Transforming Exams:

Processes and platform for e-Exams in supervised BYOD environments

Final Report 2014

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http://transformingexams.com/

Acknowledgements

List of acronyms used

ALTC	Australian Learning and Teaching Council Ltd
ASCILITE	Australasian Society for Computers in Learning in Tertiary Education
BYOD	Bring your own device (in the e-exam project this meant 'laptop' computer)
CEIT	Centre for Educational Innovation and Technology at UQ (now disestablished).
CQU	Central Queensland University
DIY	Do-it-yourself
EAIT	Engineering, Architecture and Information Technology faculty at UQ
EITT	Educational Innovation Through Technology conference
EOI	Expression of Interest
HABS	Health and Behavioural Science faculty at UQ
HERDSA	Higher Education Research and Development Society of Australasia
ICT	Information and Communications Technology
ISO (image file)	A commonly used file type for storing a complete 'package' of data that makes up a drive, CDROM or USB stick. ISO files are used in the e-Exam project to store a complete image of the e-Exam System USB stick and make this available to download. The ISO files distributed by the e-Exam project are compatible with OSX, Linux and Windows operating systems. Originally ISO images files were used to store the data contents of an optical disc, including the optical disc file system with the acronym taken from the ISO 9660 file system used with CD-ROM media.
ITaLI	Institute for Teaching and Learning Innovation at UQ (formed in August 2014)
LMS	Learning Management System (such as Blackboard or Moodle)
OLT	Office for Learning and Teaching (Australian Government; successor to the ALTC)
OSCE	Objective Structured Clinical Examination (practical examination)
T&L	Teaching and learning
TEDI	Teaching and Educational Development Institute at UQ (now disestablished).
UQ	The University of Queensland
UTAS	The University of Tasmania

Executive summary

This 'Transforming Exams' seed grant developed a proof of concept for a bring-your-own-device (BYOD) based e-Exams approach. This included the development of practice guides and technology components that were verified via live trials at The University of Queensland (UQ) and University of Tasmania (UTAS) using the prototype e-Exam System (student module) software. The approach built on prior work undertaken by Dr Andrew Fluck at UTAS and the exploration carried out though Professor Geoffrey Crisp's Australian Learning and Teaching Council (ALTC) e-assessment fellowship and Dr Mathew Hillier's subsequent Office for Learning and teaching (OLT) extension grant.

The approach to computerised examinations considered a systems view of high stakes assessment that took in the concerns of stakeholders, desirable pedagogical capabilities, technology affordances and available facilities. A multi stage research program surrounded the development of the approach that included consultation with academic and practice literature as well as a range of stakeholders including students, academics, exams officers, technology support and senior leadership of the host institution. Data was collected from students involved in exam trials at points before and after the exam event that included first impressions, technical information, exam experience, exam writing strategies as well as general writing strategies and use of computers in their learning outside of examinations.

The approach to computerised examinations entails making a 'whole computer' environment available in the supervised exam room context in a way that leverages the availability of bring-your-own laptops supplied by students while maintaining controlled, consistent software facilities for all candidates. The e-Exam system provides for a transition from paper-based assessment, though paper-equivalent assessment to post-paper assessments that can include multimedia, simulations, virtual experiments, spread sheets and the ability to host a range of discipline specific software tools. The software is highly configurable allowing for word processor based exams, and with further development, computer marked question based on an on-board Moodle learning management system. Access to the Internet is optional and configurable. Where reliable and robust network connectivity can be provided the e-Exam system can also serve as a restricted gateway to online hosted exams within an institutional LMS.

The e-Exam system software, based on a Linux Live USB stick leaves the hard drive of student owned equipment untouched while allowing the examining authority control over the software environment. The e-Exam system software client is wholly made up of open source elements thus eliminating the costs associated with purchasing and managing commercial software licenses.

As a part of this seed project, a series of dissemination events were hosted to gauge interest by audiences in the e-exam concept and to spread news of the work. The feedback gathered from event participants is included in this report, as are details of the events held. Events included conference presentations and seminars or briefing sessions held directly at institutions in Australia, New Zealand, Singapore, Hong Kong as well as online. As a result expressions of interest were received from over 30 institutions to trial the e-exam approach or to be kept in touch with project developments. Further connections were made with over half dozen institutions participating in an international online conference hosted by the project leader on e-Exams. These connections were formed with a view to facilitating information and technology exchange in the future.

The prototype e-exam system is available to the public for download from the project website at www.transformingexams.com as are all research outputs from the live trials, and user guides for students and technical administrators. Finally, a set of recommendations for the further development of the e-Exam approach is provided at the conclusion of this report.

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The Seed Project

Outcomes and Impacts

The major proposed outcomes of the seed grant were achieved. The proof of concept of a bring-your-own-device (BYOD) based e-Exams approach that includes the development of practice guides and technology components was verified via live trials at The University of Queensland (UQ) and University of Tasmania (UTAS) using the prototype e-Exam System (student module) software. The status of each of the original project outcomes and deliverables is outlined in Table 1.

Table 1 Proposed and actual project outcomes and deliverables

Proposed	Actual Output
Outcome 1: to model an e-exam platform to be used in supervised, BYOD settings that includes options for computer marked questions. Deliverable 1: a working prototype of an exams platform and documentation allowing others to reproduce it.	**Complete** (but ongoing work warranted) The e-Exam System (Hillier, Fluck & Emerson, 2014) version 5 software client (student user portion) was developed to an advanced prototype stage. It has relatively mature features with regard to 'paper-equivalent' and 'post-paper' word processor based e-Exams. The software remains at a working prototype (or demo) with regard to the more advanced features such as the computer marked question types (on-board Moodle) and remote learning management system (LMS) exam modes. Several versions of the e-Exam System software client (student user portion) have been released on open source terms. This is in the form of ISO disk images available for download. These need to be 'burnt' (written) to a USB stick for use. The e-Exam System client has been used for real assessments in courses at UTAS and UQ. The e-exam trials at UQ took the form of 'paper-equivalent' exams and the UTAS trials utilised a 'post-paper' approach in some trials. Both used the word processor features of the e-Exam System. Students at UTAS responded to video clips, accessed PDF documents and critically commented on software they ran on their computers during the exam. The document 'Demo set up guide' provides instructions to allow others to create their own e-Exam System USB sticks from the provided ISO file. Details of how the USB can be configured to enable it to serve different types of exams and how to set-up a custom exam are also provided. Although outside of the scope of the seed grant, a set of prototype administrative tools in the form of command line scripts were developed to assist technical administrators to manage e-Exam USB sticks in batches. These include the creation of new e-Exam USB sticks from a set of newly purchased blank sticks (one to many duplication), batch retrieval of student responses (many to one file copy), re-set batches of e-Exam USB sticks for the next round of exams, copy files from one source to many e-Exam USB sticks and a script to clean-up single USB after testing (prior to duplication). However, further work is needed before a 'whole e-exam workflow' can be managed in a scalable manner by non-technical personnel (see 'Future Work').

