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eExams for Transformation of Higher Education

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Abstract

Students have problems with examinations, experiencing stress due to time constraints. They also find writing on paper a very difficult and painful contrast with much of their learning which is computer-based. However, for institutions there are many authenticity and logistical problems associated with moving these high-stakes tests onto computers, even when part of a balanced assessment regime.

Students at the University of Tasmania (UTAS) used their own personal computers in examinations for the fourth consecutive year in 2010. Rationales for this practice include extending online and blended learning practices into high stakes assessment; providing interactive and multi-media scenarios on the exam desk; providing digital scripts for computer-supported marking and moderation; and improving legibility of students' scripts. To undertake an eExam, candidates start their computer from a USB stick or CD-ROM and work on-screen. The system interdicts all digital communications and local disk access. A strategic project funded by UTAS has allowed more Faculties to support eExams and trials have also been facilitated in the pre-tertiary sector. In March 2011 the Academic Senate approved the use of eExams in all disciplines. In tandem, the state qualifications authority is trialling the eExam system in the pre-tertiary sector.

The introduction of eExams illustrates institutional innovation adoption, both within the University and by other organisations. eExams provoke consideration of several important issues such as equity in text production, the comparative achievements of keyboard and pen users, envisioning new kinds of digitally-based assessments, contrasting costs and reliability of ICT and paper. All these issues are important but can also serve to obscure the leverage effect of digital assessment on new learning practices in a jurisdiction selected for initial rollout of the national broadband network which will require more advanced computing skills for commercial benefit to be realised.

Introduction

There are several reasons why tertiary education providers require students to be assessed using examinations. As part of a balanced mixture of assessment, examinations provide a timed, comparable, identity-assured element. Other styles of assessment provide other qualities. Exams also produce an element of stress amongst candidates, and this is often reflected towards their assessors. Part of this stress appears to be the contrast between increasingly digital learning environments and the intensive use of a writing implement for long periods in the short weeks of exam season. The five year project in this paper describes how one institution and state is coming to grips with the necessity for exams and defusing the tension between learning and assessment.

Background

Society and learning are being transformed by computers (Gosper et al., 2008). The Australian Government is committed to a Digital Education Revolution with a focus on students in Years 9-12 who will shortly percolate into universities (Rudd, Smith & Conroy, 2007). Government is concerned about lethargic ICT-based transformation in education: "while ICT has fundamentally reshaped whole industries, revolutionised production processes and generated massive improvements in

productivity in our workplaces, our education systems have been slower in adapting" (Gillard, 2008). This makes the adoption of ICT in education a problem of national significance, and therefore understanding the use of ICT in assessment is vital. This has been recognised overseas with an annual conference on eAssessment in the UK over the past 13 years (Ross, 2006) which involves many accreditation agencies. Research into school student acceptance of eAssessment is being conducted by the National Foundation for Educational Research (Burge, Foster & Lewis, 2006). In addition, there are emerging regulatory principles for eAssessment in school education (e.g. Qualifications and Curriculum Authority, UK, 2007). To remain competitive, Australia cannot be complacent as certification frameworks of other nations evolve to use 21st Century assessments for 21st Century learning.

Australian institutions aspire to systemic transformative uses of educational computers (Downes et al., 2002; Fluck, 2003). Therefore they need assurance high-stakes assessments will not remain dependent on old technology (i.e. on the use of pen and paper). Very little technology is allowed into the conventional examination hall. Mobile phones are banned, calculators are required to be identified on the exam paper, but a few dictionaries may be permitted. Assessment is a key driver of student learning (Biggs, 2002). Thus, student learning is unlikely to change in response to ICT without a transformation of assessment practices. Major computer companies have recently asserted the need for assessment to adopt computers in assessment because this is a pre-condition for curriculum transformation (Cisco, Intel and Microsoft, 2009). Their interest may be commercial, but they are also acutely aware of innovation adoption processes. Other factors may influence transformation such as infrastructure and training, but this project focuses on the role of formal summative assessment and its relationship with ICT-based curriculum transformation.

