Arguing again for e-exams in high stakes examinations

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This paper presents the argument that e-exams are needed and long overdue for use in high stakes examinations in the tertiary sector. Evidence is drawn from the educational and higher education literature to establish that the environment is ripe for the adoption of e-exams. A set of requirements for a suitable approach to exams is established that takes into consideration the needs of students, the pedagogical concerns of academics, while being sustainable and scalable. An outline of the features such a system will need in order to meet these requirements is discussed, along with a program to implement and trial such a system at a large university.

Keywords: computer based assessment, high stakes assessment, examinations, e-exams, e-assessment

The need and readiness for an e-exam solution in the higher education sector

Currently the use of ICT for teaching and learning, and in particular the current use of paper for high stakes exams within most higher education institutions lags behind the extensive usage of ICT by students in their study (Riddle, 2008; Riddle & Howell, 2008) and everyday lives. This is evidenced by the increasing use of ICT for a range of daily tasks (ACMA, 2012), with a recent survey of students at a large Australian university during 2012 indicated 98% ownership of mobile WiFi enabled devices with laptop ownership the highest at 91% (McManus, 2012). Surveys conducted in the United States reveal similarly high ownership rates (Dahlstrom, 2012; Williams, Drechsel & Kokil, 2012; UWM, 2012; UAA, 2011; McCue, 2012). The Australian survey also shows 80% of students accessing the online learning management system at least weekly. This provides evidence that students already have a familiarity with the technologies that can be used for e-exams; while the small minority who do not own suitable equipment can be addressed with a loan or equity program.

It is strongly evident in missions, strategic plans and graduate attributes that institutions in the Australian higher education sector are firmly committed to improving the teaching and learning environment in order to allow their students to be successful in their studies and graduate with the knowledge and skill sets needed in the modern world. These are expressed in teaching and learning plans in the areas of enhancing e-learning and blended learning that many Australian higher education institutions already have in place (for example UQ, 2012b). Further, an internal university survey of senior teaching leaders placed 'e-assessment / online marking' (UQ, 2012a) at the top of their priority list for development. So it could be argued that e-exams are the next step on from the increasing use of e-assessment and computer assisted marking for progressive assessment.

There is likely to be understandable apprehension on the part of academics and management when it comes to adopting new, fully electronic processes for high stakes exams in place of familiar paper based processes. This is a barrier that needs to be addressed by demonstrating secure and reliable digital systems and procedures and by offering a graduated transition pathway from pen to keyboard. On a national policy level information and communication tools are seen by the Australian federal government as holding great potential for realising as

yet unfulfilled potential in higher education as it has done in other sectors of the economy (Gillard 2008). Therefore it is argued that there is a strong need to develop and successfully implement suitable e-exams systems and procedures and that these will be a key enabler in fulfilling the vision and strategies at national and institutional levels.

We argue that without a suitable, computer based way of conducting exams, then such positive transformation across the education sector is less likely to occur, particularly since the form of assessment is a key factor influencing teaching and learning behaviour (Ainley & Searle, 2005). The experience in Tasmania (Fluck, 2007, 2011) has been that once the University started offering e-exams, this acted as a catalyst for the secondary school system to follow suit. Prior to this, the secondary school system was reluctant to make the move given they saw part of their role as 'training' their students to be successful in University examinations.

Increasing student numbers, spurred on by national participation targets, are placing pressure on physical facilities. For example the University of Queensland (UQ), saw an increase of 30,000 exam sittings 2007-2012 (UQ 2012c). UQ with its high proportion of on-campus students is already facing a shortage of suitable venues to hold traditional exams. A similar increase in numbers is occurring across the higher education sector while budgets are increasingly constrained. We argue that e-exams offer a possible way to expand capacity; however the strategy adopted is critical in ensuring the implementation is sustainable and scalable. While existing computer teaching lab spaces can provide some short-term relief to space shortages, these are limited in capacity and do not provide ideal layouts for exam conditions (Dermo, 2012). Custom built spaces designed for e-assessment are not commonly available in most institutions and when constructed are expensive and quickly reach capacity limits (ibid). The use of online exams with students sitting off campus, at home, provides a potential solution to looming space shortages, however it also raises concerns of potential exam protocol breaches when students are not under direct supervision in a controlled environment. Thus on-campus invigilated exams remain the preferred option for high stakes testing in higher education and it is this scenario that is the main focus of this paper.