Outcome 2: increased awareness by educators of the diversity of question types possible with e-Exams. Deliverable 2: a set of example questions that can be used in e-Exams.	**Complete** (but ongoing work warranted) Awareness has increased though the inclusion in presentations examples of e-exam question types that become possible once computers are adopted in the exam room. The provision of example e-Exams via the project website also services to increase the awareness of what is possible. Selected generic examples were included by default in the software demo download (ISO file). These take the form of word processor style example template and an on-board Moodle quiz configured as a demo exam. In addition, the work undertaken in the OLT extension grant "Transforming Assessment" included a range of e-assessment examples that can equally be applied to the e-exam context.
Outcome 3: increased awareness of quality processes and procedures for running e-Exams. Deliverable 3: a research-informed set of good practice guidelines on e-exam processes and procedures.	**Complete** (but ongoing work warranted) An e-exam bibliography was collated (see Appendix A) to inform the development of processes and practice guides around e-Exams. The e-Exams bibliography has been integrated into the more general e-assessment bibliography produced for the OLT extension grant "Transforming Assessment". This is available as an online Zotero library with the e-Exam items tagged with "e-Exams". The e-Exams items can be directly listed via the link: https://www.zotero.org/groups/e-assessment/items/tag/e-Exams The action research carried out as part of the e-exam trials conducted during 2014 further informed the development of the practice guides. These guides are available via the project website and have been developed to an advanced draft stage. Guides are available for setting up the demo e-Exam system, configuring it for use in real exams and running an e-Exam trial. A guide for students was also developed (see deliverable 4). It is intended that these guides will be further refined in the future.
Outcome 4: increased awareness by educators of how they can better prepare students for e-Exams. Deliverable 4: a guide on preparing students for e-Exams.	**Complete** (ongoing work warranted) Awareness of educators involved in the trial was increased and that of others in the sector via seminars and presentations given by members of the project team (see the Dissemination and Engagement section). A set of guides related to preparing students was developed to an advanced draft stage as per the seed grant proposal. These include a 'set-up and practice guide for students' and an outline of the steps students take to engage with the e-exam trials ('student preparation guide'), both of which were customised for the UQ trials but will form the basis of a future guide for e-exam preparation procedures. An in-room exam procedures card (double sided A4 sheet) for students is also provided. All guides are available to download from the project website.
Outcome 5: 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.	**Complete** (ongoing work warranted) A range of data was collected that includes technical data, student perceptions and observations of exam sessions. Research and discussions with other institutions internationally running various forms of e-Exams practice has also afforded further lessons. • The final report (this document) provides detail on the approach taken to trial e-Exams in this project and the project outcomes. • The results from the post-exam survey from semester 1 and 2 2014 have been disseminated via presentations and conferences. A summary of the combined semester 1 and semester 2 trial results is available from the project website. • Papers and posters on the rationale for e-Exams were published

Deliverable 5: a project report and related publications that will include a summary of the data collected and findings.	at the 'Transforming Assessment in the Digital Era' conference in Melbourne in 2013, at the ASCILITE 2013 conference in Sydney and the HERDSA 2014 conference in Hong Kong. Further publications will appear at ASCILITE 2014 and other suitable outlets.
	• A number of briefings and presentations have been given to: Bond University, Griffith University, National University of Singapore, NgeeAnn Polytechnic (Singapore), Singapore Tech University and University of Hong Kong. Invited presentations were given at Transforming Assessment in the Digital Era in Melbourne 2013, at the Exams Network conference held in Brisbane in 2013 and Armidale (NSW) in 2014, the Australian Computers in Education Conference in Adelaide, as well as at the Educational Innovation Through Technology conference in Brisbane in late October 2014.
	• Further dissemination occurred at the ASCILITE 2014 conference in November held in Dunedin, NZ and a briefing to James Cook University in early 2015. It is anticipated that further briefings to institutions will continue to occur on an invitational basis.
	• Additional trials in courses at UQ, UTAS and at other institutions are being planned or are in progress. Central Queensland University (CQU) have successfully conducted a small scale trial of the e-Exam system in their School of IT with plans for a larger scale trial underway. A UQ research higher degree student who is undertaking a dissertation relating to e-Exams in language testing used the e-Exam system on board Moodle for a pilot round of data collection with a possibility to extend its use into a university in Oman.
	• Expressions of interest in trialling and collaboration have also been received from over a dozen universities across Australia ranging from Group of Eight to regional institutions.
	• The recent e-Assessment joint online conference conducted as part of an OLT extension grant 'Transforming Assessment' was held with e-Assessment Scotland in September 2014 with 'e-Exams' as the main theme. This event has triggered the beginnings of an international e-Exams community. Early plans for collaborations with institutions in Australia, New Zealand Singapore, Hong Kong, China (mainland), Canada, Finland, Germany, Switzerland and the UK are underway. Collaborations could involve information, joint research and technology exchange.
	The above data and findings place the project team in an excellent position to carry out future work, which will see the implementation and evaluation of a robust approach to e-Exams that will be broadly applicable to the higher education sector. To this end an OLT Innovation and Development grant application is under development.

All deliverable items are available on the project website at http://transformingexams.com/

Approach and Method

The project was developed in full recognition that an approach to e-Exams must work within the broader 'system' (Ackoff, 1999; Checkland & Scholes, 1990) of high stakes assessment and the institutional context. This recognition led to a series of identified requirements and desirable features that were articulated in the original project proposal and published in a

paper by Hillier and Fluck (2013).

The project was multi track in that it sought to simultaneously explore the practices surrounding e-Exams while also developing a technology platform in the style of action research. The technology track took on an iterative prototyping approach that reacted to the findings from the practice based research activities with incremental improvements being made to the e-Exam System software. Each incremental improvement and feature was released via the project website with the software being made available via the open source repository Sourceforge.

In recognition of the complex systems nature of the problem domain the project team sought the 'multiple perspectives' (Linstone & Mitroff, 1993) of a range of stakeholders. Consultation with internal stakeholders at UQ included:
- students (via pre-implementation survey, pre-exam impressions and technical survey and a post-exam experience survey)
- academics via their participation in the e-exam trials
- the institutional central Assessment Sub-committee (as a point of liaison to faculties and as the body providing formal approval for e-exam trials)
- the university examinations office,
- heads of schools (to authorise trials),
- the library circulation desk (to allow lending of practice kits),
- student IT help desk,
- the director of the educational technology innovation unit (for advice on educational technology innovation),
- the academic IT services unit, and
- the central teaching support unit (the host unit of this project).

The research program surrounding e-exam practices started with an ethics approval being obtained from the institutional ethics committee for all phases of data collection. Formal approval for the trials at UQ was also obtained from the UQ central Assessment Sub-committee who specified a set of criteria that e-exam trials had to meet. The criteria served to mitigate risk associated with applying new technologies and approaches to high stakes assessment. These criteria were:
- giving students a choice to type or handwrite their exam in semester 1 with a case by case approval for small scale 'computer compulsory' exams permitted in semester 2,
- that exams had to be locally administered by schools (no central exams),
- that the exams could be no greater then a given percentage of the course grade (15% semester 1, increased to 25% in semester 2),
- a limit on class sizes of 100 (this was uncapped in semester 2 provided adequate resources and contingency could be provided), and
- that the exam trial had to be approved by the head of school in charge of the course.

These conditions effectively meant that the UQ e-exam trials would need to take place in the mid-semester exam period rather then the end-of-semester exam period and that only 'paper-equivalent' exams could be undertaken in semester 1. Although post-paper exams were possible on a case-by-case basis in semester 2, no such opportunity eventuated. These adjustments flowed though as changes to the iterative schedule of development and trials.

This first phase of data collection on e-exam practices was a broad-brush survey of student perceptions of the idea of e-Exams (and e-assessment more generally). This was made available online to all students at UQ with links placed on the UQ LMS and via posts on social media groups. The survey could be more accurately described as a survey of the preconceptions held by students given that there was a very low instance of formal computerised or online exams being conducted at UQ; other than formative online quizzes or 'take-home' style online exams. The results of this survey provided insight into the concerns held by students ahead of the implementation trials. The findings of this survey were presented at the HERDSA conference (See Hillier & Tran, 2014a) with a full paper of results published in the November 2014 ASCILITE conference (Hillier & Tran, 2014b).

The next phase was to undertake the live e-exam trials in several courses. These took the form of mid semester exams that provided students with a choice of the text production method via pen or keyboard. The method adopted to run trials was multi part with students first submitting an expression of interest and registering their informed consent. Those that indicated interest in typing their exam were then asked to attend a practice session at which they were able to ensure their laptop would work with the e-Exam System USB stick and to practice using the system. They were asked to report their first impressions of the e-Exam System and the technical details of their laptop via a short survey. The hardware compatibility data collected via this survey contributed to improving the system performance across a range of laptop devices while the impressions data contributed to the analysis of student perceptions of the system. The survey instrument used to collect the pre-exam data is available from the project website.

Based on their experience during the practice sessions students then indicated if they would type their exam. This provided a basis for preparing the number of required e-Exam USB sticks and the room set-up for the exam event.

