Comparison of Institutional Innovation: Two Universities' Nurturing of Computer-based Examinations

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Abstract
University students are rarely permitted to use their own personal computers in examinations. Yet this bring-your-own-device strategy appears essential for an economically sustainable transition to high stakes assessment using these ubiquitous professional tools. The focus is away from internet-based online testing, and on local use of personal computers isolated from networking infrastructure (to prevent collusion), under the watchful eye of invigilators. Our respective institutions are leading this transition in the United Kingdom and Australia, so we report on the gradual nature of the transition and the technologies involved. Further, we provide a comparison of university student perceptions about essay-style writing by hand or keyboard, and willingness to adopt computer-based examinations. Generally institutions and students prefer a graduated transition through paper-replacement examinations with free choice of writing implement, before moving to compulsory computer use and questions incorporating multimedia and software use. The paper concludes with recommendations for consideration by other universities considering adopting computers in high stakes assessments.

Keywords
eExaminations, bring-your-own-device, essay-style writing, institutional adoption.

INTRODUCTION
There is an increasing distance between university student learning experiences and culminating assessments. Online learning has grown strongly in this sector worldwide (Moore & Kearsley, 2011, p. xv; Dutta & Bilbao-Osorio, 2012, p.115), yet examination-style assessment largely uses paper-based technology (Cowling, 2012). The challenges for adoption of computer-based technology in high stakes assessment are daunting. Firstly, there needs to be sufficient equipment for all candidates to be assessed simultaneously, and institutions are rarely able to afford this for the few weeks each year dedicated to examinations. Secondly, the equipment must be reliable and provide a fair chance for candidates to demonstrate understanding on an equal basis. Finally, the system must reticulate answer scripts easily for marking. These challenges have to be met in the face of performance of pen-on-paper systems that have been refined and improved over many years.

Apart from the dichotomous student experience between learning online and pen-based assessment, why else would universities be seeking to move in this direction? Increasingly computers are seen as professional tools of the trade (whatev-

er the discipline) and therefore it makes good sense to use them in assessment. Assessment should always follow good practice guidelines and use a judicious mixture of methods, perhaps in-class practicals, take-home assignments and examinations where these offer authentic testing with assured identity of candidates. Potentially, computer-based examinations offer students a familiar writing environment for essays; and further, they can facilitate the inclusion of more sophisticated software tools into the curriculum.

The project described in this paper grew from the authors' desire to compare the motivation for students from a pair of geographically distinct institutions to choose a computer based examination.

LITERATURE

Some universities have explored the use of technology for high stakes examinations. The arguments for various technical methods have been discussed elsewhere (Fluck, 2010) and security methods compared (Bjørklund, 2010). Some 86% of Law schools in the USA and thirty three others elsewhere have investigated or adopted a computer-based approach to essay-style examinations.

Universities are not alone in considering these uses of computers in assessment. Some trials of the necessary technologies have been conducted in secondary schools. In 2012 the University of Cambridge International Examinations board provided Impington Village College candidates with Kindles and iPads loaded with the test papers, although students still had to handwrite the answers in a mock IGCSE biology exam. Whilst the majority favoured the use of technology, one third of the students preferred pen-on-paper (McPherson, 2012; Ward, 2012). In the USA, On December 20, 2010, the US Department of Education issued the Assessment Technology Standards Request for Information (Twing, 2011). This request and responses outline the range of technical matters such as compatibility standards required for widespread adoption of any new technology used in high stakes assessment. Of particular interest are the significant considerations around internet or network access of any kind, and the reliability of the equipment.

In Tasmania the state qualifications authority has trialled a system based on starting computers using special USB drives (data sticks). 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" (Tasmanian Qualifications Authority, 2012).

Where candidates have a free choice of medium for answering an examination, initial reports indicate there are no systematic differences in achievement levels (Hochlehnert, Brass, Moeltner & Juenger, 2011). More recent evidence suggests that computer-using candidates have a slight advantage, with greater word-counts and more complex language (Mogey & Paterson, 2012).

Our universities have considered the use of computers at the highest level. In November 2008 the University of Edinburgh approved the use of computers in examinations at both postgraduate and undergraduate levels. On 4th March 2011 the University of Tasmania (UTAS) Academic Senate approved the use of eExams in all disciplines. To make these decisions, consideration was given to technical reliability, equity and implementation processes.