In consideration of the above societal needs and trends, along with a review of the e-assessment literature, a set of drivers and requirements for the development of a suitable e-exams system are suggested (a mapping of each requirement covered below to proposed system functionally is presented later in this paper). It should be noted that the use of 'system' is meant more broadly than just the technology components and includes elements such as people, processes and policy. The requirements and drivers are presented from multiple perspectives including a student's view, a pedagogical or teaching view, and an institutional view.

Requirements and drivers towards a suitable e-exams system

The following requirements, drivers and surrounding arguments we have identified as likely to be of concern for various stakeholders.

Students

[R1] Students rarely hand write assessment responses anymore– they normally type. Course delivery in the tertiary sector is moving increasingly online where most items of work undertaken by students for non-supervised assessments such as reports, essays and quizzes, are typed (Mogey et al, 2010). The typed medium is also the dominant form of written communication with email and text messages. This means that students are now more familiar and comfortable with typed input than the handwritten form (Frand, 2000) particularly when it comes to assessment. Furthermore this increased computer use has been shown to reduce handwriting motor skills (Sülzenbrück, 2011) leading to discomfort in long hand written exams. Complaints from students about exams hurting their hands have appeared in the media (Ratcliffe, 2012). All of this leads to a growing disconnect between the way high stakes testing is conducted using pen on paper exams and students' everyday experiences (Fluck, 2004; Cowling, 2012; Dermo, 2009).

[R2] Students are familiar with computer based input methods and the devices they own. Just as a student can choose their 'best pens' to bring to a written exam they could be allowed to use their own familiar, comfortable keyboard and mouse. It is argued that this would mean that in high pressure situations they will be more efficient and less stressed (but not stress free) than otherwise because they don't need to worry about using unfamiliar equipment. Previous familiarity with computer use has been shown to increase student choice of keyboards over pens (Fluck & Mogey, 2013).

[R3] Students now have high ownership of laptops with surveys at Australian universities showing that student ownership of laptops is up from 60% in 2007 (Oliver & Goerke, 2007) to around 90% today (Deakin, 2012; McManus, 2012). Utilising this ready resource of student owned devices to serve as the necessary hardware for running exams would assist with minimising the costs associated with institution owned equipment.

[R4] Student owned devices are diverse (UQ, 2013a). These devices come with numerous operating system versions and software applications across even the three most common types of Microsoft Windows, Apple

Macintosh OS X and Linux (NetMarketShare, 2012). This would, if used in their supplied state, result in an inconsistent software environment between candidates; making use of these devices fraught with complexity.
[R5] Students do not like their personal equipment and software to be interfered or privacy breached by exam authorities or others. Students have a lot invested in their equipment in-terms of cost, time, personal ownership and privacy. The equipment is often important to their ongoing studies and personal lives so safe guarding its integrity is an important consideration with ethical, moral and possibly legal implications. Most e-exam solutions in the marketplace that make use of student owned equipment are intrusive, often installing and leaving behind software components that interfere with the operation of the computer. Some use biometrics while others use tools such as 'key loggers' to track candidate activities which raise concerns for privacy (Levy et al, 2011).

Teaching and Pedagogical
[R6] Technology enhances the range of assessment scenarios and question types when compared to paper based approaches (Crisp, 2010). The ability to incorporate multimedia elements including video, virtual views, scenarios, software tools, simulations, are all made possible with computer based forms of assessment. The Transforming Assessment website by Crisp & Hillier (2012) provides extensive examples of computer based questions. Traditional paper based exams provide little opportunity for feedback and has been described as a 'feedback desert' by Scoles, Huxham and McArthur (2013). Computer marked questions have the potential to provide instant feedback, or at least, faster processing of results. If matched with electronic marking tools and workflows faster feedback could also apply to essay questions, although with the latter longer return times would apply.
[R7] There is a need to provide all students with an equivalent environment for reasons of fairness while catering to equity issues (Mogey, Sarab, Haywood, van Heyningen, Dewhurst, Hounsell, & Neilson, 2007). Various exam authorities utilise different definitions of fairness (Fluck, 2012; Bouville, 2008) that range from providing the same environment to all candidates to providing different environments to ensure accessibility to those with disabilities. The exam system should have a range of accessibility features available to all.
R8 There is a need to provide orientation to students in regard to the exam environment. The use of paper based exams in the past were conducted when students commonly used pen and paper in assessment tasks and where the use of mock and practice exams prior to high stakes events meant that students could easily be accustomed to the medium prior to entering the exam room. The introduction of electronic exams will also require that practice sessions and exposure to the medium of the exam will need to be carried out. Students should be prepared in a way that places them in a good position to concentrate on demonstrating their knowledge of the topic rather than the medium and mechanics of production.