Previous Australian Learning and Teaching Council (ALTC) projects have looked at computers as a way of automating assessment (Crisp, 2008; Freney & Wood, 2008). These techniques require a high level of specific skill (designing java applets, QuickTime VR and interactive spreadsheets) on the part of assessors and the process is vulnerable to one-point failure at the server (Meyer et al., 2007). Other emphases have been upon diagnostic or adaptive testing, restricted to a specific discipline area (Newby, 2008; Solomon, 2006). A related project looks at digital formats for external assessment, particularly performance recording (Newhouse & Williams, 2008). In pre-tertiary assessment, discussions have begun in England about moving in the direction of eExams with a substantial market for successful systems (Shepherd, 2010), particularly ones that can overcome the logistical problems.

Computer based examination products are already available in the marketplace, but these have severe limitations which impede the full use of computational thinking in assessment. TCExam[1] is a web-based, platform independent, language independent (includes translations in several languages) and conforms to W3C accessibility and usability guidelines to provide equal opportunity to people with disabilities, including blind users. It includes various multiple choice, short answer and essay question types. However, our view is that this and any learning content management system assessment process depending upon internet connectivity fails to provide the candidate identity assurance which makes examinations useful in the assessment mixture. Alternatives are available such as:

(a) Electronic Blue Book by CompuTest[2] ['essentially turns students' computers into typewriters']
(b) Exam4 by Extegrity[3] ['The Armored Word Processor']
(c) Securexam by Software Secure[4] ['authenticates the identification of an online student with biometrics']
(d) SofTest by ExamSoft[5] ['employs an online/offline delivery model']

Each of these can be used on candidates' own computers, but the quoted text from sales literature highlights the shortcomings of each product. Internet delivery of exams (even into a proctored or supervised environment) has two potential difficulties. Firstly, the exam is dependent upon communications hardware working reliably for all candidates to complete the assessment. Any breakdown (especially the tremendous overload at the start and end of the exam, when large amounts of data require transportation) will invalidate the assessment for a large number of people. Second, the presence of an operational communication link makes it feasible for this to be subverted and used for collusion, and thus cheating on the exam.

Biometric authentication for unproctored students sounds useful, but it does not eliminate the possibility of additional screens & keyboards being connected to the candidate computer. Thus an assistant could enter text or whisper solutions to the candidate. Finally, two of these products unashamedly focus upon the word processing aspect of exams, and therefore inhibit the use of a wide variety of software for extensive computationally-based assessment.

[1] http://www.tcexam.org/
[2] http://www.electronicbluebook.com/
[3] http://www.exam4.com/
[4] http://www.softwaresecure.com/US/Main.aspx
[5] http://www.examsoft.com/main/index.php

These projects in Australia and abroad provide the background for the strategic project described in this paper.

Method

The project has used a robust theoretical framework, based on Rogers' dissemination of innovations (2003), and aligned with the Australian Learning and Teaching Council (ALTC) commitments to promote and support strategic change in higher education institutions for the enhancement of learning and teaching, including curriculum development and assessment. Based on the Rogers' framework, the project is providing opportunities for potential adopters to perceive the relative advantage of the innovation. This affords our university an opportunity to facilitate a national approach to address how technology affects learning and teaching. Simultaneously, teachers of pre-tertiary subjects in Tasmania have used the eExam System to conduct trials with mid-year examinations. This linkage has turned out to be quite important, because discussions have revealed reluctance for the pre-tertiary sector to change practices whilst university achievement depends upon prowess with pen and paper.