On the exam day the room was setup with power boards, instruction sheets and arranged, where feasible, to minimise the direct line of sight between computer screens. Each trial took place in a different room on campus; each being different in its layout, furnishings, power supply and acoustic characteristics. As such the arrangements for each exam took different forms depending on the room fit out (power socket locations in walls or in fixed tables, tables being fixed or mobile). In two of the six exams the typists and the hand-writers were placed in separate rooms. Further details of each trial undertaken at UQ, including details of each exam, participation and room fit-outs are available in the document 'e-Exam Trial Cases' which can be obtained from the project website.

At the start of the exam students entered the room and were seated. They placed their laptops on the table and were each handed an e-Exam USB stick. Students started the computer using the USB stick and awaited instructions to begin. The exam supervisor checked all was well; a unique 'security image' that was set as the desktop 'wallpaper' indicated that each student had booted the correct USB stick. Both typists and those handwriting started at the same time. At the end of the exam the typists were asked to ensure they had saved their file before shutting down. The USB sticks were collected and then students were handed a post-exam survey to complete before they left the room. This ensured a high response rate for this survey. The survey covered a range of issues from their experience of the exam, the e-exam system, the suitability of the exam content for computerisation, their typing and writing behaviours during the exam and in the general course of their studies. The results from the semester 1 2014 trials were published in brief in the form of poster (Hillier & Fluck, 2014). The aggregated summary of results covering all six trials conducted across semester 1 and 2 2014 is available in the document 'e-Exams: UQ Trial Results' obtainable from the project website. The aggregated results include a range of statistics and charts covering all items on the post-exam survey completed by students.

The action research aspect or 'research through doing' resulted in the further refinement of the trial procedures and the refinement of practice guides. These are presented in an advanced draft form and are available from the project website.

Building Knowledge and Forming Links

This section provides information on how the project used and advanced existing knowledge. Links are drawn with OLT program priorities and current or previous OLT (or predecessor bodies') work. Details of an 'e-Exams' bibliography is also provided.

Building on prior work

This e-Exams seed project builds on two steams of previous activity. This includes the prior work of Dr Fluck at UTAS on the use of BYOD laptops for e-Exams and the ideas on e-assessment developed through Professor Geoffrey Crisp's ALTC fellowship in 2008 followed by his national fellowship in 2011. The 'Transforming Assessment' webinar series that has continued under the auspices of the OLT extension grant lead by Dr Hillier provided the catalyst for the merger of these two streams of activity. A presentation by Dr Fluck of his 'eExam' approach for the 'Transforming Assessment' monthly webinar series in early 2013 lead to a realisation that the current lack of e-assessment within high stakes testing could potentially be overcome. Bringing together several years of exploration of e-assessment for formative assessment (under 'Transforming Assessment) and the broad and open approach of Dr Fluck's eExam would allow a wide range of e-assessments to be possible within the high stakes setting. The open, 'whole computer' platform adopted meant that no longer would computerised testing be limited to 'armoured word processors' or online multiple choice questions. At that point onwards the rationale for the development of the e-Exam approach was developed and has been articulated in the published paper by Hillier and Fluck (2013). This paper drew upon a systems approach to considering the complexity within which an e-exam solution must fit and in doing the authors drew upon relevant literature.

Making links

The potential of a 'whole computer' approach to examinations that this seed grant has expanded upon will enable many of the ICT enhanced learning and assessment approaches used in progressive assessment to become possible within the supervised exam room setting. Just like a desktop computer environment, the e-Exam System permits the use of a full office suite that includes a word processor, spread sheet and presentation software, graphics drawing software, multimedia players and the ability to run a range third party software tools. However, we have taken the environment beyond that of a standard desktop computer by adding the capability to run a range of web applications directly within the system, all without requiring an Internet connection. Such a facility within the exam room will dramatically increase the 'pedagogical landscape' available to examiners. Examples of the type of tools and approaches that could potentially be made available within a high stakes testing scenario now include Virtual microscopy (CG7-398 Kumar et al. 2009), Virtual side box (CG7-467 Farah, Mills, Aland, Lakhani & Maybury 2010), and computerised histology resources (Meyer 2011). Tools such as the Conversation Sim (SD12-2258 Nelson & Dawson 2014) and digital patients (CG7-431 Newby et al. 2011) could also be integrated. In addition, the use of 3D virtual environments as constructed for 'Get a MUVE on' (PP9-1392 Matthews & Agutter 2014) and simulations such as VirtualPREX (PP10-1775 Gregory, et al. 2013) and the immersive Chinese foreign language environment (SD13-3445 Grant et al 2013) could be enabled by adding open source web applications as proposed in Gregory, Jacka, Hillier and Grant (2014).

A shift to e-Exams has the potential to lead a range of systemic changes in almost all discipline areas. The possibility for unblocking some of the limitations to changing curriculum though alleviating the need to 'teach towards a paper exam' is also a tantalising prospect. The impacts will be felt to differing degrees and will manifest in various ways in each discipline area just as the application of ICT in progressive assessment varies across the disciplines. The ability to combine the tools that have been used in progressive assessment to date with the capabilities provided by the e-Exam System platform will allow for pedagogical possibilities in the exam room beyond anything currently available.

Further we took the view that the operation of the e-Exam System must fit within the broader assessment workflow and educational context. The products of this seed grant fit into a wider landscape of related tools. The project team is aware of OLT projects such as ReMarksPDF (PP10-1751 Colbran 2014) and the Computer aided feedback and assessment system (PP654 Freney 2010) for their potential to provide e-marking capabilities for word processed e-exam responses. Meanwhile the development of computer marked question

capabilities via the on-board Moodle LMS will mean that a range of exam question types can be automatically assessed. However, further technical work is needed on this element of the system before it can be used in a scalable manner.

OLT priority areas

This seed grant builds on the previous OLT program priorities in assessment and technology enhanced learning and continues to be relevant to the refined focus the OLT has on assessment across institutions. The recent work commissioned on learning analytics (Siemens, Dawson & Lynch 2013) has highlighted to the project team the current gap that exists with respect to the knowledge of student performance in current paper-based examinations. This in the main stems from the difficulty in obtaining detailed student activity and performance data and then making this available in a usable format. As a result we see relatively sparse feedback being available to students and only very rare analysis of the efficacy of the exam questions. The computerisation of the exam space will lead to a vast array of data points becoming available that will open up the possibility for research and detailed feedback on the behaviour and assessment choices of students during exams. The early ALTC learning analytics project by Dawson and McWilliam (2008) highlighted the potential of data mining from LMSs but also warned about the risks of closed source platforms in hampering innovation and progress. The adoption of open source components including the Moodle LMS, used by half the universities in Australia, for the e-Exam platform will mean that detailed data from student actions and assessment responses in exams will become much more readily available for further analysis. The later OLT commissioned project summarising the field of contemporary analytics (Siemens, Dawson & Lynch 2013) provided extensive examples of how such data could potentially be used to improve educational outcomes. The flow of data from computerised examinations will greatly improve the ability for higher education institutions to 'close the feedback loop' to students with regard to high stakes exams. It will also provide academics with detailed information on the efficacy of individual questions through techniques such as item response analysis.

Exploring discipline contexts

The trials undertaken in this seed project occurred in several discipline areas across UQ utilising the 'paper-equivalent' features of the e-exam system. The mid semester exam trials have included the following courses and exam types:
- animal Biology: 45 min, mixed short answer and MCQ (type an 'x' to respond),
- zoology (BIOL): 50 min short answer, some with diagram prompts (and MCQ section done pen on OMR sheet),
- criminology: 70 minutes. Single long essay response section (a MCQ section was done pen on OMR sheet),
- occupational Therapy: 100 min mixed short answer and MCQ (type an 'x' to respond),
- physiotherapy: 15 min watch video case and write observations, prior to an OSCE practical exam, and
- veterinary technology: 90 min theory, mostly short answer with some MCQ (type an 'x' to respond) and image prompts.

All exams undertaken by students contributed to their final course grade. Further details of each trial undertaken at UQ are detailed in the document 'e-Exam Trial Cases' which is available from the project website. Also available from the same website is the aggregated results from all six trials that includes a range of statistics and charts covering all items on the post-exam survey completed by students.

