Implementation of on-campus digital examination practices

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Abstract: Despite much learning now being conducted through computer-mediated forms, universities still use paper-based examinations to validate individual achievement. This creates dissonance between teaching and assessment; and prevents adoption of computer-based techniques on a large scale in curriculum design. Some institutions are striving to eliminate this dissonance by trialling computer-based system for examination-style assessment, and in addition add efficiencies to the labour-intensive process of marking. This paper presents the implementation of computer-based examinations in Scotland, Nigeria and Tasmania, with an emphasis on the diversity of current approaches. The paper also attempts to describe pathways for institutions contemplating such a radical innovation.

Introduction

Perhaps the most widespread use of computer-based examinations can be found amongst law schools in the USA where a variety of software is used to facilitate essay writing. These approaches generally lock down the computer to prevent candidate collusion or importation of pre-written material during the exam. Some are web-based which makes for easy updating and convenient reticulation of both questions and answerscripts. Others are software based, requiring programs to be loaded onto workstations. For example:

- SofTest (ExamSoft) at Lewis & Clark law school, Portland, Oregon; Columbia Law School; University of Pittsburgh Law School.
- Exam4 http://www.exam4.com/ [the armoured word processor; students individually or institution pays for a licence to install PC/Mac] at University of Washington School of Law; St. John's University School of Law.
- Electronic Blue Book http://electronicbluebook.com/ [Electronic Bluebook essentially turns students' computers into typewriters. PC/Mac. Has a network version and MCQ component; institution pays for a site] at University of Michigan Law School; Duke University School of Law.

Beyond this circle of paper-replacement institutions (where students and faculty staff can generally decide which text-production instrument to use) I would like to describe work done in three other places.

1. The University of Edinburgh in Scotland has used Exam 4 on students' own laptops in essay-style Divinity examinations.
2. The University of Minna in Nigeria uses an institutional network with thin clients to deliver multiple choice questions to pre-tertiary and early year degree students.
3. In Tasmania the eExam System is used at the University and for pre-tertiary students to undertake high stakes examinations in law, education, history and medicine.

The University of Edinburgh

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In 2008 approval was granted in Edinburgh for a software-based system to be loaded onto students' computers for them to write their essays in response to questions provided on paper. The minutes of the approving meeting included the following notes:

> In discussion about extension of the pilot to a wider group of students members noted that it would be important for students to retain the choice of whether to handwrite or type examination answers…. In the longer term it would be necessary to take into account the implications for capacity for large scale delivery, security and invigilation. Senatus Undergraduate Studies Committee (SUGSC) was content that security measures at present were robust.

> SUGSC approved the use of computers for essay type examinations and encouraged course teams who wished to offer students this opportunity. (SUGSC minutes, 7 November 2008)

The procedure for Exam4 to be used in an examination requires the School to notify the central exams team, and specify if spellcheck and/or grammar check tools are to be allowed. Students are subsequently directed to a download site to obtain the client software, and strongly encouraged to try it. On the day of the exam, an exam receiver server is set up. On entry to the exam hall, students connect to the university wireless network and activate the pre-installed Exam4 client. Following the exam, the answerscripts are decrypted, printed and delivered to the school for marking.

In late 2012 an investigation was conducted to compare experiences of students in Edinburgh with those in Tasmania.

In response to a post-examination 9 question survey (paper & online after the exam) (Fluck & Mogey, 2013) , more Tasmanian students reported typing faster than they could write (UTAS 81%, UoE 45%) and more Tasmanian students reported typing accurately compared to their northern hemisphere

comparators (UTAS 44%, UoE 17.5%). The Tasmanian students were significantly more likely to feel that the overall structure and argument were better on computer compared with the Edinburgh students (UTAS 84%, UoE 52.5%; Fishers exact test, p=0.018).

