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Lessons learned from implementing remotely invigilated online exams

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Abstract
This paper outlines the key issues of remotely invigilated online exams (RIOEs) and presents ways to avoid and resolve the issues for educators who are considering implementing them. The purpose of this paper is to share the lessons learned during the process of implementing and evaluating RIOEs and highlight the key considerations required to conduct RIOEs more seamlessly, whilst minimising students' cognitive load. With the continued growth, and future importance of online tertiary education, this paper provides an important contribution to the understanding of the best methods and practices by which to conduct online examinations and provides a foundation for continued research and enhancement of effective RIOEs.

The paper follows an extensive Action Learning process to develop and present a case study that was conducted across nine fully online business courses in a start-up venture for the University of South Australia. Cognitive load theory underpins the case study, which enabled the researchers to gain profound understanding into the RIOE process, identify issues and offer resolutions. RIOEs require more systematic and effective design compared to traditional paper-based exams and should be supplemented by early and clear communication with students. Educators should enable and encourage students to rehearse the exam service access procedures prior to their exams and students should be provided with real-time responsive technical support for any ad hoc issues that may present during the exam. These factors play a critical role in ensuring the successful implementation of RIOEs.

Keywords
exam invigilation, exam proctoring, digital exam, online exam, computer-based exam, electronic exam, e-Exam, e-Assessment, authentic assessment, online testing, exam design, cognitive load

Introduction

As online education grows in popularity, many universities are moving toward the development of online courses (Boitshwarelo, Reedy & Billany 2017). With the continued growth and development of such online tertiary courses, it is important to track, develop, and enhance the best methods of delivery to ensure such courses continue to provide the highest quality education and suitable student learning experience. This paper provides an important contribution to assist educators within the development and delivery of remotely invigilated online exams (RIOEs) to reduce students' cognitive load. The growth of online education has led to several challenges including how to adequately assess student learning in an online environment (Boitshwarelo, Reedy & Billany 2017; Hollister & Berenson 2009). Exams remain common tools for assessing student learning and assigning grades but the ways of conducting them continue to evolve (Prisacari & Danielson 2017, p. 1). In recent years, online exams for students have been conducted via learning management systems (LMS) or other testing platforms (Prisacari & Danielson 2017). This has raised both academic and non-academic issues, such as how to design and administer online exams as well as monitor students' behaviour during the exam.

Much of previous research has focused on students' reactions and experience with using online exams (Adewale, Ajadi & Inegbedion 2011; Al-Mashaqbeh & Hamad 2010; Daffin & Jones 2018; Fask, Englander & Zhaobo 2015; Harmon & Lambrinos 2008; James 2016; King, Guyette Jr & Piotrowski 2009; Mirza & Staples 2010; Thomas et al. 2002). There is still much to be learned and shared as online exams are evolving rapidly with technological change (Bohmer, Feldman & Ibsen 2018). According to Weiner and Hurtz (2017), there is a lack of research on comparisons between different means of invigilating exams and the implications of these. Much of the research about online exams is in a setting where the exam is done on a computer, but in every other aspect the conditions are the same as a traditional paper-based exam, where they are undertaken on campus and invigilated in person (Bohmer, Feldmann & Ibsen 2018; Öz & Özturan 2018; Riera Guasp et al. 2018; Weiner & Hurtz 2017). While Weiner and Hurtz (2017) compare in person invigilation to live RIOEs, their study focused on the RIOE effects on test scores and the examinee experience. Their study looked at exams administered concurrently at different test sites that offered in person invigilation in exam centres or live RIOEs in exam centres where testing was invigilated via internet connected video communication and surveillance. However, with the many formats that RIOEs can take, there remains significant room for additional research into the process and the best way to deliver these exams with the different RIOE methods available to educators.

This paper contributes to this research area by presenting a case study using cognitive load theory (Paas, Renkl & Sweller 2004) and the practical reflection of Action Learning (Revans 1979) in nine online courses that constitute a new online offering at the University of South Australia Online (UniSA Online). This case study considers the issues in organising and running RIOEs, where the students bring their own device (BYOD), sit their exam remotely and student recordings are invigilated post exam. UniSA Online was newly set up by the University of South Australia (UniSA) in 2016 to provide a suite of complete online degrees, and consequently presents an excellent context for current research into the advancement of online tertiary education. Courses (subjects) within the degrees in UniSA Online are delivered within a 10-week term with the completion of all assessment, including exams. From the outset, academics were encouraged to consider the best ways to assess course objectives without the use of exams, unless these were required for accreditation purposes. The exams discussed in this paper are part of business degrees that require exams to meet professional accreditation requirements. The exams complement other forms of assessment used throughout the degrees.

UniSA Online explored several ways to conduct computer-based exams for online students as various modes exist. Some institutions provide computers on campus or at exam centres and the students are required to take the exam at the set location with computers provided whilst they are invigilated in person (Weiner & Hurtz 2017). There is also live invigilation available from a remote location where the invigilator may interact with the students while observing the scheduled exam session in real time via the student's webcam (Lilley, Barker & Meere 2016; Weiner & Hurtz 2017) and remote invigilation using biometrics (Mitra & Gofman 2016). Others use a system where the exam content is delivered to students' personal computers remotely, whilst their actions are recorded. The footage captured is then reviewed after the event (Bohmer, et al. 2018; Weiner & Hurtz 2017).