Institutional
[R9] Sustainable provision of computer hardware and facilities will need to be achieved. It is unlikely to be sustainable or economic for institutions to provide each student with hardware for large infrequent assessment events such as exams. The cost of providing a large number of computers for each exam candidate for short periods each year makes this logistically difficult and costly. The construction of large enough dedicated exam facilities would represent a significant investment in physical infrastructure that may not be well utilised outside of exam periods. The hiring or construction of a temporary facility and provision of computers would represent a high re-occurring cost. Given the already high ownership of suitable equipment by students a way to make use of this equipment would be desirable. Software licence fees for proprietary solutions also add to the cost impost. The approach to financing ongoing technical and procedural support is also a matter for consideration.
[R10] Each institution has different technical infrastructure that makes it difficult to provide solutions that are applicable across the higher education sector, especially those that are easily integrated into existing software and hardware environments. Most technical solutions offered by commercial providers are platform dependant or are intrusive to privately owned equipment (JISC, 2010 pp.30-49; Chesney & Ginty, 2007). There is a need to develop an open and modular exam platform that would be inter-operable with existing infrastructure.
[R11] There is a need to provide a robust and reliable solution. Exams at universities are of the highest stakes. The process needs to be at least equivalent to paper based solutions in terms of reliability and validity to be accepted by stakeholders (university administrators, academics, students, parents, employers, governments and the public). Without a secure and reliable solution academics in particular will be reluctant to adopt e-exams. If things were to go wrong with the exam process, the university would risk loss of reputation as to their status as guardians of standards and as reliable accreditors of graduate achievements. The impact on students affected would also be significant with increased distress at a time of already high stress.
In developing an exams solution consideration will need to be made regarding the stability and security of computer hardware, networks, software, and the physical environment in regard to both controlled elements such as institution owned networks and uncontrolled elements such as student owned mobile communication devices. Similarly during the course of the exam invigilators should be able to easily identify that each candidate

is using authorised software.

[R12] Unauthorised data and communication must be excluded from the exam environment. A controlled software environment that provides the ability to prevent students accessing unauthorised resources such as web sites, mobile devices and communications, other candidates, 3rd party helpers outside of the exam room or the hard disk drive of the computer. Network or wireless access would need to be prohibited or access permitted only to specific locations containing the exam questions and resources or to channels that allow secure transfer of answers. Due consideration of the principles of information security (Whitman & Mattord, 2010) can guide developers in the early stages of system planning to help ensure a secure and reliable platform.

[R13] There is a need to provide efficient workflows for set-up, conduct and post-processing of exams. Universities already expend significant amounts of money and resources in running examinations and we do not want to unduly add to this impost. Therefore we should aim for the introduction of e-exams to be at least cost neutral over the longer term. To assist with efficiency the exam platform should easily accommodate automatically marked questions to be used when pedagogically appropriate and to minimise manual processes associated with setting-up exam scripts, running exam events, retrieval, processing and marking of student answers.

The above provides a framework for choosing a suitable e-exams solution.

Current e-exam solutions

An environmental scan of available e-exams solutions provided by commercial and other providers shows that the majority do not address the full range of the concerns above.