A classification and regression tree was constructed to explore the survey data. Classification trees can be used to perform univariate splits, examining the effects of predictors one at a time (Breiman et al., 1984). This identified individual typing accuracy, anxiety and whether students felt they had used their time effectively as the items that had the highest impact on students' deliberations about using the computer version of the exam. But it seemed likely that these sorts of factors interact, hence a categorical principal components analysis was undertaken. This suggested that there are probably two main factors influencing student choice. One of these, which combined typing speed and accuracy, had a very strong link to whether students would consider using a computer in an essay exam (p<0.01). An analysis of survey responses from the combined cohorts in Edinburgh and Tasmania showed students were not universally attracted to choosing keyboards over pens. Pens caused less stress (62% of respondents) but keyboards were acknowledged to produce text faster (87% of respondents). Keyboards also gave more legible text (94%) but on balance the essay production process with pens was considered superior and to give a better structure (56%).

The University of Minna

Olawale Adebayo and Shafi'i Abdulhamid are Lecturers in the Department of Cyber Security Science, Federal University of Technology Minna, Nigeria. They undertake research in software engineering, cybersecurity, computational intelligence and operating systems. As part of a nation wide program to make university entrance meritocratic and impervious to maladministration, one of six purpose built e-examinations centres was built on the campus by The Electronic Testing Company (eTC) based in the capital Lagos. It was equipped with air-conditioning, battery backup electricity and a standby generator, central servers and thin client workstations for up to 500 candidates at a sitting. This system provides mainly multiple choice questions from a bank and is used extensively. A 1TB CCTV system records the activities of candidates during the examination. All first year courses are required to assess university students using the system, and it is an option available for second and third year courses.

In February, 2010 the Federal University of Technology, Minna in Nigeria approved the use of computers in examinations. To make these decisions, consideration was given to technical reliability, equity and implementation processes. Olawale and Shafi'i reviewed the eExams systems in FUT Minna and some other Universities in Nigeria and designed a new system which uses data encryption in order to protect the questions sent to the e-Examination centre through the internet or intranet and a biometric fingerprint authentication to screen the stakeholders.

Due to the usually large population of university applicants, four or more days are usually earmarked for the local assessment exercise, where students are normally grouped based on their intended course of study to ease the conduct of eExaminations and enhance effective management.

The candidates are expected to have previous knowledge of answering online questions as no tutorial of any kind is usually given. They are expected to log into the system with their name and

identity number. At the end of the examination they are expected to purchase a scratch card (which contains a unique pin code) to check their result just twenty four hours after the examination. The students after twenty hours of the examination can log in to the university portal through their identity and registration numbers and enter their scratch card pin in order to check their results. This very rapid turnaround is a major benefit of the eExamination system provided by eTC.

2013 will see another milestone in the evolution of eExaminations in Nigeria because the JAMB (Joint African Matriculation Board) is preparing to start conducting e-testing for its candidates as part of university entry requirements. The computer based test (CBT) takes place over a period of 17 straight days at different centers across the country. Initially, the eExamination will run in harmony with the old manual test (parallel change over), giving candidates the option to choose either the CBT test or the old manual test; but over several years the old system will be eventually phased-out.

Tasmania

At the University of Tasmania the eExam System was first used with institutional computers in an information technology course as part of the Bachelor of Education course in 2006. Candidates booted (started up) computers with CD-ROMs containing a live Ubuntu (Linux distribution) in computer laboratories run in shifts to cope with the large number of candidates. Over time, specialized programming efforts modified the live operating system to include anti-collusion features and moved from the CD-ROMs to USB sticks. The strategy behind this innovation was twofold. First, to build a sustainable basis for the necessary equipment (each student provides their own computer for any examination); and secondly to ensure equity of opportunity through providing the identical operating system and application software suite to every candidate. At the time of writing the system has been successfully used by over 1000 candidates in high stakes assessments. The software is open source and can be downloaded from www.eExams.org[1]. The fourth version was developed in late 2012, based upon Ubuntu 12.04 with a design specification which allows both Windows PCs and Macintosh computers to boot from the same USB stick.