For UniSA Online, it was decided from the outset that the exams would be remotely recorded, which raised stakeholders' expectations with the advertising promoting, "Sit your exam on your sofa". RIOEs at UniSA Online are conducted via a third-party service, offering exam invigilation and technical support, which allows students to participate in online exams from a remote location using their own device, whilst ensuring the integrity of the exam. The remote invigilation application authenticates students' access to the exam located in the LMS and records the students' computer screens and their behaviour via their webcam. Following the exam, the students' recordings are reviewed by third party invigilators who identify any possible exam breaches. UniSA Online deemed students would be more comfortable with a remotely recorded exam, rather than one where they were watched remotely in real time.

Considering the above, UniSA Online presents an excellent and current context by which to advance the understanding and enhance the delivery of this specific ROIE method. The paper outlines key issues in this delivery method of RIOEs and important factors for educators to avoid and remedy these issues, thus by extension enabling them to minimise the cognitive load of the students. These benefits are provided through the shared lessons learned in the process of developing and implementing RIOEs at UniSA Online, where key considerations are discussed in order to better conduct RIOEs more seamlessly with the aim of minimising students' cognitive load.

Literature review

Cognitive load

There is some evidence in the literature that online exams may impose a greater cognitive load on students compared to a traditional paper-based exam (Prisacari & Danielson 2017). Students must demonstrate that they have met their course objectives as well as deal with navigating technology and the added complexity that an online exam brings (Jarodzka et al. 2015). If the online format creates high cognitive load then students' ability will be hampered, resulting in lower exam results. Cognitive load theory suggests that learning is impacted by the amount of cognitive resources required to process the demands of a particular activity (Paas, Renkl & Sweller 2004; Schmeck et al. 2015). Learning is thought to be more successful when the amount of cognitive resources (e.g., working memory) available is sufficient for the amount that is needed to process the thinking (Paas, Renkl & Sweller 2004; Prisacari & Danielson 2017). As a result, learning activities such as exams should be designed to reduce unnecessary load on working memory so that more is available to focus on the exam (Jarodzka et al. 2015; Parshall et al. 2002; Schmeck et al. 2015, p. 94). The concern with RIOEs is that students would consume cognitive resources in a variety of ways, including validating their identity via the RIOE service, accessing the LMS, using spreadsheet software to answer quantitative questions, and dealing with any technical problems on their own device. All of these draw on the cognitive resources available to interpret and answer the exam questions.

Prisacari and Danielson (2017) explored the relationship between taking an exam on paper or via a computer and the impact on cognitive load. They measured cognitive load using two self-reporting questions on "perceived mental effort" and "level of difficulty". The exams included algorithmic, conceptual and definitional chemistry questions. They found that the computer-based exams had no more impact on cognitive load than the paper-based ones regardless of the type of question. They concluded that computer-based exams did not increase students' cognitive load.

This paper is concerned with avoiding the distraction of students by the technical tasks that surround the process of taking an exam online as this may "waste" students' cognitive resources (Schmeck et al. 2015, p. 94) so that they are not available to focus on the aim of successfully answering the exam questions. As Parshall, Spray, Kalohn and Davey (2002, p. 5) suggest: "The more 'intuitive' the computer test software is, the less the examinee needs to attend to it, rather than to the test questions". As Paas, Renkl and Sweller (2004, p. 1) suggest performance "degrades" with excessively high cognitive loads so it is important to consider the impact of the exam design on students. The way the online exam is designed imposes "extraneous" load on learners (Paas, Renkl & Sweller 2004, p. 3). While online exams are a new phenomenon to students they are likely to experience greater use of cognitive resources as they have to control far more of the exam situation than a traditional paper-based exam where the invigilators ensure that everything is organised for the students in real time.

Jarodzkda et al. (2015, p. 805), using eye tracking, tested whether splitting the screen to have the exam questions and information required to answer them on one side and the answers done on the other, led to unnecessary searching and thus increased mental effort and cognitive load compared to an integrated format. Contrary to what they expected, the students performed more efficiently with a split format. There are many variations on how exams can be organised; the more each of these vary from the traditional paper-based format with which students are familiar, the more likely the increased impact on cognitive load. It should be noted, however, that as RIOE uptake becomes more commonplace and students adapt to this approach, the cognitive load is likely to be reduced and may in fact become less than for the paper-based exams.

Exam spectrums

A review of recent exam literature revealed that there are many terms used to describe exams and they are not used consistently amongst different authoring groups. For example, one paper may refer to an online exam as a "digital exam" whilst another uses "computer-based exam". To address the issue this paper seeks to create a common language by which online exam research can be grouped and discussed.