Existing solutions include one or more of:

- Built in quiz tools within a Learning Management System (LMS) such as Blackboard, Moodle or Sakai. In the main these LMS are not designed to be e-exams environments and this usually means students have access to other tools within the LMS. Their use for exams therefore requires close invigilation and currently requires the use of computer labs on campus; which leads to the next point.
- Tests and exams undertaken in fixed computer teaching labs on campus. Such spaces are normally limited to 20 or so students in a room, the number of labs is finite and layouts of these rooms is often not suitable for high stakes exams.
- Proprietary testing software applications. The majority of these are dependent on the use of a particular operating system with very few being cross platform. This means that the previous point again comes into play if institution owned equipment needs to be supplied upon which to run it. Further, many also install invasive components into computers.
- Outsourced testing centres or services, where control is passed to other organisations/individuals. Such services are mainly intended for small numbers or external/distance education students and tend to be costly on a per student basis. Further, the scheduling of exams occurs within a narrow range of dates meaning it is unlikely to be viable to use such services for the majority of students.
- Online proctoring services used by distance education students who are off-campus at the time of the exam. Being off-campus raises risks of exam protocol breaches in uncontrolled environments. Solutions also usually involve intrusive software being installed into student owned computers in an attempt to secure the inherently insecure environment of a student controlled operating system.

Judging from the current market place there is a need to develop a new solution to e-exams. However, rather than entirely re-inviting a solution from scratch it would be more efficient to draw upon existing ideas, processes or software. To do so would mean using existing software in new ways or making changes to such software. The closed source, proprietary software licensing regime of the current providers makes doing so difficult. The open source movement potentially holds a solution to the problem and fortunately such a suitable base is found in the already successful 'eExam' system being used at University of Tasmania (UTAS) and in pre-tertiary exams (TQA, 2012; Fluck, 2012). The solution utilises the highly customisable open source Linux operating system and allows students to bring their own laptop to the exam room. This overcomes two large hurdles when it comes to developing an enhanced e-exams solution, that of scalability and the availability of the technical components for change.

The features of the UTAS approach align with many of the requirements outlined above. Such features include being open and highly configurable, which means it is available for customisation and sharing of innovation in that there is an absence of concerns over commercial licence compliance (which also removes some costs). Further the system is cross platform and extremely light touch on student owned equipment.

However the system as it stands also does not meet all of the requirements and therefore needs further work to

improve its capabilities (a greater number of question types) and efficiency (computerised marking and greater automation of current manual set-up and response reticulation processes).

We argue that the strong need for a strategic, scalable and sustainable e-exams solution that meet the needs of tertiary intuitions and students can be brought about by improving upon available open technology components. To begin this process, we propose a set of design features and strategies as displayed in the following section.

Design for a suitable e-exams system

A design for implementing the above requirements is inevitably going to be multifaceted including a mixture of technology and procedures. To this end we have compiled a set of desirable functionality and strategies which have been aligned with the requirements discussed in the first half of this paper.
These are displayed in Table 1 while the complex interplay of these factors and subsequent features are displayed graphically in the concept map presented in Appendix 1.

Table 1: Matching functional strategies and requirements

Functionality or Strategy	Requirements
The approach should utilise student owned equipment. Students should bring their own devices (BYOD). This will be in the form of a laptop along with any additional hardware such as separate keyboard, trackpad or mouse.	R1, R2, R3, R9, R10
Enable the provision of an equivalent and controlled environment therefore addressing potential unfairness of disparate computer systems in any one exam.	R4, R7
The e-exam software environment should accommodate reasonable adjustments to cater for equity of access in terms of usability and accessibility resources. This should include features such as text size change, colour contrast adjustment, subtitles on video, transcriptions of audio tracks and to ensure the software environment can be used with alternative input devices.	R4, R7
The e-exam software should work on the vast majority of laptop hardware available in recent years. The ability to function on any Intel based laptops that can run MS Windows, Mac OSX and Linux will cover the vast majority of cases.	R4
Provide access to a loan or equity program for students who do not have suitable hardware and provision of spare computers and power sockets for students with older equipment needs to be part of contingency planning for e-exam events.	R3, R7
Student owned equipment should be completely returned to its prior state after the exam event, leaving no trace. E.g. by restarting the computer after the exam. Therefore the system architecture must maintain a separation of the student owned portion of the platform from the exam authority controlled portion without the latter interfering with the former.	R5
It should be capable of a range of question types including computer marked question types. These include question types typically available in modern learning management systems such as Moodle and Blackboard.	R6, R13
It should be capable of sophisticated constructed answer questions that take full advantage of the capabilities of computerised platforms. Including specialist or discipline based software tools such as simulators, calculators, multimedia scenarios will allow students to build, experiment and produce answers within the exam context. For example students could run a simulated chemistry experiment and submit results or progress through a multi stage scenario with multiple decision points submitted for assessment.	R6
Ensure students have prior exposure of the features of the software environment and the processes needed to undertake a live exam. This can be done through provision of supervised pre-exam test run sessions and mock exams to assist students to adjust. A copy of the software environment and trial exam could also be made available to students so testing of processes and candidate hardware can occur at home.	R4, R8
User documents and guides should be provided for students, academics and administrators.	R8
Ensure appropriate transition strategies from paper to electronic. For example, a phase in period where paper and electronic exams are run side-by-side with students having a choice.	R8
Allow institutions to choose the components and options that best suit their needs. Using a modular architecture and open source software for all components (e.g. for test creation, student software environment, question engine, backend post-processing) will allow institutions to put together custom configurations.	R10, R13