In the pilot stage of this project, cohorts of approximately 180 students were assessed through a supervised computer-based examination system. Institutional computers were started up from a specially prepared 'live' CD-ROM. The preparation of this CD-ROM was analogous to the printing of an examination paper. The examination was pre-burnt onto the 'live' CD-ROM, automatically appearing as a desktop folder once the computer had completed the boot-up procedure. The exam system on the CD interdicted network functionality, and prevented them inspecting the local hard disk drive. The inclusion of a unique artistic feature on the desktop background allowed non-technical supervisors to ensure the correct operating environment was present on each candidate's computer. Students were able to complete short answer questions and provide sketch drawings. The system was extremely reliable, and resilient to operator error or equipment failure. The completed scripts were collected from each workstation using a USB data-stick, copied on a computer and then e-mailed to the external marker. The results of this piloting have been extensively reported elsewhere together with analysis of surveys and student comments (Fluck, Pullen & Harper, 2009). The development to version 3 of the eExam System has replaced the live CD with a live USB which is issued to every candidate. This simplifies delivery and script collection, and speeds up operation: candidates with old computers have been amazed at how fast their machines run when using a solid state hard drive (the USB memory stick).

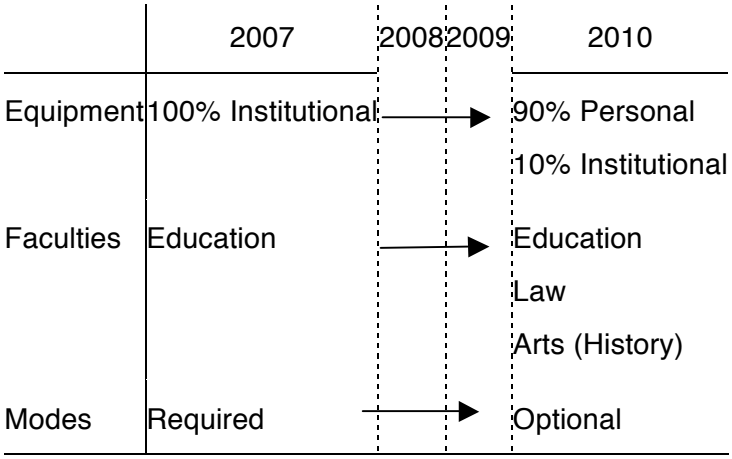
In the development stage reported in this paper, the eExam System has been further developed and additional cohorts of students used this new version in 2010. This version has also been used in five Tasmanian schools for mid-year examinations. Preparation of large numbers of complex USB sticks has been simplified by the acquisition of a NexCopy duplicator which can be considered the digital age equivalent of a photocopier.

The underlying live operating system for the eExam System is Ubuntu. Ubuntu is a free and open source operating system, in contrast to other commercial products such as Microsoft Windows or Apple OS-X. Like other operating systems, it provides the capacity for a modern computer to undertake basic functions such as respond to keyboard and mouse, and place results onto the screen or printer. As Ubuntu is progressively improved, the eExam System has to be re-constructed on the latest release. The project has now converted the computer start-up procedure to work from USB data sticks (flash drives) which also contain separate partitions for the examination questions and the answer scripts. This makes it much easier for candidates, because they only need to insert the USB stick into their laptop to begin the exam. A technical difference means Apple Macintosh computers still need the optical medium, but this works in conjunction with the same USB stick as for all other candidates. We advise students are given a previous year's exam on their own USB drive a month prior to their own examination to become familiar with the environment and master the use of their 'one-time boot key' which varies from one laptop model to the next.

Figure 1: A set of USB sticks each containing the eExamination system, question paper and answer partitions

Over the period of innovation acceptance, the institution has made some interesting transitions. The initial trials were conducted in computer laboratories, thus all equipment was institutional. For logistical reasons and the staffing resource requirements, students were gradually allowed to use their own computers until 90% of equipment was supplied by students in 2010. Over the same period, other Faculties of the university have trialled the eExam system. In those cases, traditional exams were supplemented by an eExam option, equivalent to a different kind of writing implement. This has caused interesting discussions about equity of text production rates which hitherto were not problematic in the handwriting environment. Please see Table 1 for a summary of these changes.

Table 1: Transitional aspects of eExams adoption



A risk analysis was carried out which considered innovation engineering problems and technological issues. These were divided into high and low probability scenarios which were matched with possible responses. This is an example of a low probability, low impact innovation engineering risk:

> A student or lecturer refuses to participate in a mandated eExamination on grounds of principle.
>
> *The project presumes pen-on-paper alternatives will be made available as backup or for conscientious objectors through the piloting phase to reduce the incidence of such stances.*

Results

Two uses of the eExam System are reported here. The first was with university students undertaking a compulsory unit in computer education. The second was with Year eleven and twelve students across Tasmania taking the university entrance subject *Information Technology and Systems*.