Following the approval for computers to be used in examinations by the academic senate in 2011, a range of disciplines have sent faculty staff to training sessions and offered this mode to students as an option or made it a requirement for assessment. The eExam System has subsequently been used in History, Law, Education and Medicine, illustrating the diversity of subject applicability. Some of these examinations have been offered to candidates as an option – so they can be described as paper-replacement assessments. Candidates have answered the same questions, but some used the computer keyboard to write their answers, and others have used pens. In other cases, post-paper examinations have been set, so every candidate has required a computer. Examples include Mathematics Education, where a video of classroom practice was provided and candidates asked to criticize the teaching activity portrayed. In 2012 candidates were required to provide their own computer for these assessments, but institutional practice has been to provide a few computers in reserve to cover any shortfall or reliability issues.

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[1] Note, the web-site now has a DIY section to allow anyone to create their own eExam.

Following presentations of the way the university was moving to local audiences in the school and training sectors, the Tasmanian Qualifications Authority commenced a trial of the eExam System. This authority is responsible for the administration of subject-specific pre-tertiary examinations and the calculation of a national ranking for all students potentially entering university. One subject (information technology and systems) requested to use the eExam System in 2011, and subsequently continued in 2012. A report on the 2011 trial stated "the e-exam in Information Technology & Systems was done by 93 students at 10 exam centres. Each school had used e-exam for their mid-year examinations and was familiar with the system. There were no issues with major equipment failure" [11]. In 2012 a post-paper question was on the same USB data stick, where students were required to view a local copy of a tennis club website.

In 2013 the students for this course sat a mock examination using institutional computers without restrictions. Questions were provided, full internet access permitted and answerscripts saved onto USB sticks.

Important considerations

Before I describe our work further, it's worth reflecting on what computers are. They are one of the first devices invented that can self-simulate. In technical areas, there is a current plethora of virtualised computers and servers. My own work laptop contains three virtual computers. What has this to do with assessment?

Well, this is a very powerful concept, and if we ignore it during high stakes assessments we will be using new technology for old purposes – and probably do it very poorly. On the other hand, if we grasp the huge potential of new technology in high stakes assessment, we can facilitate the huge revolution which has hitherto passed the education business by – despite other areas of life being revolutionised by information technology. This is an argument against web-based solutions. They restrict what we can assess, and therefore throttle what can be taught.

Online assessment purports to provide access to multimedia. However, there are likely to be some significant problems reticulating video content for mass exams. For instance, let's say a question required an HD video clip of 3 minutes duration. Students could elect to view this simultaneously, or staggered over time. The HDV (h.264) 1080i video standard requires a bit rate of 25Mbps and therefore ~ 11 GB per hour[2]. Therefore 3 mins of video will be 550Mb of data. Over a room with 300 candidates, wireless access points will be strained well past breaking point to deliver this in an ad hoc manner as each student clicks to request to view the clip. In a medium-load scenario, the wireless access point(s) would be expected to carry 3750 Mbps. But wireless access standard IEEE 802.11n-2009 can only provide 600Mbps – assuming there is only one user (without contention with others).

It's therefore salutary to list a few considerations for the ideal eExam platform:

- e-Assessment should provide the same <u>full</u> operating system to every candidate

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[2] stackoverflow.com/questions/701991/h-264-file-size-for-1-hr-of-hd-video

- High data rates of rich media delivered simultaneously to all candidates cannot be supported by existing infrastructure

In the design of the eExam System we have responded to these considerations by using the following features:

- Live, Ubuntu-based operating system is provided for all candidates
- All communications interdicted
- No access to local disk drives (inbuilt or USB)
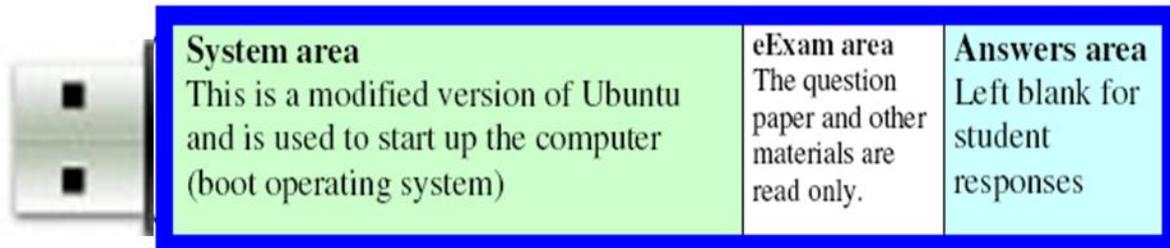- Security image on desktop background (to assist non-technical invigilators).