Trials took place at UTAS that utilised the 'post-paper' capabilities of the exam system with the result of the exams contributing to student course grades. The e-Exam System has been used at UTAS in disciplines such as Education (technology in schools), History, Law and Medicine. The UTAS trials used the word processor based functionality of e-exam system, with some also making use of applications such as media players, presentation software and educational software. The trials provided further insight into the variation of approaches

used by academics in high stakes exams across a range of disciplines. The post-paper examination in Digital Technologies (Education) was conducted in three campus locations in Tasmania, and 35 sites around Australia and Qatar. This contributed 50% to the final assessment for each candidate, and illustrates how the e-Exam system can work within the broader context of systems surrounding examination administration.

Further, CQU took it upon themselves to run a small e-exam trial within their School of Information Technology. They received guidance from the project team via regular email communication. This was successful and they are now looking to expand the trial to multiple courses and campuses.

Making connections

Towards the end of the project an opportunity arose to further leverage the activity of the OLT 'Transforming Assessment' extension grant activity in the form of a forum for dissemination. The OLT seed grant focus on e-Exams was recognised through adopting the theme of 'e-Exams' for the e-Assessment Scotland/Transforming Assessment joint online conference held in September (Hillier, 2014). This led to the gathering of interested experts in e-Exams from institutions in Asia, Australia, Europe, the UK, and North America. This event in turn sparked the beginnings of an international e-Exams community where the sharing of expertise can take place. To date a number of international links have been made with institutions in Australia, New Zealand, Singapore, Hong Kong, China (mainland), Canada, Finland, Germany, Switzerland and the UK. In addition, a range of connections were also made domestically through participants who attended presentations and seminars conducted at conferences and at institutions. Further details of these sessions are available in the Evaluation section.

It is anticipated that this burgeoning community will be leveraged in developing partnerships to undertake future work.

Key lessons

This section provides a brief analysis of several factors that were critical to the success of the approach.

Approvals

Seek and obtain approvals early on in the trial as committee processes often take longer than anticipated due to infrequent meeting timing, lack of a quorum or rescheduled meetings. Approvals from a central, senior committee lends authority and credibility to the e-exam trials. This facilitates cooperation where input requires the deployment of resources from other organisational units.

A gentle introduction

There are many variables to consider in developing a successful approach to e-Exams that will work within the local context at each institution. A gradual implementation approach is recommended, starting with 'paper-equivalent' exams that provide students with the choice of pen or keyboard. This allows both students and staff to gain experience in the logistics and dynamics of e-Exams. The limitations placed on e-exam trials as outlined in the method section would be a good place to start in developing new trial sites.

Pre-exam preparation for students

Paying attention to preparing students and checking over the laptops they propose to bring into the exam room. Pre-checks and providing the opportunity to practice e-exam procedures will go a long way to catching a problem before it gets into the stressful

environment of the exam room. The running of pre-exam set-up and practice sessions is of much greater significance when undertaking e-Exams with students from non-technical disciplines who are less familiar with operating systems and hardware. In disciplines where the student body has a greater use of IT then the use of DIY set-up by students will reduce the need to run as many set-up sessions.

Pre-exam preparation for teaching staff

Providing a timetable for actions and deliverables in the run up to the exam event will assist planning and timely submission of key items (e.g. timely notification to students in the course, submission of the exam script). Providing templates for messages, notices, and example exam files for paper equivalent exams will allow academics to construct exams that will work in both paper and keyboard mode. The lessons learnt from iterations of e-exam trials lead to the templates being refined over time. The final version of the exam script needs to be tested and adjusted in the exam system itself to ensure any minor formatting differences are corrected before producing the USBs for each student. Example exam question templates are available from the project website.

Generalisability

The concept of e-Exams is broadly applicable to all institutions in the higher education sector. However the shape this takes will be different in each, as is the implementation and use of many other teaching focused technologies. Current paper-based examination procedures vary between institutions and so too will e-exam approaches. The technical and procedural approach being advocated though this project has found success in the trials and use in 'real' exams at the two project partner institutions and at one external institution to date.

The trials undertaken at UQ were focused on examinations taking place on a centralised campus setting. At UQ the exam trials were undertaken on two campuses and in one course where distance education students were enrolled. However in each case the courses were wholly offered on that campus and all students were required to attend the campus to undertake examinations. All exams in the trial were administered locally by each school rather than via the central exams office. This afforded a high level of control over the conduct of each exam by the project leader who steered the e-exam elements of each exam and prepared the e-Exam System infrastructure. The limited number of trials were manageable under this arrangement but scaling in due course will require involvement of the central exams office.

The trials undertaken at UTAS involved some multi-campus and external courses and were administered via the central exams office. The multi-campus environment brings the need to adjust procedures around examination training, instruction, adequate and timely distribution of exam materials (USB sticks), technical support, collection and return. External exam centres or locations bring additional challenges to ensure exam materials arrive on-time as there is no ability to 'fax through' the script at the last minute. Providing clear instructions as to procedure and the nature of BYOD equipment provision will avoid confusion when students turn up to the exam carrying their own laptops.

Further, interest from the School of Information Technology at the CQU saw them run a small trial of the e-Exam system in September 2014. The trial was successful with plans being made to run larger scale trials.

Dissemination and Engagement

In developing dissemination and engagement strategies significant attention was paid to the D-Cubed Guide (Hinton, Gannaway, Berry, & Moore, 2011). Details of the dissemination and engagement activities and techniques used during this project are outlined in this section.

Website

The main website for the project was established at <transformingexams.com> and is a gateway to all project resources.
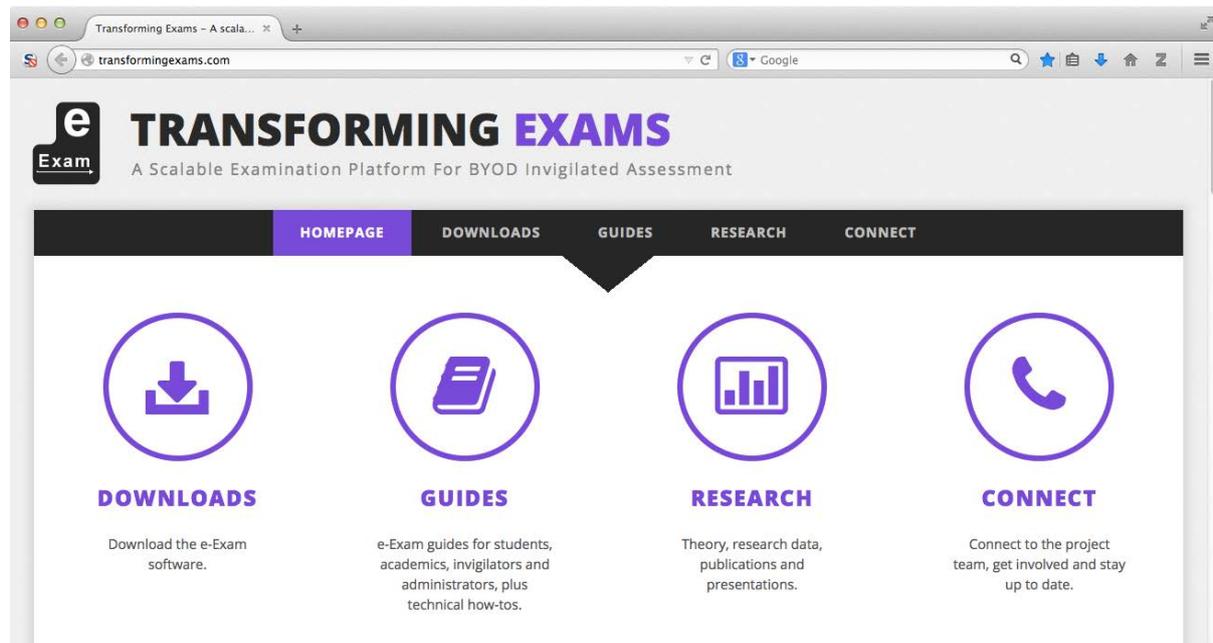
Figure 1 Transforming Exams project website home page
The website has areas for downloads, guides, research and contacts. A page was also created for the UQ trials and this is can be found under the research section.