Computer education unit in pre-service teacher training

At the end of 2010 one hundred and eighteen students took an eExam at the Newnham and Cradle Coast campuses mostly using their own laptop computers and some institutional laptops (for about

10% of the cohort) or desktop computers. In preparation for this event, a copy of the eExam System was made available to the students beforehand (with an old question paper) and a one hour tutorial was devoted to demonstrating and practising with the system. When the students entered the examination hall, they had access to filtered mains power. The written paper was used by a couple of students who appeared to be resisting the change of format on principle, but they were unable to take questions with multimedia content.

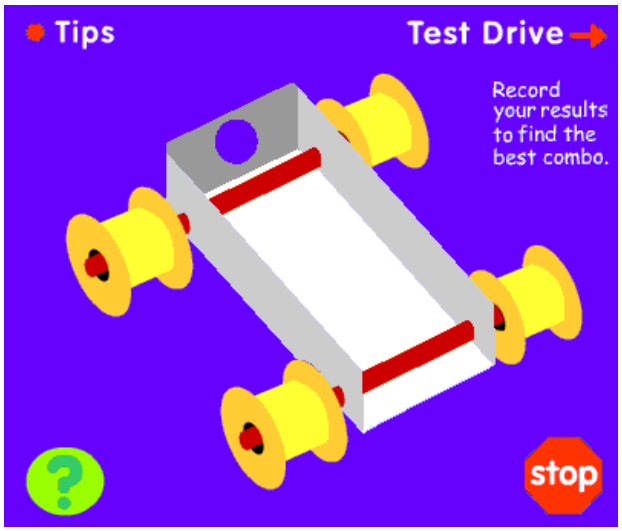
Because the material assessed in this unit were related to using computers for teaching in schools, it was compulsory each candidate had computer access. The materials included a powerpoint pupil product which candidates had to assess using the local skills checklist which was provided in digital format. An interactive piece of software designed to run under the Windows operating system was supplied so candidates could assess its educational potential. This ran under the WINE (Windows is not essential) emulator, showing that specific software can be included in eExams. Finally, candidates viewed a video promoting a new educational software product (they used earphones) and were asked to respond to related educational theory questions (see Figure 2). These examples begin to show the potential of the eExam system. Video content as a way of presenting scenarios relating to authentic assessment have been most appreciated by other academic staff.

Pupil product for assessment – powerpoint file with animations and sounds

Years 5/6 ICT Skills Checklist

Class: Date: Teacher: Ratings: C-Competent, N-Not yet competent	Pupil name
Inquiring with ICT	
Retrieve information relevant to an inquiry by conducting an effective search.	
Cite all sources used when presenting research.	
Compare and evaluate information sources relating to a research topic.	
Investigate, question, analyse and problem solve while playing interactive educational games.	
Contribute ideas to online networks and reflect on the contributions of others.	
Demonstrate understanding of real-world concepts by using simulations.	
Creating with ICT	
Plan and create digital products with logical sequences and content for specific audiences.	
Integrate materials such as images and sound files into digital products	
Reflect on digital products, refining/editing them.	
Use digital tools to collect, analyse and represent data for a specific purpose.	
Manipulate layout, style and content to create a digital product appropriate to a text type.	
Adhere to copyright regulations when creating and downloading.	
Communicating with ICT	
Identify and consistently follow online etiquette (netiquette).	
Describe appropriate levels of personal information disclosure for specific online environments.	
Establish and use an online identity to broaden communication with friends.	
Contribute to planning for, participating in and evaluating class-to-class online exchange projects.	
Send messages with relevant files attached.	
Use a variety of devices to collect and share ideas and information ethically.	
Operating ICT	
Identify how ICT systems become infected with malware and describe how to reduce infection risks.	
Follow problem solving strategies to solve common ICT problems.	
Identify factors that assist people to use ICT healthily, comfortably and safely.	
Organise electronic folders and files.	
Distinguish between input, output and storage devices.	