METHOD

We had ethical clearance to gather data from a cohort of students at each institution in late 2012 using a survey form provided in the Appendix. This instrument had been used previously, and was mutually agreed by the authors. In Edinburgh the students were Divinity candidates who undertook a short familiarisation session. In this process they answered one short essay question using their personal computer in the Exam4 system, and another using pen-on-paper. The students could then

respond to the survey questions comparing these different text production process-es. The investigation was limited to conventional examination conditions where students were not allowed to communicate with anyone else, preserving identical assessment conditions for all candidates. Also, our focus was on extended essay-writing, an important sub-set of examination assessment styles.

Exam4[2] (by Extegrity) requires each student to load an examination response software program onto their computer. At the beginning of the examination a physical question paper is provided to the student. The software is marketed as 'the armoured word processor', so it is ideal for essay style assessments. At the end of the examination the answer scripts are downloaded from a server and printed for the assessors to mark.

In Tasmania, a cohort of Law candidates was given the option to use their personal computers to undertake the final examination for a unit of study using the eExam System[3]. Subsequently they were invited to complete an online version of the same survey. Well before the examination they were given access to a web site on how to download and write a special Ubuntu (Linux) image onto a personal USB stick. Following a copy of the exam room instructions, they could become familiar with the booting process and examination environment. In the exam room they were issued with new USB sticks containing the question paper. Although students had used the same system with personal equipment in previous years, in 2012 the cohort used institutional equipment to provide some greater assurance to managerial staff on the campus involved. At the end of the examination the USB sticks were collected, the answer scripts downloaded and burned onto a CD-ROM for the assessors.

Both technologies effectively lock the computer down so the student is unable to access the Internet, the hard disk or read information from an accessory device such as a USB stick or CD-ROM.

RESULTS

The cohorts at each institution had very similar mean ages and slightly more female candidates. However, the University of Edinburgh (UoE) cohort had a greater age spread and a lower median age (see Table 1). None of the UoE students have ever used a word processor in an essay-type examination, but 9% of the UTAS students had done so. The majority (70% at UoE, 60% at UTAS) of students had considered using a word-processor for an essay-type examination.

Table 1: Demographics

	N	Female	Age (years)		
			Mean	Standard Deviation	Median
Tasmania	32	56.25%	22.66	2.52	22
Edinburgh	40	62.5%	22.87	10.04	19

Contemplating using a computer in examinations, both cohorts felt more anxious, felt they thought carefully before starting and took pauses to think. Few would restrict changes to their text in the computer environment (6.5-12.25%) but would change, move or correct words or phrases most (85-94%). Just over half the students felt using a computer they would make more effective use of the time available (50-62%), but a significant proportion felt they would run out of time (17-19%).

In a series of other attitudinal measures the UTAS students expressed much more confidence using a computer than the UoE students. For instance, the UTAS students felt they would write more words using a computer (90% compared to 37% at UoE) and they would write in a style that feels more normal (62% compared to

25% at UoE). Furthermore more UTAS students expected the overall structure/argument of their essay would be better when using a computer (84% compared to 52% from UoE). Twice as many UTAS students reported reading through their exam essay as UoE students (62% at UTAS, 30% at UoE). Despite their demographic similarities and shared anxiety about using computers in examinations, the UTAS group expressed a far greater propensity to actually use the computer as a text creation tool.

These differences were continued in the responses to other questions in the survey, with UoE students preferring notes using pen and paper (80% compared to only 53% at UTAS); and the UTAS students preferring to plan on the computer itself (66% compared to 20% at UoE – please see Table 2). The self-reported skills difference between the groups was pronounced when directly questioned, with 81% of UTAS students claiming to type faster than they could write by hand (only 45% of UoE students agreed); and to do so with far greater accuracy (62% at UTAS, 17% at UoE – please see Table 3).

Table 2: Writing process for coursework

	Tasmania	Edinburgh
I make lots of notes using pen & paper	53.13%	80%
I make a detailed plan on paper before I starting writing properly	34.38%	42.5%
I make a detailed plan on computer before I start writing properly	65.63%	20%
I only make a quick plan	25%	35%
I don't really make a plan, I just start writing	15.63%	15%
I tend to go back and re-read and revise my essay quite a lot	68.75%	77.5%

Table 3: Comparison of self-reported computer skills and handwriting

	Tasmania	Edinburgh
I type faster than I handwrite	81.25%	45%
I type more slowly than I handwrite	9.38%	27.5%
I type and handwrite at about the same speed	9.38%	27.5%
I type pretty accurately with few errors	62.5%	17.5%
I make errors but correct them quickly as part of typing	40.63%	57.5%
My typing often contains errors	12.5%	25%

These differences apart, there were some areas in which both cohorts were substantially the same – only making a quick essay plan, re-reading their essay, correcting errors as they go.