The literature reveals three spectrums along which exams can be organised, describing the format, location and invigilation method. At the left end of the spectrums are the more traditional approaches to organising exams such as paper-based on-campus, with invigilators walking around. At the other end of the spectrums are more modern approaches, such as online exams where students as required to bring their own device to a remote location of their choosing (provided it meets certain criteria) where the exam is recorded and invigilated after the event. Any given exam could sit at different points on each of the three spectrums. For example, an online BYOD exam held on campus that is invigilated remotely live via cameras. The spectrums of exam modes are illustrated in Figure 1.

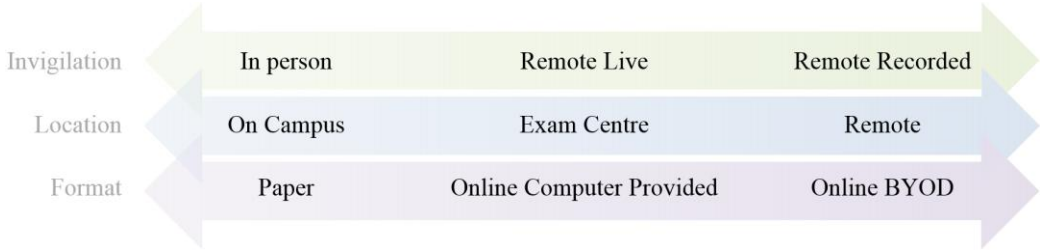

Figure 1: *Exam Spectrums - Invigilation, Format, Location*

These three spectrums were used to group the recent literature reviewed to determine the gaps therein, the results of which are displayed in Table 1. This table indicates that more research is required regarding exams that are recorded and invigilated remotely, post examination. This paper seeks to contribute to this area of research by elaborating on these spectrums and associated literature below.

Table 1: Classification of recent exam literature along three exam spectrums - invigilation, location and format

Reference	Invigilation				Location			Format		
	In Person	Remote Live	Remote Recorded	Not Invigilated	On Campus	Exam Centre	Remote	Paper-based	Online Computer Provided	Online BYOD
Alessio et al. (2017)			√				√			√
Bohmer, Feldmann and Ibsen (2018)	√				√			√		
Bohmer, Feldmann and Ibsen (2018)	√				√				√	
Bohmer, Feldmann and Ibsen (2018)				√			√			√
Borges et al. (2017)	√				√				√	
Daffin and Jones (2018)		√					√			√
Daffin and Jones (2018)				√			√			√
Davis, Rand and Seay (2016); Dawson (2016)	√				√				√	
Davis, Rand and Seay (2016); James (2016)				√			√			√
Davis, Rand and Seay (2016); Jefferies et al. (2017)		√					√			√

Frankl and Bitter (2012)	√				√				√	
Laurila, Anderson and Niemi (2017)		√	√			√			√	
Lilley, Barker and Meere (2016)		√					√			√
Milone et al. (2017)		√					√			√
Mitra and Gofman (2016)		√					√			√
Mohanna, Patel and Amanullah (2015)				√			√			√
Öz and Özturan (2018)	√				√			√		
Prisacari and Danielson (2017)	√				√			√		
Prisacari and Danielson (2017)	√				√				√	
Tsai (2016)	√				√				√	
Tsai (2016)				√			√			√
Washburn, Herman and Stewart (2017)	√				√			√		
Washburn, Herman and Stewart (2017)	√				√				√	
Weiner and Hurtz (2017)	√					√			√	
Weiner and Hurtz (2017)		√				√			√	
Wibowo et al. (2016)	√				√				√	
Wood et al. (2015)	√				√					√
Ying (2016)	√				√				√	

Advantages to online exams

There are a number of advantages to online exams, though these are not restricted to RIOEs. For example, in courses where students have to write software programs, they can do these online and test them under exam conditions (Bohmer, et al., 2018). Students can demonstrate their ability to use coding and run it during online exams and they can use *Calculator*, spreadsheet software, *Mathcad*, *Matlab*, *Paint*, *Pycharm* development environment and *Word* (Frankl & Bitter 2012; Laurila, Anderson & Niemi 2017; Richter, Boehringer & Ieee 2014; Wibowo et al. 2016). In UniSA Online, accounting students use spreadsheet software during their online exam; this is the most commonly used software tool by management accounting graduates (Spraakman et al. 2015). Students can be provided with videos or an audio file for language exams, to which they can respond (Dawson 2016; James 2016). Recent cohorts of students are more accustomed to typing than writing by hand and have been found to give longer answers in computer-based exams and prefer them to paper-based exams (Dawson 2016, p.593; Wibowo et al. 2016).

RIOEs have some advantages over online exams on campus in that they may be more convenient for students so long as they have an appropriate quiet place at home and a strong and stable internet connection (Jefferies et al. 2017; Milone et al. 2017). The convenience may arise for example, from

having to consider employment or childcare responsibilities. Importantly, online exams may provide better access for students with disabilities (James 2016; Jefferies et al. 2017).