Institutions should be able to leverage existing software and systems as they see fit. E.g. use the e-exam software environment but linked to an isolated copy of their own LMS.	R9, R10
The exam authority should be able to gain complete knowledge of the software environment. Using the open source Linux operating system allows this to happen to a greater extent than closed source alternatives.	R11, R12
The configuration of the software environment should be controllable by the exam authority This includes having high level of control over candidate access to hardware features and data sources during the exam. Options include preventing local hard disk access, excluding one or more network interfaces, restricting network access to a given destination e.g. LMS or exam server, using restricted rights student account so that students will not be able to access any configuration services e.g. root, sudo, system files. Again, Linux is highly configurable which makes it a good candidate for security hardening.	R11, R12
Exam invigilators should be able to easily check if candidates are using the authorised version of the software. Special colour schemes and images can be chosen by the examiner to be used for desktop images along with custom logos and sequence numbers printed on USB sticks will facilitate quick visual inspection by invigilators.	R11, R12
It should be possible to restricted network or internet access to specified destinations. This will facilitate specific access to chosen websites or to allow transfer of student answers using specified network protocols/ports to institutional servers.	R11, R12, E13
It should be possible to establish secure and isolated wireless networks. For example, to run in-room server(s) and wireless access points as an isolated network in places where wireless infrastructure is unavailable.	R9, R10
Is should be scalable to large numbers of students. The BYOD approach means the number of computers required by students will scale exactly according to need. Given computers will be provided by the students themselves it is anticipated whole process will scale in a similar way to paper based exams.	R9
It should be cost effective. The costs of using UTAS 'eExam' system has been found to be lower than that compared to commercial solutions. The BYOD aspect of the approach means equipment costs are greatly reduced compared to scenarios involving institution supplied equipment. The use of readily available open source software and commodity hardware meaning only minimal support is needed to keep the platform up-to-date. The ability to freely share the platform across the higher education sector should also enable economies of scale in terms of future development. Given the lack of proprietary or commercial licences fees the costs associated with tracking and auditing usage is eliminated.	R3, R9, R13

In practical terms the features and strategies will take a physical and procedural form. A representation of how a suitable e-exam platform solution would work is depicted in Figure 1.
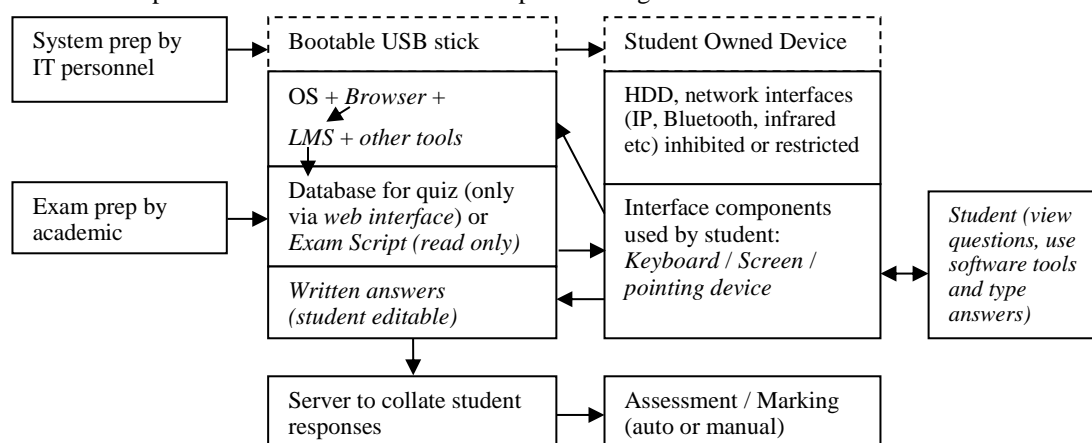
Figure 1: components of the e-exam system