Sharing Resources Electronically + Webpages, online repositories, audio-visual material and online content

All products of the project are freely available to the higher education community on open licence terms via the project website. This includes:
- the e-Exam System software for download as an ISO file made available on open source GPL licence terms,
- all written materials such as guides, template and example files are available under creative commons,
- demonstration videos were also created and made available via the website on creative commons terms, and
- research findings, presentations and publications.

Branding

A brand logo (e-exam logo) and a colour scheme for the project unified the products, documentation and communications of the project. The e-Exam logo and branding remains copyright all rights reserved to ensure only officially released materials are identifiable to the project.

Conferences + Meetings, discussions, roundtables and invited presentations

The basis for development of the e-exam approach as well as the outcomes of the project has been disseminated via presentations, conference papers and directly via briefings.

The initial requirements framework for the development of e-Exams was published as a refereed conference paper (Hillier & Fluck, 2013) early in the life of the project at the Australasian Society for Computers in Learning in Tertiary Education in December 2013 titled "Arguing again for e-Exams for high examinations". The paper can be obtained from http://transformingexams.com/files/hillier_fluck_2013_ascilite_fullpaper.pdf. Further invited presentations were given by Fluck (2013) and Hillier (2013a) at the July 'Transforming Assessment in the Digital Era' conference held in Melbourne and by Hillier in both the 2013 and 2014 Exams Network Conferences held in Brisbane (Hillier, 2013b) and Armidale respectively (Hillier, 2014a) as well as the Educational Innovation Through Technology conference held in Brisbane (Hillier, 2014c). At the Melbourne event and the Brisbane Exams Network conference the audience was surveyed for their views on e-Exams and expressions of interest in future collaboration collected (results are available in the Evaluation section).

The results of an institution wide student survey conducted at UQ in late 2013 sought to gather the preconceptions of students prior to running the e-Exams trials. This served to assemble the concerns held by students which in turn informed the development of appropriate mitigations strategies for introducing e-Exams. The results relating to the views of students on e-Exams was published in two phases. First, a portion of these results was presented at the 2014 Higher Education Research and Development Society of Australasia (HERDSA) Conference in Hong Kong during July, in a special presentation by Hillier (Hillier & Tran, 2014a) titled "Student Perceptions of e-Exams: Hopes and Fears". An abstract of the presentation is at http://chtl.hkbu.edu.hk/herdsa2014/abstract/s173.php and the presentation slide file containing a number of result charts is at http://transformingexams.com/files/HERDSA_special_presentation_july_2014_pre_survey-final_version.pdf. Secondly, a full paper containing all of the the findings relating to the views of students on e-Exams appeared as "The Very Idea of e-Exams: Student (Pre)conceptions" (Hillier & Tran, 2014b) at the 2014 Australasian Society for Computers in Learning in Tertiary Education conference in Dunedin, New Zealand. This paper is available from http://transformingexams.com/files/hillier_2014_ascilite_full_paper_prepress.pdf

Finally the broader implications for curriculum change as a result of the introduction of e-Exams were put forward in a refereed paper written by Fluck and Hillier (2014). The paper titled "eExams Transforming Curriculum" was presented at the Australian Computers in Education Conference held in Adelaide during late September and early October. The full paper can be obtained from the conference proceedings at http://acec2014.acce.edu.au/sites/2014/files/2014ConfProceedingsFinal.pdf. Further uses of the e-Exam System platform as a basis for an offline formative assessment infrastructure for "Using virtual worlds in rural and regional educational institutions" and remote students was written up as a co-authored conference paper by Gregory, Jacka, Hillier and Grant (2014). This was presented at the October 2014 Society for the Provision of Education in Rural Australia conference in Armidale, NSW. The paper can be obtained from http://transformingexams.com/files/SPERA_2014.pdf

Early progress on the UQ e-Exam trials was presented as part of a joint online presentation (Hillier & Seow, 2014) titled "Bring-your-own-device to e-Examinations" for the ASCILITE Live Webinar Series hosted by the National University of Singapore in May. A latter summary of a portion of the findings from the first series of 2014 e-exam trials at UQ was presented in the form of a poster (Hillier & Fluck, 2014) titled "e-Exam System v5: A Secure, Scalable, Ethical Approach to High Stakes e-Assessment". The poster was displayed at the July 2014 Higher Education Research and Development Society of Australasia (HERDSA) conference in Hong Kong. The poster abstract is available at http://chtl.hkbu.edu.hk/herdsa2014/abstract/p184.php and the poster itself is online at http://transformingexams.com/files/herdsa_poster_2014.pdf.

An invited presentation on the e-Exam project was given by Hillier (2014c) at the October Educational Innovation Through Technology conference held in Brisbane. An update that

covers both the first and second series of 2014 trials will appear as a poster at the 2014 Australasian Society for Computers in Learning in Tertiary Education conference in Dunedin, New Zealand. The full set of summary results from all six trials held at UQ is available from the project website and will also appear along with an expanded discussion in further refereed publications in due course.

Fluck (2014) presented an online seminar titled "BYOD on-campus eExams at University of Tasmania (UTAS)" as part of the joint eAssessment Scotland and Transforming Assessment Online Conference on 8 September 2014. This session covered the experience of running exams at UTAS as well as some of the procedural and technical challenges to be addressed in developing highly robust e-Exams. The session synopsis and a video recording is available from http://transformingassessment.com/eAS_2014/events_8_september_2014.php

Publications planned in the near future include a look at the pre-exam 'first sighting' impressions survey results and technical data collected during setup/practice sessions. Further data analysis is also planned that is anticipated to enable us to follow a number of participants from the point of first contact though to exam completion. The findings of this analysis will appear in presentations or publications in due course.

In addition to formal presentations, several workshops and briefings were held (or are planned) at individual institutions. These provided an opportunity to speak directly with decision makers and interested staff in order to share the progress of the project and seek their views on the issues surrounding e-Exams. On several occasions a short feedback survey was issued to seminar participants allowing for written feedback and the collation of expressions of interest in future collaboration. These events are listed in Table 2 and the results of the feedback survey are available in the Evaluation section.

Table 2 Schedule of seminars hosted by institutions and private briefing sessions

27-28 Aug 2014	Griffith University, Gold Coast and Nathan campuses	Seminar on e-Assessment (with Prof. Geoff Crisp) and e-Exams. Survey administered and EOIs collected.
16 July 2014	Singapore Institute of Technology	Private briefing to discuss e-Exams ideas.
16 July 2014	Ngee Ann Polytechnic, Singapore	Private briefing to discuss e-Exams ideas.
15 July 2014	Centre for Development of Teaching and Learning, National University of Singapore	Seminar given to NUS academics and support staff on e-Assessment and the findings of the semester 1 2014 UQ e-Exams trials. Private briefing session with leadership of CDTL to discuss e-Exams ideas.
4 July 2014	Center for Enhancement of Teaching and Learning, University of Hong Kong	Private briefing with centre leadership to discuss e-Exams ideas.
15 May 2014	ASCILITE Live webinar series, [online]	Online webinar session to disseminate "UQ e-Exams trial preliminary findings". Hosted by the National University of Singapore.
4 April 2014	Bond University	Global Links Speaker Series presentation and post session discussion forum to discuss "Transforming Assessment with e-assessment for e-Exams". Survey administered and EOIs collected.

Presentations held within the UQ provided opportunities for dissemination and the collection of expressions of interest in running trials from academics. These are detailed in Table 3.

Table 3 Schedule of presentations held within University of Queensland

3 Nov 2014	UQ T&L Week	Major presentation of UQ trial results to the institution.
5 Feb 2014	UQ Assessment sub-committee	Provide overview of project and e-exam platform for purposes of seeking formal trial approval.
29 Jan 2014	Vet Science Teaching Innovation Day, UQ Gatton Campus	Provide overview of project and demonstration of prototype.
30 Oct 2013	UQ T&L Week (Science-EAIT T&L Showcase)	Provide overview of project and hands-on demonstration of early prototype.
28 Oct 2013	UQ T&L Week (Flipped Classroom Expo)	Provide overview of project and hands-on demonstration of early prototype.