Where the online exam takes the form of a multiple choice quiz or some other type of question, that can be marked automatically by the computers, it provides efficiencies and cost savings to the university (Boitshwarelo, Reedy & Billany 2017) and instant feedback to students (James 2016). Even where the exam is not multiple choice the readability of the answers makes marking easier and more objective (Frankl & Bitter 2012).

Advantages to the university include not having to organise students to sit their exams at a large number of exam centres across Australia and a lower cost to invigilate (James 2016). Exam centres typically cost A$100 per student per exam while online remote invigilation services cost about A$20 per student per exam. Exams are also available immediately for marking, as they do not have to be mailed back to the university (Wibowo et al. 2016, p.6).

Student response to online exams

Despite the advantages of online exams to both students and universities from a cognitive load point of view, one issue that stands out is whether the mode of exam has a negative impact upon students' results, independent of their understanding of the course content. Weiner and Hurtz (2017) found that test results did not differ significantly between in person and online exams. While Washburn, Herman and Stewart (2017) found that although students did better in online exams, they preferred those that were paper-based, Lilley et al. (2016) found that although they expected that live online invigilation may have had a negative impact on students it did not affect their performance in the exam. Davis et al (2016, p. 38) also concluded that lower exam results are not an effect of technology but may be due to less incidents of academic misconduct.

Washburn, et al. (2017) compared paper-based multiple choice quizzes for veterinary students against online ones and found that although students did slightly better in the online exams, 87 percent of them preferred the paper-based exam due to the additional anxiety associated with an online exam. Increased stress and anxiety due to electronic exams was also reported by Da'asin (2016, p. 10). Wibowo et al. (2016, p. 19) also concluded that students found the online exam more stressful due to unfamiliarity with the online exam service and students emphasised the importance of having practice exams in the online environment (Paas, Renkl & Sweller 2004, p. 1). Yet 80 percent of Wibowo et al.'s (2016) sample of students were willing to take online exams again. Familiarity with online and electronic exams over time is likely to reduce students stress levels (Davis, Rand & Seay 2016, p. 27) (Davis et al. 2016, p. 27).

While Washburn et al. (2017) found that students preferred paper-based exams, Laurila, et al. (2017) concluded that students generally preferred online exams. This may vary according to the type of questions asked and how well students are prepared for the online exam experience by their facilitator. To ensure students are not disadvantaged due to their different technological proficiencies facilitators need to prepare students for the exams (Boitshwarelo, Reedy & Billany 2017, p. 11). Boitshwarelo et al. (2017) suggest this is particularly true of older students, indigenous students and certain countries as they may not have as much experience with the technology.

A concern of online exams is that students seem to be more anxious about this mode of assessment and this is likely to increase their cognitive load. However, the literature generally suggests that the performance of students in paper-based and online exams is comparable. Although the technical issues around online exams may increase cognitive load these may be countered by the ability to type answers and to work in a format more similar to how students study compared to paper-based exams.

Challenges with RIOEs

Bohmer, et al. (2018) used online at-home exams at the end of the teaching period in engineering exams. They outlined common issues with RIOEs including how to monitor the student, having a secure authentication process to ensure the person sitting the exam is the student enrolled in the course, academic integrity, and privacy and data security. Bohmer et al. (2018) selected exams that they thought would easily adapt to an online environment. They noted that the facilitators believed that developing an exam for online was more time consuming than a paper-based exam as creating quizzes in the LMS (Moodle) was considered "tedious". Bohmer et al. (2018) ran their remote online exams using the quiz function in Moodle and only had it available to students for a limited time. Due to German laws about recording students sitting exams they did not invigilate the exams.

Frankl and Bitter (2012, p. 163) found that academic staff needed support both during the preparation of the online exam and while it was being conducted, that the support needed to come from staff with expertise in using computer programs, and that students also needed technical support during the exam to minimise anxiety from sitting exams in a new environment.

Facilitators have to take into account the limitations of the LMS and the constraints of working on a computer rather than paper (Borges et al. 2017), such as the difficulty with students drawing diagrams and graphs on a computer compared to the speed of doing so by hand. Facilitators may also have to rethink the way they set the online exams, which may require technical support from staff with the requisite technical skills (Wibowo et al. 2016, p. 7).

Davis, Rand and Seay et al. (2016, p. 27) used the same remote invigilation provider as this case study and reported issues such as students having a poor internet connection, having old hardware and software and not completing a practice exam. These problems became less common as students used the remote invigilation service more. Some students found navigating the online exam environment challenging which put them off online exams (Wibowo et al. 2016, p. 18) and they were also concerned about power failure or internet issues.

The experience of the present research also suggests that RIOEs require more effort from course facilitators to set up the exams and they will generally need technical support. The students also tend to experience a number of technical issues, however these become less common as they do more online exams and become familiar with the processes involved.

Method

The case study method used was based on the theory and practice of Action Learning (Dick 1997; Revens et al. 1979, 2011). Action Learning is a communication and project management process involving a series of experiential and reflective learning cycles so that collaboration amongst a group of people can facilitate the way they learn from their experience of problem solving (Dick 1997). One of the founders of this approach, Reg Revans (1979, 2011), emphasised the benefits of professionals from different disciplines or organisational contexts coming together in, usually, a leaderless team, known as an "action learning set", to develop their learning through action focused on a mutual problem.