Figure 1: An eExam USB stick from which candidates start their computers

Figure 1 illustrates the candidate USB stick devised for the eExam System. The core candidate client is Free Open Source Software, but UTAS has a greeter add-on to the eExam System which is locally owned intellectual property.

In general, there are a set of technical issues to be considered by policy-makers. Decisions on these matters have a direct link to the affordances of the e-examination system chosen, and thus the link with a transformed curriculum. These areas of concern and opposing policy stances are listed in Table 1.

Table 1: Areas of concern for e-Examinations and opposing policy stances.

Area of concern	Opposing policy stances	
Reticulation of questions and answer responses:	Networked	Standalone
Computer ownership:	Institutional	Personal
Computer functionality:	Kiosk (locked) mode	Wide range of software (sometimes using virtualization or a compatibility layer)
Candidate communication:	Logging/monitoring	Function blocking
Candidate familiarity:	Common learning environment	Test environment requires familiarization/training
Licencing costs:	Commercial	Free, open source software

The issue of cost effectiveness is one that will be raised by many administrators. Examination costs can include printing, storage, distribution, staffing and marking. A cost comparison of printing question papers compared to using USB sticks showed the USB sticks paid for themselves after 10

re-uses. Beyond this simplistic approach, there were no costs for answer booklets, and both storage and distribution costs for USBs were lower. Since answerscripts are in digital format there are un-costed possible advantages in reticulation and speed efficiencies for electronic as compared to physical transmission. Future technologies (automated essay marking) could capitalise upon this digital format. At the moment the handling of USB sticks is a limitation, but as with reliable photocopying, this may be automated in the future, and restricts any possible impact of equipment failures.

Reliability is a key ingredient for institutions to perceive a relative advantage for e-examinations. We have been challenged to match the reliability of pen-on-paper exams of around 1 failure per thousand scripts. Our experience has been less than half this – depending upon what you regard as a failure. Simple computer crashes do happen, but in every case a reboot has found the auto-saved answerscript intact with less loss than a trip to the toilet would entail.

Ultimately institutions will need to ask what the risks of not changing to computer-based exams might be. The negative costs will be the physiological problems of students lacking muscle tone to wield pens for 3 hours in a high stakes assessment. Other costs will be the inflexibility of the curriculum unable to update to significant innovations such as computational chemistry or physics (where Nobel prizes have been awarded since 1998[3]). The question is, will academics in all disciplines adopt computer-based methods to the extent they demand access in the exam setting, or will the failure to innovate for exams inhibit adoption in the classroom?

Recommendations

1. Aim for a BYOD eExam solution for scalability
2. Build trust with stakeholders (students, administrators, IT support, academics)
3. Get institutional authorisation (at the academic summit)
4. Start with paper–replacement...... and transition to post-paper

Whatever process is adopted for conducting e-examinations, answerscripts in digital format open up many new opportunities for automatic marking. These include

1. Multiple Choice Questions (often through a learning content management system)
2. Adaptive Comparative Judgement (similar to pairwise comparison marking)
3. Semantic analysis
4. Programming assignments
5. Dataset analysis (big data)
6. Anonomised peer assessment
7. Portfolio sampling
8. Pairwise comparison marking

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[3] Walter Kohn and John A. Pople

Conclusion

I hope this paper has shown that eExams are technically feasible and should be chosen to suit the context. It is clear that current and future student perceptions matter (and particularly their self-confidence in using a keyboard). If Scotland, Nigeria and Tasmania can use eExams, so can you!

Ultimately assessors can require candidates to operate software within the exam. Since every candidate has exactly the same operating system and software, the assessment can be authentic yet fair and equitable.

At UTAS we are moving to post-paper exams where no reasonable paper-based alternative is possible. At the University of Edinburgh they are trying to abolish resits. Research is being conducted and is encouraged on the relative benefits of handwriting and keyboarding.

References

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