Additional internal dissemination occurred through direct email contact and updates sent to Associate Deans Academic for each faculty and with the wider UQ community via the 'UQ Update' publication (sent via email to every UQ employee). Attendance at various faculty and school T&L committees also provided opportunities to notify the community about the project.

The OLT Seed grant received coverage in the 'Teaching at UQ' publication produced in late 2014 that showcases teaching and learning activities and innovations at UQ.

Guides and Teaching Materials

These took the form of user guides, technical guides, procedure guides and sample exams, all made available via the project website. The guides page of the project website http://transformingexams.com/guides.html has the following available:
- information flyers showing a 'features overview' and some example 'screens' from the e-Exam System,
- a 'demo features walk though' that graphically explores the system features detail,
- technical 'demo set-up guide' (how to create, configure, use and manage e-Exam USB sticks),
- a guide to 'setting up Moodle mode exams' (how to import and manage Moodle course content/quizzes),
- a series of laptop set-up and start-up guides for users that cover both Apple and different types of 'Windows' laptops,
- a pre-exam 'student preparation guide' (this provides an overview of the process students need to follow to participate in an e-exam trial),
- help videos that show how the e-exam software is started and used for exams; one each for Apple and 'windows' laptops,
- sample exams with question templates for academics, and
- links to further e-assessment question examples.

The web page for the trials at UQ http://transformingexams.com/uq_trials/ also provides the following:
- the trial process (step by step) used at UQ (as a web page),
- an information flyer and information slide set (for use in lectures),
- a do-it-yourself 'set-up and practice guide' for students. This was bundled as a kit made up of a document that contains relevant parts from the set-up, user and practice guides and an e-Exam USB stick configured to allow a manual 'reset' for the

next user (these were placed in the UQ campus libraries on short-term loan),
- the trial forms and information sheets for academics and student participants that have received institutional Ethics Committee approval,
- an in-room procedure guide (a double sided A4 sheet that is made available on each e-exam table that shows the e-exam process on the front and reminders of how to boot laptops to the e-Exam System USB on the back), and
- an email template for academics to seek head of school ('gate keeper') approval.
- links and copies of the data collection instruments used in each phase of the e-exam trials.

The UQ trials page will form the basis for a resource package to be made available to institutions wishing to trial the e-exam system and participate in the research program.

Influencing Policy at the Institution Level

Participation in university committees related to 'teaching and learning' and 'educational technology' allowed for increased awareness of the e-exam project and an opportunity to influence discussions as they related to policy formation.

Gaining approval via the UQ central Assessment Sub-committee (a subcommittee of the central Teaching and Learning committee) allowed for an open channel in relation to reporting and, when the time comes, making recommendations related to policy; including the policies governing the operation of the university examinations. This process is still ongoing but the open channel will make contributing to these discussions possible. In addition, the UTAS Academic Senate has approved the use of e-Exams as an option for centrally administered examinations and at the time of writing is undertaking a review to address broader expansion of its use.

Networks and Communities of Practice

Dr Hillier, as the project leader of the seed grant is also the leader of the 'Transforming Assessment' online webinar series on e-assessment. This has afforded opportunities for promotion of the e-Exams project and for making connections with others working in the field. Dr Hillier was also in a position to set an 'e-Exams' theme for the most recent eAssessment Scotland / Transforming Assessment joint online conference (Hillier 2014b) held in September 2014. This saw a series of international speakers share their experience on e-Exams from their own institutions. This event afforded the opportunity to develop an international network around e-Exams research and practice which will prove valuable in sustaining work moving forward.

Evaluation

While no independent evaluation was required for this project, a formative evaluation survey was undertaken following information sessions and seminars run on e-Exams at conferences and institutions. The attendees were made up of representatives of several stakeholder groups that had been identified earlier (see page 11). Participants held a range of positions in their organisations; of those that submitted the feedback survey the largest number were academics and teaching staff (40%) followed by exams officers (27%) and faculty support staff (19%). The count of their self-reported job classifications is presented in Figure 2.
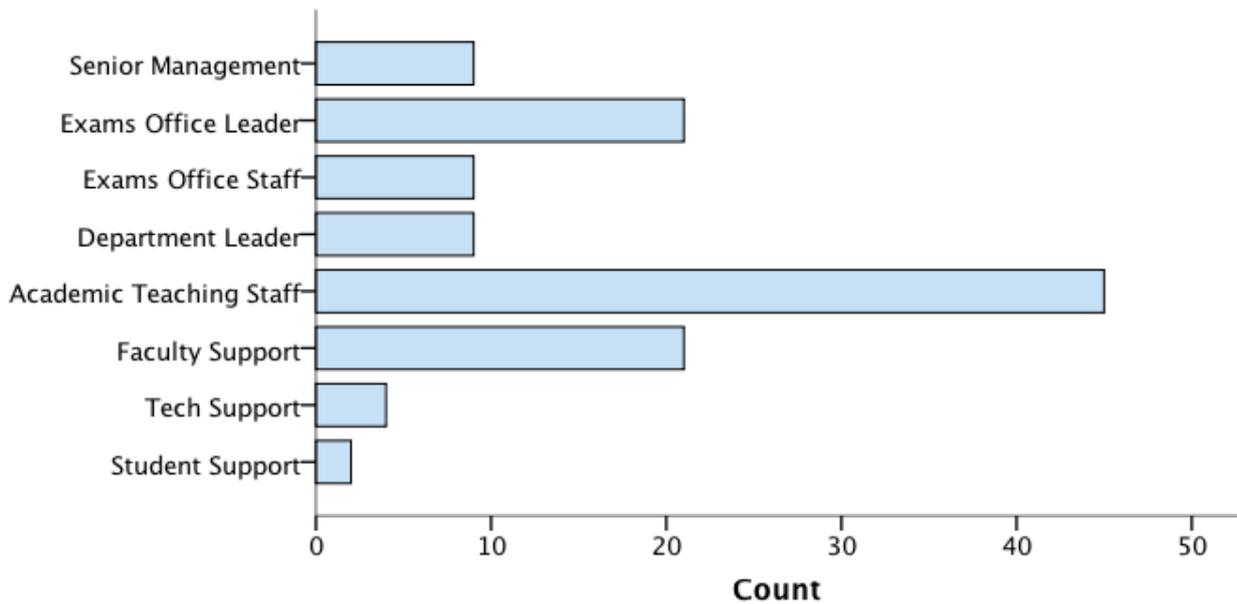
Figure 2 e-Exam sessions: attendee count by job classification

Based on just over 100 responses we were able to evaluate the state of attendees' knowledge prior and following the information session as well as the perceived value they placed on e-Exams.

The first six Likert items on the survey and their mean ratings are listed in Table 4 with boxplots for each displayed in Figure 3. Each item was rated on a five-point scale. The choices were: 5 'strongly agree', 4 'agree', 3 'neutral, 2 'disagree' and 1 'strongly disagree'.

Table 4 e-Exam sessions: attendee self reported knowledge and significance of e-Exams

Likert Items	Mean	Std Dev	N
Prior to this session, I had a detailed knowledge of e-Exams and related issues	2.5	1.2	111
Prior to this session, I frequently used or engaged with e-Exams	1.9	1.1	111
This session has improved my understanding of the issues surrounding e-Exams	4.1	0.7	110
I plan to use information from this session in my own work / institution	3.6	0.9	109
I think my institution should allocate more resources to e-Exams	4.0	0.9	110
I would like to learn more about e-Exams	4.1	0.9	109

As a result we observed a relatively low level of prior knowledge of e-Exams reinforcing indications of the 'newness' of e-Exams. The results also show that the sessions were effective in increasing participant's knowledge about e-Exams and further that they felt it was an important issue worthy of increased resourcing by institutions.