This describes well how the UniSA Online teaching team formed and operated in response to being early adopters in the use of an RIOE service in fully online business courses. When problems were encountered in the respective implementations of online exams in the LMS and their online remote invigilation arrangements, facilitators sought each other's assistance and learned and shared in an interactive series of small group meetings in various configurations.

Initially one facilitator worked with our technical expert (online educational designer) on setting up their exams within the LMS, as has been the case in other studies (Frankl & Bitter 2012; Wibowo et al. 2016). As an issue arose, which also pertained to the other facilitator's course then the two would watch and learn from the online education designer. However, as these two-on-one learning sets needed higher level academic support, their academic supervisor (Associate Dean: Online Education) would join the learning set and the facilitators would share their learning from listening to the online education designer and applying and reflecting and sharing.

The Associate Dean was the conduit with the central exams and results unit of UniSA that liaised with the online invigilation service provider. Further technical support from the custodians of the LMS was required as technical issue arose for students. So eventually from an inner circle of two teachers, an academic supervisor and a technical officer, the learning set had a combined circle of nine key participants engaged in face-to-face meetings and email exchanges so that the learning set's implementation and review learning cycle progressively applied and reflected on the processes and subsequent improvements.

To summarise and analyse the process of the reflective learning meetings, there were four basic reflective action learning loops (Dick 1997; Edmonstone 2014) as follows:

A. *Action and reflection:* Identifying the problems (inner circle of two, then three, then four) and reflecting and sharing amongst this learning set (e.g., initially how to layout and embed suitable graphics for quantitative short answer exam questions, then developing and presenting screen capture of the steps the students must follow to enter the exam software interface).
B. *Action, reflection and action*: Managing the problems (inner circle of four) researching the literature and reflecting and sharing amongst this learning set (e.g., alerting students to the cautions based on the team's findings; then after further experience, developing messages to subsequent students, reinforcing their need to comply with relevant preparations).
C. *Action, reflection, action, review, planning and action:* Critiquing and communicating the solutions and lessons learned (engaging with the outer circle of five and reflecting and sharing amongst this expanded learning set of nine participants) to prepare a framework for the process (e.g., to convey to the RIOE service the difficulties students were experiencing with their software interface).
D. *Improving and documenting:* Reflecting on, and sharing, the whole process amongst this extended learning set and then to their wider stakeholder groups (e.g., conveying to the wider University an improved online exam interface and official administrative announcements to students).

It was in the last *reflective action loop D* that the team realised the importance of sharing their experience and reflections with a wider circle of stakeholders, hence the preparation of this case study and other relevant documentation. This also enabled the sharing and improvement across the whole University.

Discussion - lessons learned

As the team progressed through each reflective learning loop, many lessons were learned moving from conjectures to plans of action. The following discussion details the principles developed that are generalisable to other institutions and contexts. The actionable insights of which are summarised in Table 2.

Exam design

Anecdotally, many academics new to online exams are under the impression that they can just "copy and paste" their paper-based exams, with little attention to adapting it to a digital medium. While this might be somewhat accurate for multiple choice questions this is not leading practice. In particular, for questions that require students to calculate and represent their mathematical reasoning in formulas or diagrams, or questions that require students to digest, interpret and analyse complex information (whether that be paragraphs of text or information organised in tables, graphs and images) there are additional academic and technical considerations.

This means that time needs to be allocated to the task of translating and redeveloping formerly paper-based exams into purpose built exams ready for digital consumption (Bohmer, Feldmann & Ibsen 2018). Depending on the experience of the academic, this process will likely need to be supported by staff with technical expertise (Frankl & Bitter 2012; Wibowo et al. 2016).

In some instances, the question will need to be completely redesigned. It may not be possible for students to hand draw a graph in the LMS, so dependent on what is being assessed graphically, this would need to change. For example, instead of asking students to draw a graph (in the paper-based exam), the question may ask students to recognise the correct graph from a choice of four with the additional task of identifying all the variables (Sharp 2018).

One of the primary focus areas of UniSA Online was to reduce students' cognitive load by decreasing the total amount of mental effort to complete information processing tasks and thereby lower the associated stresses induced by wasted mental effort and time (Prisacari & Danielson 2017; Schmeck et al. 2015). This necessitated investigation into various elements of exam design.

Navigation

The first element of exam design is navigation. At first glance, students should be able to glean the structure of the exam to improve navigation. Where possible the exams were sectioned so that students could determine what concepts were assessed within each section and to see which questions were related to each other (Parshall et al. 2002). Attention was paid to the naming (or titling) of each question, which further informed what students would be required to demonstrate without reading the question text (*reflective action loops A & B*). This was to help students focus on their areas of strength within the exam by also taking into account the relative weightings of the questions.