State ICT checklist as a portable document format (PDF) file.



Small interactive program designed for Windows operating system

Video expounding the benefits of new software learning package

Figure 2: multimedia content in an eExam

Anecdotal comments by the students indicated the vast majority were exceptionally pleased with the exercise. Questioned by the UTAS exams office staff, all approached were very happy with the smoothness of the examination. Noise was not a problem – the quiet working environment mirrored that of conventional examinations.

Year 11/12 Information Technology and Systems

In the pre-tertiary sector in mid-2010, fifty-six students in five schools used the eExam System to take their mid-year assessments. They were all shown or given a practice copy beforehand to become familiar with the system. It was noted that institutional-owned equipment was used throughout.

Feedback from the pre-tertiary teachers was generally positive and noted the resilience of the system. A similar technical incident with a networked or communication-dependent system may have affected every student instead of just one.

- *Had one incident where a student's computer locked up and they had to reboot, but document was saved and no other problems ensued. Was a capable student so coped, but a lesser student may have been thrown.*
- *Went very smoothly*
- *All went very well, easy to use system for this type of exam.*
- *I liked the ability to mark work without having to be able to read handwriting. However, eExams are not exploiting the possibilities e.g. videos describing the case study etc.*

- *It was good*

Feedback from students was also generally positive, but one potential security flaw was identified:

- *Happy with process*
- *No problems at all. It was just like using Microsoft Word.*
- *Yes, enjoyed it very much.*
- *Power failure could be a potential problem. Scrolling up and down was required.*
- *I don't see there being any advantages to the end-of-year exam being a written exam. I would much rather another computer based exam.*
- *No advice needed for the eExam system designer. I believe that the eExam was good. All exams should be done on computers.*
- *Students like it - technology was not a handicap - all could type fast.*
- *Students weren't fazed. They all refused the choice of doing the exam on paper.*
- *My 2 best students weren't impressed with the security. Felt that it was too easy to save the answer document into the Answers folder, go back into normal [operating system - Windows] log on and re-open it where you could access other documents/internet.*

Cheating in examinations is a constant threat to validity, and the eExam development team are working on encrypted log files for startups/shutdowns to address risks such as the one illustrated in the final comment. Vigilant supervisors with technical assistants will be important in any transition phase.

The overall assessment from participants has been very positive and indicates further trials should be conducted. The trial revealed the resilience of the system (coping with a major equipment failure) and also a security concern (which further development is addressing). This small scale exercise required supervising teachers to mark scripts from the USB sticks themselves. In a larger scale trial these will be batched and data collected automatically, then copied to CD-ROM. This provides a permanent medium for the student scripts (which can then be further reticulated in digital format) but also rapidly releases the USB sticks for use in another examination.

A report on the trial in the mid-year pre-tertiary assessments for the Tasmanian Qualifications Authority (TQA) was provided to the TQA Board. The Board accepted a recommendation to trial the system state-wide in 2011 for *Information Technology & Systems*, with a practice eExam, logistics trials in combination with the mid-year assessment, and the use of the system by all candidates in the subject at the end of the year final examination.

Conclusion

The introduction of eExams as an alternative to handwritten examinations is just a first step. This first step can be accomplished with little or no change in practice for examiners who submit their question papers digitally for printing. However, in the future it will become possible for examiners to write questions such as the following (note the use of hyperlinks to particular resources):

> Watch the video Complex DNA [95 seconds] and use the enzyme replication simulation software to construct a molecular junction to inhibit the binding process. Submit your enzyme design template together with an explanation of how it will perform the required task.

Thus, not only can question papers be set in digital format, but responses can be data files for the specialist software used for the answers. This kind of change will reflect potential changes in teaching practice and should not involve great skill acquisition on the part of examiners. Conversations with pre-tertiary teachers of information technology and systems reveal their interest in short video case studies of business situations. This will ameliorate the time taken to read detailed descriptions of the same situation, and reduce the complex literacy burden from candidates.