The box plots for each Likert item follow in Figure 3.
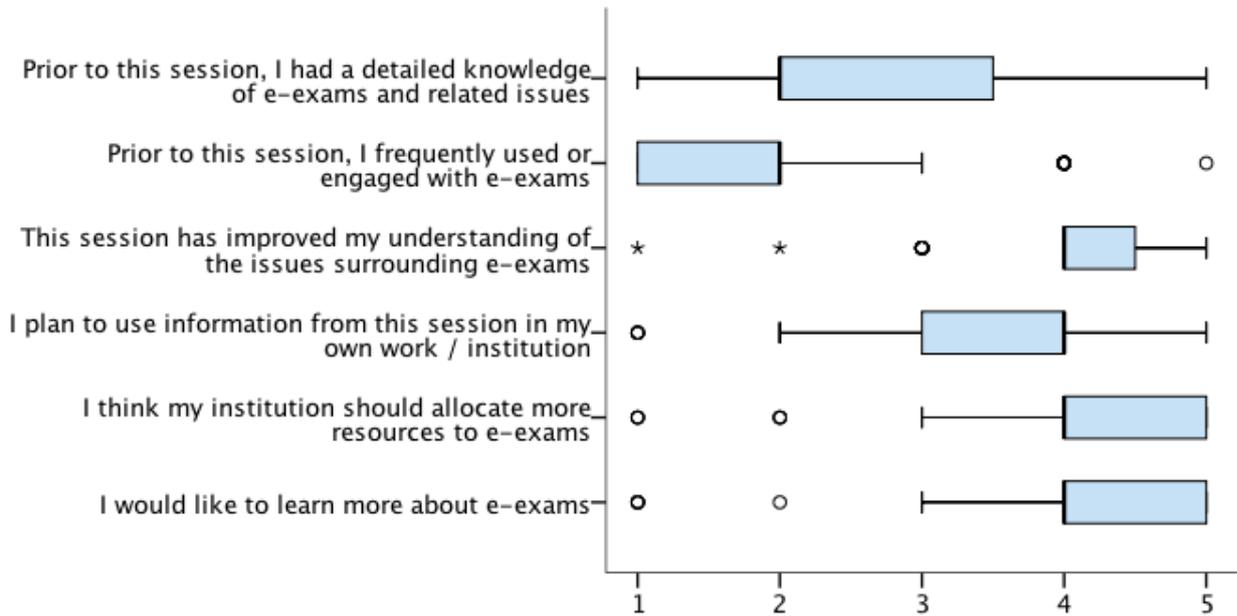
Figure 3 e-Exam sessions: attendee knowledge and priority for e-Exams

We also asked the attendees what they intended doing following their participation in the information session or seminar. The most common response was 'tell colleagues' (40 people) followed by 'apply learning in my own job' (29). This would indicate that a reasonable portion of the attendees felt the information provided in the session was actionable and that they felt it worthy to further spread news of the e-Exams project via word-of-mouth. The variety of intended follow up actions are presented in Figure 4.
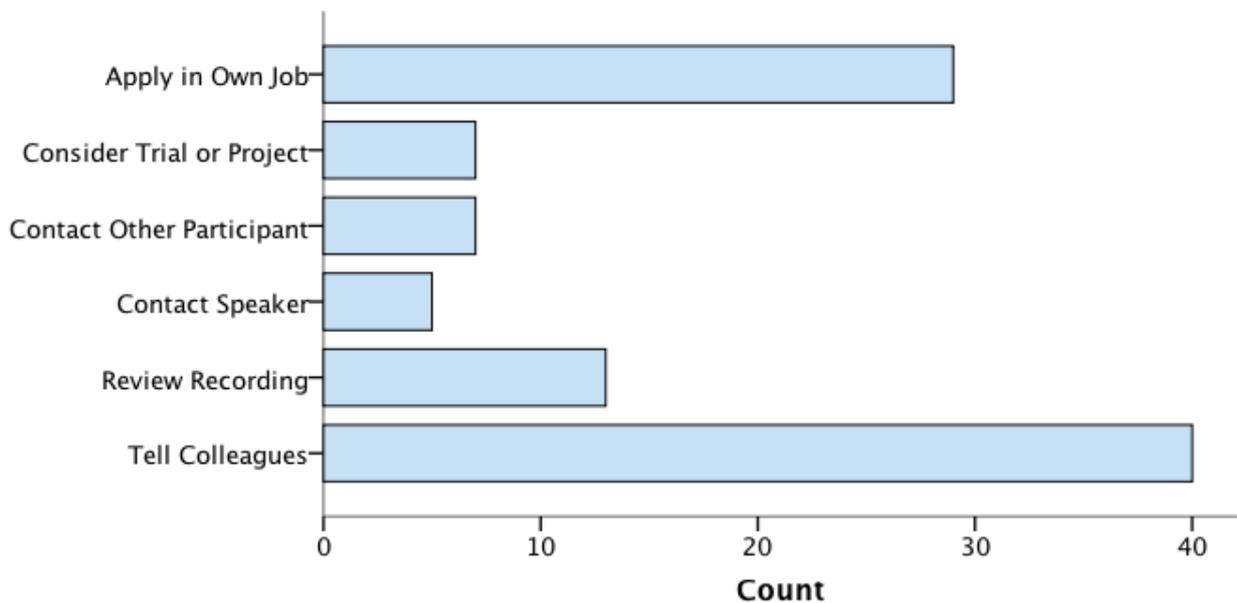
Figure 4 e-Exam sessions: attendee intended post-session follow up actions

The attendees were also asked if they would like to engage with the e-exam project in the future and if so how. As a result expressions of interest were received in running e-exam trials from 29 individuals who represented thirteen Australian universities, two government agencies and a large Vocational Education and Training (VET) provider. 61 direct requests to be kept up-to-date with project outcomes were also received from representatives of the prior mentioned organisations plus a further nine Australian universities, three New Zealand

universities and three commercial training organisations. This would suggest that the e-Exams approach advocated was seen as viable and could well be adopted by a number of other institutions. Table 5 summarises possible future engagement according to institution type.

Table 5 e-Exam sessions: interest by institutions in future e-Exams project engagement

Future Engagement by Institutions	Higher Education Institutions	Other Organisations	Total 31
Expression of Interest in e-Exam Trials	13	3	16
Other (news, ref group, give feedback)	12	3	15

Figure 5 provides a breakdown of how individual attendees would prefer to engage with the e-Exams project in the future.
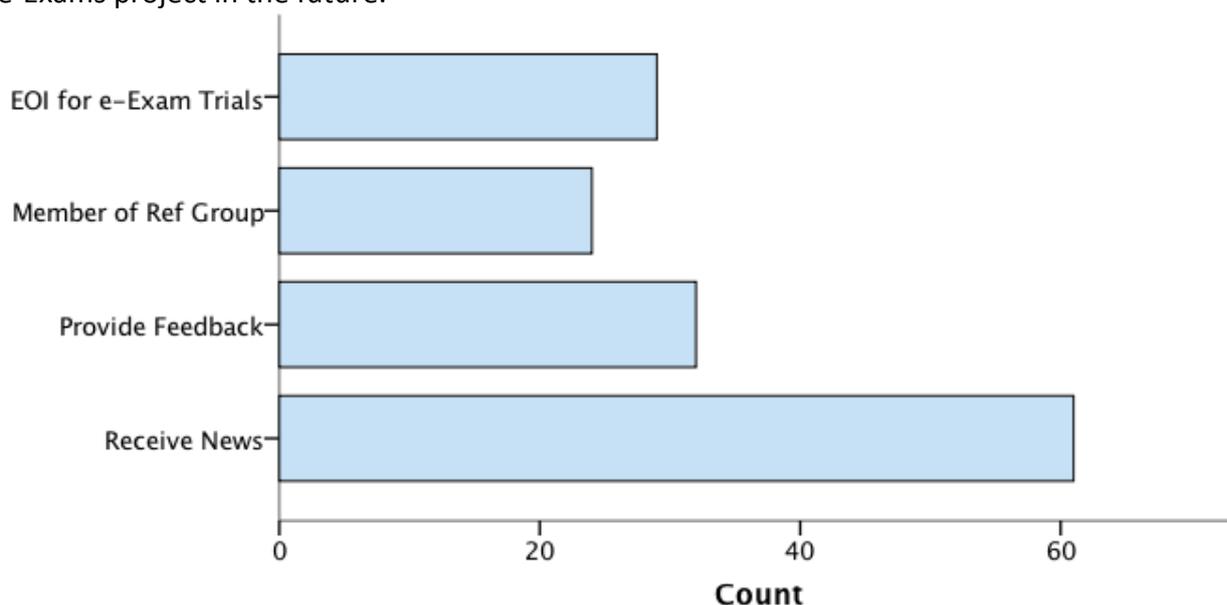
Figure 5 e-Exam sessions: attendee future e-exam project engagement methods

In addition to the quantitative survey items on the feedback survey attendees were also asked to comment on the best and problematic areas of the session as well as any concerns they held about the approach to e-Exams or e-Exams in general. This data is still being analysed and will be published in due course.