Question comprehension

Attention was paid to the consistency of question format so that students could recognise the pattern established and focus on answering the question rather than having to determine what each question was asking them to demonstrate. This required careful consideration of the structure and text formatting of each question (*reflective action loop A*).

A uniform structure (or layout) was created and employed for every question within an exam, which minimised the amount of effort it would take for a student to understand what was being asked and thereby reduce their cognitive load. This was done by ensuring that the task directives were separated out visually from the question context or data associated with the question. Wherever possible these directives were itemised stepwise, such that at a glance, students could see what they needed to include in their answer and could be used as a form of checklist. Alongside this information the marking allocation was made explicit, for example, two marks for listing two examples and four marks for the underlying rationale. This transparency complemented by the

amount of lines provided in which to answer, communicated the level of detail students needed to include. This process (*reflective action loops A & B)* minimised any uncertainty thereby reducing cognitive load (Jarodzka et al. 2015; Parshall et al. 2002; Schmeck et al. 2015).

How many items students need to pay attention to per question was minimised by reviewing what elements were key to communicate (*reflective action loops A & B)*, such as key terms commonly overlooked (e.g. "and", "or" and "choose one option only"). Not only was the degree of signposting per question reduced, it was also only formatted as **bold** text, as it is arguably more noticeable than *italicised* text.

Multitasking

When it came to digitising a paper-based exam, the following considerations were front of mind: how will students interact with the content and how can the amount of information students need to keep in their working memory be limited? All steps that reduced the amount of multitasking were explored (*reflective action loops A & B)*, such that students could perform at their best.

One focus area was to ensure that (where possible) all content was viewable on a single screen, limiting or removing the need for students to scroll to garner all pertinent information (Jarodzka et al. 2015). The ideal was to have all question directives viewable at the same time as the question context, including all tabulated data etc., otherwise students would be required to scroll back and forth continuously to cross check between what they are being directed to do and the question context.

Careful thought was given to multi-part questions (*reflective action loops A & B)*. Any question that requires students to use information that they have provided in a previous answer or that requires them to use newly provided information in conjunction with information provided in a prior question adds considerable complexity and cognitive load. This is compounded if the question text and associated student workings are on another webpage, which requires them to constantly click back and forth. Hence, where possible the multi-part questions were combined into one larger question to preserve context. This places more importance on the previously made point about explicitly and clearly communicating the task directive (stepwise), breaking down what students are required to produce into key deliverables.

Many of the exams developed thus far have involved providing access to tools outside of the exam system: primarily this was spreadsheet software. This meant that students were required to interact with two systems at once, their exam and spreadsheet software. The easiest way for students to complete the exam was to have both open at half screen width so that they could be viewed concurrently. Hence, question text was designed to make sure that it presented as intended at half screen width (at 100% zoom).

Many of the exams had some form of reference material provided, such as appendices of equations or tabulated data. Dependent on how access is provided to this form of information, it could potentially mean that a third (or more) window would need to be open at any one time, which considerably affects students' working memory. To avoid this, the appendices were incorporated into the spreadsheet that students were already accessing, enabling students to dip in and out as required without the need to open a third, potentially distracting application (or application window).

Authenticity

One of the key affordances of exam digitisation is that it enables unique exam questions not formerly possible using traditional paper-based exams. The online exam provides the opportunity to design

an exam that approaches a more authentic assessment in a "real world" setting (Frankl & Bitter 2012; Laurila, Anderson & Niemi 2017; Richter, Boehringer & Ieee 2014; Wibowo et al. 2016). This benefit was exploited by giving students access to spreadsheet software that they would commonly have access to in a workplace setting (Spraakman et al. 2015). The spreadsheet software was used not only as a tool to compute solutions but also as the method to submit answers.

Provided students are familiar with the use of the spreadsheet software (either by requisite knowledge or explicit teaching), the tool enables quick calculations, minimises transcription errors and affords easy edit of past calculations. However, the primary benefit to both student and marker is that students can represent their mathematical reasoning and computation in a single step (*reflective action loop A)*.

Many business courses in UniSA Online require the use of spreadsheet software in RIOEs. It is often used as an answer sheet in the online exams hence a moderate level of competency in spreadsheet software is required. To scaffold students with the use of spreadsheet software, UniSA Online courses provide weekly learning tasks and/or mid-assessments in spreadsheet software. The online exam and a frequent use of spreadsheet software enable the students to experience authentic industry related courses.

Response input

As well as improving question design, efforts were made (*reflective action loops A & B)* to improve the setup of the associated answer sheet, which, in the present study, was a spreadsheet. The spreadsheet needed to seamlessly integrate with the exam questions and not impinge upon students' cognitive load. The remainder of this subsection describes the approach used to render the spreadsheet more intuitive and user friendly, thereby supporting students in demonstrating what they know and understand.

From the initial small group meeting (r*eflective loop A*), it was determined that only one answer sheet would be created, which would not only save students from multiple downloads and the ensuing file management issues, but also allow for easy editing of previously submitted responses. It was also determined that for consistency it would be better for students to submit responses to every question within the answer sheet, even though some questions could be answered directly within the exam system text box (because they required no calculation).