The solution illustrated in Figure 1 can be further explained with an example use case. A typical process used to prepare and run an e-exam using the system is as follows:

1. A re-usable base USB model is prepared by institutional IT services in the form of a 'Bootable USB stick' data image. This would contain appropriate network configuration and access rules matched to the institutional context. Having a reusable base set-up means that the majority of the work in preparing the exam student platform only needs to be done once for each location in which it is to be used or upon software updates (e.g.

once a year per exam mode – 'open book', 'closed book' etc) rather than for each individual exam paper. Decisions as to the actual configuration would be made by the institution depending upon the nature of their infrastructure, i.e. availability of reliable wireless, use of institutional LMS, rules in place for conduct of examinations etc.

2. The base model and a dummy exam along with user guides would be made available to students. This is to allow them to practice the process of undertaking an e-exam and to allow them to gain familiarity with the e-exam software environment.

3. Each exam script (which may contain a combination of computer marked quiz questions and human marked questions) and a unique photo or image (to be used as a desktop background to facilitate invigilator identification of unauthorised or incorrect e-exam software) are prepared by the examining academic.

4. The exam script and chosen security image are placed on to a copy of the USB base model and then duplicated onto USB sticks by support services - one USB stick per candidate, using commercially available mass duplicators.

5. In the exam room the student boots their own laptop using the USB stick. The USB stick takes control of the hardware thus defining what the student can and cannot do during the exam (e.g. prohibit access to the hard disk, data ports, Bluetooth etc, restricting or prohibiting network access).

6. The student logs into the software environment using a generic restricted rights account to do the exam.
   a. In quiz based exams/sections, the student reads the exam questions in the LMS/question engine via a web browser. The student can only respond to questions via the browser interface as they would if they were using regular online quizzes in an online LMS. Quiz answers are progressively saved into the database by the LMS/question engine as the student progresses. For security, the database files are not directly readable or writable by the student account or the web browser itself.
   b. In paper-replacement essay exams a question paper set as 'read only' in the form of a word processing document of PDF. This 'essay' format is the fall-back in cases where computer marked questions are not appropriate or cannot be used. Essay responses are put onto an answer partition on the USB stick by saving a text document.

7. Student responses (quiz or written) are transferred to a server for collation. The method used depends on the style of the exam and the available infrastructure (see 'variations' below).

8. Quiz questions are marked by the LMS and results forwarded to examiners or the LMS gradebook.

9. Written student responses are forwarded onto examiners or markers for manual assessment and then entered into grade book. Manual marking is naturally the fall-back position. Although beyond the scope of this paper, it is worth noting that a range of electronic tools are available to assist human markers assess written student work if a fully electronic workflow is still desired (see TEDI 2013).

Some variation is possible and desirable. The pedagogical needs of the exam and the available technical infrastructure at the institution should be catered for by the platform. It is anticipated that an open, modular architecture will allow variations according to institutional need. Paper-replacement exams in the form of typed essay or short answer style exams, which are essentially electronic versions of traditional hand written exam script books, would be the fall-back position for this system.

In locations without internet access or where higher levels of security are required, isolated ad hoc local networks using portable servers and an array of wireless access points can be deployed in the exam room especially for the exam. The investment in a limited number of these machines would be sustainable (shared across many candidates and reusable) and maintainable in comparison to the hundreds or thousands of machines that would be needed if an institution were to supply computers for each candidate.

Inclusion of computer-marked question types would bring the power of modern quiz engines to the exam room and can be enabled either via an LMS on-board the USB stick or via a web browser interface to an LMS on a network server accessed over a restricted network connection. Within this capability three possible scenarios are foreseen that vary according to available infrastructure:

- Wireless always on mode – can be used where reliable, redundant and high capacity wireless network access exists in the exam room. This doesn't require an LMS on-board the USB stick. A web browser can be used to access a LMS server via restricted network access (access to other IP's / protocols / ports etc can be prohibited). A custom network configuration is set-up by each institution's IT services. This is done once to create a base model per institution/location which is re-used for each course/exam paper.