A thematic analysis was undertaken of comments on the main differences between handwriting and typing an exam essay. Sixty of the respondents provided a comment, but one was illegible, and therefore discarded. In order of comment frequency, the main themes respondents mentioned were stress, legibility, essay structure, speed of text production, equivalence and fairness (see Table 4).

Examinations are high stakes assessments; therefore it was to be expected stress would be the most prominent consideration. Anxiety about computer reliability is nearly balanced by the relief from hand cramps when using a keyboard. Respondents acknowledged using a computer significantly improved legibility and increased text production speed, but opinions about the writing process were more

mixed. Four respondents considered using a computer exactly equivalent to hand-writing in exams, and one commented on fairness.

Table 4: Thematic analysis of comparative comments

Theme	Mode (Example)	UTAS	UoE	Combined
Examinations are less stress-ful for me	on a computer (because I have no hand cramps)	7	3	10
	when handwriting (no head-aches from eye strain, or anxiety about information technology breakdowns)	9	7	16
Legibility is bet-ter	on a computer (it is easier to edit text using cut and paste), with spell check.	9	12	21
	when handwriting (more accu-rate)	0	1	1
My essay pro-duction process and structure is superior	on a computer (because I am not accustomed to handwriting)	4	5	9
	when handwriting (which is more normal for me, and I tend to be more aware of er-rors/spelling mistakes on a computer, and spend time cor-recting them).	3	9	12
Text production is faster	on a computer	10	4	14
	when handwriting	0	2	2
Handwriting is equivalent to using a computer in examinations.		0	4	4
Examinations are probably fairer	on computers (because poor handwriting is not apparent)	1	0	1
	when everyone handwrites (be-cause some people may get around the disabled computer functions to essentially cheat; and there is less variation in handwriting speeds than typing speeds).	1	0	1

DISCUSSION

Given the broad demographic, gender and discipline similarities between the groups, we sought some explanations in respect of technical computer skills. The first consideration was the likely exposure to computers in the home environment in their formative years. Students in the UTAS cohort were aged 14 in 2003, when 85% of households with children under the age of 15 had internet access (Australian Bureau of Statistics, 2004, p. 7). They therefore had a strong chance to become familiar with computers from a young age. Comparable figures for Scotland showed that around 70% of households with families had home internet access (Martin, Dudleston, Harkins, Hewitt, Hope, MacLeod & Murray, 2005). These levels of ac-cess appear to be similar, and it seems unlikely the disposition of these students in 2012 could be attributed to differences in computer access as children.

The second consideration to explain the technical proficiency differences be-tween UTAS and UoE students was the teaching methods on their courses. At the

UTAS Law School, the main lecture theatre is fitted with a power supply socket for every student seat; students are expected to download a synopsis of the lecture notes beforehand from the learning content management system; and their attendance is recorded by sighting a name label affixed to the screen casing of their computer. Therefore these students are encouraged to become computer competent during their course, and trained to access legal databases as part of their professional skills training.

By comparison, the Divinity course at UoE is mostly taught through traditional lectures and reading groups, with an emphasis on personal interaction, but is also supported with the institutional virtual learning environment. Students in Divinity are expected to submit essays electronically and all Divinity students take an online academic skills module which includes library usage, IT and writing skills. Hence these students are also expected to develop confidence and competence in use of computers and technology.

Educational institutions provide an important social role and their behaviour is often determined by political, financial and reputational policy levers. Increasingly a first degree is seen as the basic entry level to employment and together with government policy this is driving up the number of students in higher education. At the same time resources and funding are being squeezed, so Universities are challenged to maintain and develop reputations in an increasingly global market. Students are increasingly "paying customers" who expect to achieve the qualifications promised, but Universities must strive to maintain standards and be able to robustly counteract media charges of "dumbing down". Assessment has a critical role in the quality processes of Universities, and the established practice of invigilated examinations has become trusted by all stakeholders.

For students the stakes are equally high. The award of a degree is not only a testament to their proven learning and skill, but potentially a contribution towards their career progression. It is not in their interests to have peers succeeding through the use of assignment-writing services (which devalue the degree's usefulness) or to have any infringement of the key high stakes assessment – the examination. Therefore students need to build trust and confidence in any new technology for text production in an exam setting. They need to be sure their revision and preparation will not be erased at a single stroke by computer failure.

