages such as Mathematical formulas embedded in the LMS environment and other tools that could be integrated into one single software platform would benefit higher education settings to reduce cheating and enhance academic integrity in online exams. In addition, future research will consider the introduction of professional training and scaffolding for various stakeholders as they play a vital role to overcome the issues identified during the invigilation process of the online exams. Future research would focus on improving our proposed OEBIT framework to ensure adaptability in other similar situations for designing, developing, and administering online exams. A comprehensive evaluation of the effectiveness and efficiency of our approach will also be conducted.

Appendix A - Abbreviations List

All abbreviations are listed in alphabetical order.

	Abbreviation	Explanation
1.	HE	Higher Education
2.	BIT	Bachelor of Information Technology
3.	COVID-19	Coronavirus Disease
4.	DBR	Design-Based research
5.	GMDR	Generic Model for Design Research
6.	LMS	Learning Management System
7.	NUHEP	Non-University Higher Education Provider
8.	OEBIT	Online Exam for Bachelor of Information Technology
9.	OECP	Online Exam Control Procedures
10.	TAFE	Technical And Further Education
11.	TEQSA	Tertiary Education Quality and Standards Agency

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