- Ad-hoc wireless mode – In this mode an LMS will be on-board the USB stick itself. Periodically a connection is made to upload/update student answers on a collation server. This may occur in the background using a 'drop-box' style folder or via a student initiated submission with confirmation shown on screen.

- Non wireless mode –Again an LMS will be placed on-board the USB stick. This approach requires duplicating equipment to reverse copy student answer files/databases from the USB sicks to a collation location. Where such equipment is not available a manual processes of copying each student's answer file would be the fall-back.

Proposed Research

The research program will take on the characteristics of interpretative (Greene 1994) action research (Galliers, 1991) in information systems in that it will be implementing changes in a, 'messy' (Ackoff, 1999), 'wicked' (Churchman 1967), real world educational environment and taking into consideration the multiple perspectives or view points of stakeholders (Mason and Mitroff 1981). The project will be based at a large research intensive University over a period July 2013 to June 2014. The research program will investigate multiple aspects relevant to running successful e-exams including technical, pedagogical, process, policy and people factors. The anticipated benefits and matching tangible outcomes are displayed in Table 2.

Data collection will entail two rounds of pilots utilising the new custom made software for assessment in active courses along with surveys, interviews and focus groups with stakeholders including students and academics. University educators involved in offering exams at the host university and at least one other institution will be invited to participate in interviews, which will aim to capture staff perceptions of the issues faced by academics in preparing and offering exams. An attempt will be made to purposively recruit participants from a range of discipline areas including Science, Education, Engineering, Languages, Pharmacy, and Veterinary Science in order to gauge different perspectives on these issues. Similarly students will be asked to trial the software system and asked to complete a pre-test and post-test survey. Student participants will also be invited to a focus group aimed at capturing what strategies they use to prepare for exams and their impressions of current and proposed formats of exams both paper based and electronic. The focus group data will be analysed and used in conjunction with a review of the literature to inform the development of the prototype and a set of draft guidelines for educators. The purpose of the guidelines will be to: raise awareness on the part of educators as to the issues faced by students when preparing and undertaking e-exams; offer concrete strategies for effectively preparing these students for the e-exams; and identify potential institutional and disciplinary challenges and strategies for implementing e-exams. The prototype and draft guidelines will be piloted along with the software at the host university in two rounds which will allow the iterative testing and refinement of the exam platform and related procedures in a real world application. Ethics approval will be sought via the host university's ethics committee drawing upon lessons learnt from prior studies done by Fluck (2004; 2013) to ensure equity for students involved. The program will be evaluated via the pre-test and post-test survey used to collect data, which will elicit perceptions from students on their experience of preparing and undertaking an e-exam, the effectiveness of the prep session and guides. Data will be collected from educators about the processes, procedures and the impact on their workflow and workload by the use of e-exams as well as on the draft practice guides. In the final stages of the project the set of good practice guidelines for preparing students as well as running e-exams will be drawn up.

Table 2: Anticipated research outcomes and tangible outputs

Outcomes	Tangible Outputs
To model an e-exam platform to be used in supervised, BYOD settings that includes options for computer marked questions.	A working prototype of an exams platform and documentation allowing others to reproduce it (see Design Specification).
Increased awareness by educators of the diversity of question types possible with e-exams.	A set of example questions that can be used in e-exams.
Increased awareness of quality processes and procedures for running e-exams.	A research-informed set of good practice guidelines on e-exam processes and procedures.
Increased awareness by educators of how they can better prepare students for e-exams.	A guide on preparing students for e-exams.
A collection of data to develop a further project application that will implement and evaluate a fully robust e-exams platform which will involve implementation in multiple institutions.	A project report and related publications that will include a summary of the data collected and findings.

Conclusion

The argument presented in this paper is that given the range of environmental conditions, drivers and requirements that exist there is a strong need develop an e-exams solution for the Australian higher education sector. Further, that such an effort needs to include the development of a multifaceted systems solution covering not just technology in the form of software and hardware elements but also the associated good practice guidelines covering, policy, process and procedures. These deliberations have so far give rise to three main questions that will drive further research. These are:

(1) How can e-exams be developed that are scalable, sustainable and valid across different contexts?

(2) How can educators prepare and run e-exams?

(3) How can educators prepare students adequately for e-exams?