These outputs offer many advantages over other systems since candidates can take the test on screen without requiring an internet connection; there is no restriction as to question types (standard examination formats can be used to require essays, diagrams or even video responses, as well as the multiple choice types). Test preparation only requires the same skills as if preparing for the paper to be printed. Being open-source, the system is low-cost and can be improved/adapted by adopting institutions. This open-source licence also makes it legal to give students practice examinations based on the system. The successful piloting indicates these outcomes are realistically attainable.

The eExam system has raised numerous questions which are all worthy of consideration. Here are some of which the author has become aware:

1. Should every student use a computer or should this be a choice of writing tool as is currently the case (some use biros, some use fountain pens, others use pencils etc.)?
2. Does the kind of computer give any specific advantage to candidates?

3. At what point in the innovation process should we move on from replication of pen-on-paper exams to incorporate features only possible in a digital environment such as video-based scenarios, questions requiring complex analysis with software tools (e.g. calculus and computer algebra systems or spreadsheet-based mathematical models) etc.?
4. How are the pre-tertiary and university sectors linked in respect to this assessment innovation?
5. Will the advent of digitally-based high stakes assessment tools automatically engender the adoption of ICT tools in teaching?

These questions were discussed by the university academic senate on 4th March 2011, and the following motions were subsequently passed:

- Approved the use of eExaminations; and
- Approved the recommendation that Heads of School and Unit Coordinators consider where eExaminations are deployed and how students are to be advised.

The national benefit from this project has been new knowledge about the relationship between ICT-based assessment practices and ICT adoption for curriculum transformation. In addition, there is a potentially commercialisable tool for economically replacing printed examination papers with a digital equivalent. The benefits for students include bridging the gulf between IT-based learning and paper-based assessment; the capacity to perform changes and re-organise written replies at any time up until the end of the examination without messy crossing out; and fewer students with disabilities permitting keyboard use will need separate rooms, leading to inclusivity of practice. For university staff, the system offers a simple way to transfer examinations into a computer environment; invigilation is made easy through the use of a unique desktop image for each paper; and marking is simplified through digital duplication of all candidate scripts.

The project outcomes are significant for higher education in Australia because the collection together of several hundred computers solely for examination purposes is unlikely to happen on cost and logistical grounds. The project makes it possible for students to bring their own laptop into the examination hall, because the assessor can choose to forbid access to the local disc drive and/or networking. The adoption of a computer-mediated supervised examination framework is strategic in terms of change management and cultural adoption. This contributes to the enhancement of learning and teaching in higher education by allowing high stakes assessment to be conducted with minimal assessor development, by students using personal computers or laptops. Once this become accepted as a genuine alternative, curriculum transformation becomes possible, since eExaminations can be based upon new software and new digitally mediated ways

of understanding the world. There are significant environmental savings to be made by eliminating or reducing the use of paper.

The eExam project has built upon two years of successful piloting at UTAS (Fluck, 2009) and exemplifies the key principles for such digital assessment:

- Portability – it should be possible to set it up using almost any available equipment, including a student's own personal computer.
- Equity – it should be accessible to a wide range to students, including those with disabilities.
- Familiarity – students should have every opportunity to practice essential skills in this environment.
- Technical capacity – it should not limit students' creativity or expression.
- Archivability – the environment should produce material which will be accessible in future years.
- Inviolate – students should not be able to alter the environment to gain an unfair advantage. (Fluck, 2004)

In early 2011 training in the preparation and use of eExams was offered to staff throughout the university. Within three hours of the offer, the training courses had been filled, so additional sessions were arranged. Forty two academics and three professional staff attended, representing all the different Faculties and several other teaching areas of the university. The conversion rate for uptake will become evident over the coming year.

The eExam System has provoked a useful set of institutional responses. It remains to be seen how rapidly the paradigm for high stakes assessment will change, and whether this will have flow-on effects in curriculum.

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