Within the answer spreadsheet there was a sheet designated for each question. Even if a question contained multiple parts all were to be answered in the one sheet. This was to prevent students from the requirement to click between sheets to determine what their prior responses were. The individual sheets were minimally labelled by question number only, i.e. "1", to minimise horizontal scroll when navigating the spreadsheet, and were colour coded to match the sections within the exam (if any).

No question text was included in the template (unless a prepopulated table was provided). This not only prevented students from having a copy of the question text (post exam) but also ensured there was no duplicated information that required students to read information twice. When required, question text was edited such that it could be readily copied and pasted into the spreadsheet; for example, by putting commas within numerical values rather than spaces and putting units in table headers rather than in every cell.

In the instances where data and/or table formatting was prepopulated into the answer sheet, these cells were locked and protected with a password to prevent students from inadvertently deleting or altering information. These cells were filled with a predefined colour to signal what could not be altered and thereby which cells needed to be populated in the students' response.

In the cases where information was provided in appendices this was built as a separate sheet within the template to enable students to view both the question directive and the appendices simultaneously. An index was created at the top of the sheet and corresponding bookmarks created to enable students to jump to pertinent sections. To save students' valuable time in the exam the spreadsheet was preformatted as much as possible to streamline the input of their responses. Examples include, changing the default width of columns, aligning cells right (so that decimal places align) and selecting the number of decimal places displayed.

Testing

As with their paper-based counterparts exams should be checked independently to ascertain whether the directives make sense and that the questions are solvable (and their corresponding solutions are correct). However, in a digital medium, functionality and user experience also needs to be tested. Ideally this testing should be completed by someone who represents a student (and gains access to the content like a student) and who is not familiar with the exam process.

Examples of items to be checked during testing include whether a mock student could locate the exam within the LMS, the tables (if any) were responsive, there was excessive scroll, the hyperlinks (if any) worked as expected, there was different functionality between PC and Mac users, and the cells could be edited in a protected sheet as intended (*reflective action loops A & B*).

Communication

Various advantages and challenges in RIOEs have been identified in the literature review section of this paper. Like Frankl and Bitter (2012), UniSA Online has identified that issues in RIOEs occur due to lack of students' preparation and understanding of the systematic requirements (*reflective action loops A & B)*. The experience in UniSA Online goes beyond that found in existing literature with respect to the need for clear communication to students and a requirement to undertake a mandatory training exam prior to the actual exam to limit the number of technical issues (*reflective action loops C & D)*.

UniSA Online found that many issues which students experienced during RIOEs could have been avoided if the students were familiar with the RIOE process and requirements (addressed in *reflective action loops A, B & C)*. Being familiar with the RIOE process prior to exams would also help the students focus on the course related information during the exam and reduce interference of the students' cognitive load. Hence, UniSA has created a webpage called "Online Exams Preparation & Mandatory Training Quiz" providing systematic instructions to prepare the students for their online exams (*reflective action loop D)*. This webpage contains important information of which students must be aware prior to taking their online exams, including the exam rules, a link to download the remote invigilation service and instructions to access the online exam.

Despite the availability of this webpage and various reminders, approximately a third of students did not do the mandatory training quiz and experienced technical issues in the exam. Therefore, it has been mandated that all students read the information provided in the online exam preparation webpage and do the quiz before every exam (*reflective action loop D)* even if they have done this before. If students fail to complete this mandatory training quiz prior to their exams, application for secondary exams can be denied. This strong sense of emphasis seemed to have attracted students' attention and more students have completed this task prior to their RIOE. This has resulted in a significant reduction of RIOE issues.

Depending on the remote invigilation service, the system requirements may differ, which also needs to be communicated with the students as early as possible. UniSA Online communicates the system requirements to prospective students before they enrol and to current students prior to their course commences. For instance, the remotely invigilated service that UniSA uses does not operate on tablets, mobile phones and hybrid devices. Other system requirements include the use of a single monitor, microphone and webcam. There are other system requirements, such as the latest version of Flash and/or minimum connection speed. The mandatory training quiz enables the students to test all the system requirements at any time prior to their online exams.

In communicating important exam information with the students, UniSA Online has taken a collaborative approach (*reflective action loops B, C & D)*. Previously, the roles relating to RIOEs were segregated and not clearly communicated at UniSA Online. For example, the exam office is responsible for setting up the exam schedule and administration rules of RIOEs including communicating with the remote invigilation service providers. The exam office also sends emails to students with information regarding the exam schedules and exam rules. Then the facilitator is responsible for setting up the online exams on the course sites and communicating the course specific information to the students.

Before the collaborative action learning approach reported in the present study, lack of understanding of RIOE processes and blurred lines of responsibilities had created confusion. When students contacted the teaching team with various issues, the teaching team had limited understanding of how to resolve the issues and who to contact. For example, one of the first courses using RIOEs had approximately 15 per cent of the students experiencing the same issue regarding the exam password. When the students tried to access the exam, the system had an error message showing "Incorrect Password". When the issue was raised, the teaching team was not aware what caused this issue. After an investigation (*reflective action loops A, B & C)* it was learned that the students had selected a wrong course which they were not enrolled in. As was learned through the *reflective action loops A, B & C* this issue could have been resolved quickly by advising the students accordingly.