Future Work Recommendations

This seed project has allowed the successful demonstration of the feasibility of the e-Exams paradigm within the supervised exam room setting. It is our recommendation that the trials be expanded across the higher education sector. The trials undertaken so far in several discipline areas at UQ and UTAS have shown the approach to be broadly applicable. However, the use of the e-Exam approach in all discipline areas as such has not yet been explored and it is our recommendation that further trials be undertaken in a broader range of discipline areas across multiple higher education institutions. This will serve to further strengthen and develop the approach and the technology.

Areas for further attention range from hardware to software, technical procedures, exam room procedures, policy, workflow design, user guides, systems documentation, exploration of use in different discipline areas, training for academics, students, IT and exams personnel.

The e-Exam System (client) while operational as a prototype for e-exam trials needs further development. This includes:
- extending the pedagogical capabilities though plug-in modules, for example the development of plugins for: computer programming exams, mathematics or algebra questions, a language testing suite and tools for drawing or sketching,

- enhancing the compatibility and interoperability of the platform with major LMS platforms available in the Australian marketplace,

- developing performance analytics logging capabilities,

- enhancing platform robustness in terms of automatic recovery after a hardware or software failure or human induced failure (be it accidental or deliberate). This includes automating frequent backups and improved logging of system and user events for later diagnosis,

- enhancing the security of the exam platform including enhanced prevention and detection of interference by applying information security principles,

- enhancing the usability of the platform to ensure students can better concentrate on their exam rather than the technology,

- enhancing the accessibility of the platform to ensure students with a range of physical and cognitive impairments are able to undertake examinations and concentrate on the examination rather than the technology,

- enhancing the efficiency of the platform for users and administrators,

- establishing methods for improved technical maintenance and testing (such as the roll-over e-Exam code into updated versions of the underlying operating system that will deliver benefits such as improved hardware compatibility).

In order to ensure that e-Exams will work in the 'real world', it is important to consider the broader workflow for doing examinations. For example:
- the pedagogical design of e-Exams and individual items, in terms of principles, exploration of uses in different discipline areas and options that target 'higher order' learning activities and learning outcomes,

- the technical design and construction of e-exam course 'packages' (exam question script, individual exam items, associated files, resources, multimedia),

- administrative procedures and tools for pre and post e-Exam management. This includes:
  - quality control measures to ensure mistakes in exam scripts are minimised before they get to the exam room (this could include facilities to allow for pre-exam peer review of exam scripts and technical testing)
  - the submission and tracking of e-exam 'scripts' within an institution

- o collation of exam 'packages' from the materials submitted by examiners ready to place onto the e-Exam System client

- o improved mass production/duplication of USB sticks (for each student) as well as turning around USBs already used for prior exams. Or the development of approaches to allow a 'generic' e-exam platform with download/upload of exam content via secure networks

- o policy and procedure around timely and accurate provision of exam 'scripts' (USBs) to exam venues

- o setup and in-room operations at exam venues including procedures for tracking USBs so they do not get lost

- o collection and reticulation of exam responses (from individual students to common repositories). This post-exam processing of responses could occur via a 'USB reverse copy' and/or network reticulation

- o collation and distribution of responses to assessors (by cohort, by question, by academic staff member etc) or automated assessment in the case of Moodle based exams

- o marking and assessment sub-workflows according to selected or constructed response items; including grade reviews and submission

- feedback and reporting that would involve developing performance data analytics and reporting capabilities. This would see data drawn from e-Exam System clients used by individual students that could then be analysed on mass to produce macro and micro level analyses. Coverage could include the behaviour of students during the exam, the performance of students on each exam item and the efficacy of individual exam items (e.g. item response analysis). The computerisation of exams has great potential to finally 'close the feedback loop' to students and academics; something that is sorely lacking in current paper based examinations,

- the efficacy, efficiency, security, integrity, robustness of all of the above.

The physical facilities in which e-Exams take place, which includes:
- the space itself (seating, tables, layout, visual lines/dividers and acoustics within and between rooms),

- power requirements and electrical infrastructure (including battery back-up),

- data infrastructure (wireless, wired, monitoring, backup, server, spare laptops etc),

- health and safety (e.g. power/network cables, room capacities, safe passage),

- flows and activity of people, data flows etc within the space and in its immediate surrounds,

- leveraging opportunities to integrate these requirements when new buildings are in the planning phase. While the approach to e-Exams is not dependant on having all faculties 'built-in' it will reduce the reoccurring costs and inconvenience at exam time. Further, such facilities can be leveraged for regular class and study activities that are increasingly utilising BYOD so would not represent a capital cost unique to exams. There is very little additional cost involved in including such facilities at build time compared to retrofitting existing buildings with additional power or network infrastructure. Such inclusions at build time represent a tiny fraction of the overall capital cost of a new building.

The institutional environment also needs attention. This includes policy (assessment, exams, equity, access), alignment with institutional strategy, professional development (for academics, exams office personnel, exam invigilators, technical support staff), funding and resourcing.

Conclusion

The Australian higher education sector is at a cross roads in a number of ways. The continuing trend towards deregulation will place increasing pressures on Australian higher education institutions to remain competitive. Their current competitive advantage as expert accreditors of graduate learning outcomes could also be under threat if the status quo is maintained with regard to the use of pedagogically limited paper-based high stakes assessment. A thoughtfully developed e-Exams solution that offers a 'whole computer' environment could enable Australian higher education institutions to offer significantly more sophisticated forms of assessment within the supervised, high stakes context. The wide pedagogical landscape available to academics in the progressive and formative assessment arena will become available for use in high stakes examinations too.

In order to leverage the capabilities that ICTs have bought to the progressive assessment space, the Australian higher education sector should give due consideration to e-Exams. This assessment mode provides an ability to deeply assess the capabilities of graduates in a way that allows institutions to verify to a high degree of certainty their ability to apply knowledge in the real world.

Further, the burgeoning field of learning analytics has the potential to mine and distil learning from the vast stores of data collected by institutions as students work their way through technology enhanced progressive assessment. At the present time the high stakes, paper based examination is a 'data desert' and a 'feedback desert' with regard to our ability to collect, process and feedback activity and performance metrics to students and academics. The computerisation of the exam room offers us a unique opportunity to fill in a large piece of the student performance puzzle.

The e-Exam trials undertaken for this seed project re-enforced the stance taken at the outset, that we need to be paying attention to much more than just a piece of software. As a result, the broad systemic changes that are needed require a magnitude of attention akin to that of the shift from 'chalk and talk' to blended and e-learning.

The development and extension of the e-Exam System client prototype and subsequent testing suggests the e-Exams concept is achievable and applicable to multiple discipline areas and multiple institutional contexts.

On the basis of the progress and attention garnered to date it is the recommendation of the project team that further resources be invested in the 'whole computer' approach to e-Exams developed in this seed grant. Taking this work to the next level requires further research, development and engagement in order to achieve the aim of making a comprehensive, pedagogically sophisticated, sustainable and scalable computerised examination tool set available to the Australian higher education sector.

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