To launch the research program we have presented a preliminary set of design specifications and the associated processes to illustrate how a suitable e-exam platform might be used in practice. It is anticipated that the findings from further research will result in the development and refinement of a robust e-exams implementation as well as a body of evidence to demonstrate the use of the system across a range of discipline areas and institutions.

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Appendix 1 – Concept map of the components of an e-exam system
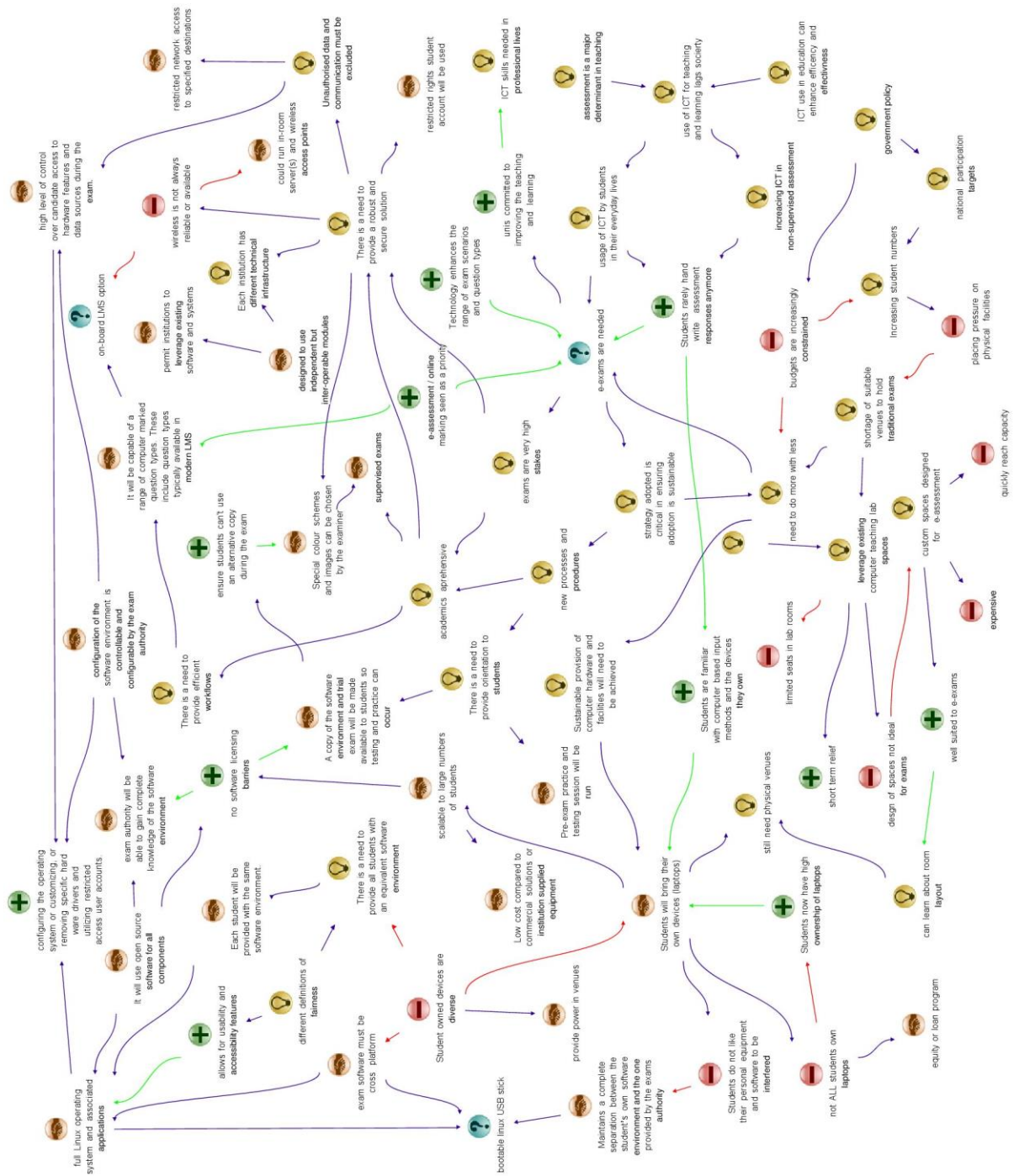
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