As a result of the UniSA Online Unit's approach to RIOEs there has been extensive collaboration regarding online exams across the whole University. The exam office, teaching team, student services and IT Help Desk are working closely together and communicate more frequently (*reflective action loops C & D)*. Also, various training sessions were held to practice RIOEs and educate the staff members. This has reduced the number of escalated RIOE issues as the staff members directly involved in the course can resolve the issues in a timelier manner without further escalation.

To prepare students for their RIOEs, practice exams are set up to replicate the format of the actual RIOE (addressed in *reflective action loops A, B & C)* (Paas, Renkl & Sweller 2004, p. 1). The practice exams are available from the beginning of each course to enable students to familiarise themselves with the format of the online exams and use of the spreadsheet software.

Table 2: Actionable insights to consider when implementing remotely invigilated online exams

Summary of Lessons Learned

Enablers	Workload allocated to the translation and redevelopment of paper-based materials to online format
	Requirement for support staff to assist in first attempts and/or professional development provided
Navigation	The structure should convey meaning with questions grouped into sections and related questions immediately identifiable.
Question Comprehension	Establish structure and format and be consistent in how they are applied.
	Separate question context from question directive.
	Question directives broken down into key deliverables akin to a bulleted list.
	Explicit marking allocation linked with key deliverables.
	Implicitly communicate breadth and depth required by size of text field provided.
	Limit how many items you draw student attention to, use one formatting option only, bold being the preferred.
Multitasking	Multipart questions incorporated into one larger question to preserve context.
	Ensure question information is viewable on one screen with no scroll.
	Limit simultaneously interaction with software/content to two applications/instances e.g. question text and spreadsheet software.
	If simultaneous interaction is required, design content such that it presents on one screen even at half screen width.
Authenticity	Exploit affordances of online format by incorporating more authentic assessment
	Consider digitisation of permitted materials e.g. swap out handheld calculator for spreadsheet software.
	Consider providing access to online information that is readily accessible outside of education context.
Response Input	Consistently use the same response input method to limit confusion.
	Use only one file to minimise file management issues and support the seamless edit of past responses.
	Ensure no duplication of question context and/or directive in answer sheet.
	Ensure that information presents on one screen even at half screen width.
	Prepare question context, data and appendices such that information can be readily copied into the student's calculation/response.
Testing	Check functionality of entire exam e.g. login, passwords and hyperlinks.
Communication	Collaborate with other stakeholders to unify approach and communication strategy.

	Ensure all staff involved with exams (both academic and professional) are trained in the use of the exam systems and how to troubleshoot them if their role is to provide technical support.
	Communicate system requirements prior to enrolment.
	Have one authoritative source for all pertinent online exam information and ensure it is clear, concise and available from the beginning of the study period.
	Create a trial exam that allows students to become familiar with the systems/interfaces that they will use to complete their exam.
	Mandate completion of trial exam prior to every exam period (to cater for software updates, etc.) with a due date well in advance of the actual exam.
	Create extrinsic factor to encourage completion; i.e. incompletion may impact upon secondary assessment approval.
	Explicitly communicate the need and rationale for completing trial exam including how this differs from past exam practice.
	Check completion of trial on due date and send reminder to non-completers.
	Provide access to a past exam that replicates the method by which students will complete their actual exam with the exception of the invigilation step e.g. quiz in LMS.
	Communicate to students who they are to contact (with technical capability) if they experience technical issues.
	Provide staff available to respond to students pre, during and post examination.

Conclusion

This paper outlines the key lessons learned during the implementation of RIOEs. Our review of the literature determined a dearth of information within this space, which highlights the contributions made by this paper. The generalised insights summarised in Table 2 would be easily transferred to other institutions. The paper also introduces an exam spectrum (Figure 1) to provide a common language by which online exam research can be grouped (Table 1) and discussed.

This case study is primarily informed by cognitive load theory. To prevent or alleviate students' cognitive load, RIOEs should be systematically and purposefully designed considering the digital consumption and technical requirements. Prior to RIOEs, students should be well informed and equipped with the technical requirements and appropriate computer skills. In addition, accessible and responsive technical support must be provided to students which plays a pivotal role.

The primary focus of this paper was RIOEs, identifying issues and providing resolutions which UniSA Online has put in place. One of the key advantages of RIOEs is the ability to enhance the authenticity of the assessment by enabling the inclusion of an authentic and practical tool which should be explored further. This paper also foreshadows future research into other issues in online exams such as academic integrity, advancing pedagogical approaches through online exams, and improving student learning outcomes in the online setting compared to the traditional paper-based approach. In the Australian tertiary institution landscape, RIOEs are still in their infancy and we anticipate and encourage more scholarly work in this field of study.

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