Caught in the middle are the staff of university examination offices who have honed procedures over many years to be resilient, equitable and reliable. These staff have quality assurance processes in place to ensure the correct question paper is delivered to sometimes hundreds of candidates simultaneously in multiple locations. They are not equipped or staffed to deliver these vital documents in an alternative medium, particularly not one which varies with student choice. To do so requires major modifications to their systems, and may necessarily include candidates making firm choices well ahead of exam day.

Our joint experiences allow us to highlight a number of common approaches or considerations, which have assisted with the successful introduction of computers in university examinations:

1. Some students resent mandatory pen use in assessments when their learning has been predominantly computer based (and this is perceived as the modern format for knowledge); equally, others would resent mandatory typing.
2. Students using computers for essays in examinations type more, create richer texts and thus score more highly;
3. Assessment of computer-based answer scripts is easier (through improved legibility over hastily scrawled handwriting) and thus more equitable in the marking phase;
4. Computer use in examinations provides an opportunity for posing questions better related to professional activity in the modern world, leading to authentic skills assessment instead of factual regurgitation.

5. Digital answer scripts can lead to better marking through cheap replication and reticulation to multiple markers, and even pairwise comparative judgement approaches which are faster (Newhouse, 2011).
6. Institutional computers can be used initially; but familiar student-owned equipment is required when scaling up sustainably.

Each of these arguments has various values according to the audience, and pre-supposes the challenges listed in the introduction are adequately met.

CONCLUSION

At UTAS the initial trials of eExams were conducted using institutional equipment to build confidence in staff and students. This trust-building exercise may be needed on each campus to establish confidence amongst the front-end staff who will have the ongoing responsibility for organising, managing and running the examinations. However, UoE considered the use of institutional equipment unsustainable and would not scale upwards in the long term, so have used student-owned computers for essay style examinations from the outset (large scale multiple choice questions have used computer labs, but this has its own problems).

Building trust and confidence with students and assessors is also important. Initially they prefer setting questions for which either pen or keyboard responses are suitable. An initial experience of a 'free media choice' examination provides much more positive perspectives on subsequent assessments which use multimedia or otherwise are impossible to provide in a paper-based alternative. Experience in Tasmania has shown that over a period of 5 years the proportion of students able to provide a computer for such examinations has grown from 20% to 100% (even though some have to borrow equipment for the few hours of the test).

From this study, it is clear that computer-based examinations are feasible and students choices are based on experiences gained well beforehand. Their familiarity with typing and the extent to which they are able to plan an essay using a keyboard appear to be important factors affecting their choice to use a computer.

For other institutions considering undertaking this transformation of examination style assessments, from our experience we would advise the following strategies be considered:

- Start trials with small groups using institutional equipment, perhaps for in-class tests
- Establish trust and confidence amongst faculty staff, students, academic managers and technical officers
- Building upon these initial efforts, obtain institutional approval for the use of computers in high stakes assessments
- Continue to build momentum in a range of disciplines, advocating paper-replacement examinations with free candidate choice of media at first.
- As numbers grow, consider a gradual move to multi-media and compulsory computer use with candidates providing the greater proportion of equipment
- Cultivate links with feeder pre-tertiary institutions in respect of this changing style of assessment.

We commend the growth of computer-based examinations to other universities and other disciplines.

NOTES
[1] http://www.exam4.com/Lawschools
[2] www.exam4.com
[3] www.eExams.org

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APPENDIX

Survey instrument (UTAS version)

E-Assessment Survey – for students who have just completed the XXXXXX exam. This survey is optional – you don't have to complete it. It should take about three minutes.

1. What is your gender?
2. What is your age?
3. Have you ever used a word processor in an essay-type exam before the XXXXXX examination?
4. Would you ever consider using a word processor for an essay-type exam?
5. For each of the following statements please tick ONE box considering examination conditions:

		Using a Computer	Pen on paper
i	I feel more anxious		
ii	I write more words		
iii	I think more carefully before I start		
iv	I pause to think most		
v	I write in a style that feels more normal		
vi	I try not to make changes unless they are really important		
vii	I change, move or correct words or phrases most		
viii	I think the overall structure/argument is better		
ix	I make more effective use of the time available		

6. For each of the following statements please consider how you respond to examination conditions (BOTH boxes may apply for these items):

		Using a Computer	Pen on paper
i	I run out of time		
ii	I read over my essay(s) before submitting		

7. How do you normally prepare a coursework essay/assignment?

		Yes	No
i	I make lots of notes using pen & paper		
ii	I make a detailed plan on paper before I starting writing properly		
iii	I make a detailed plan on computer before I start writing properly		
iv	I only make a quick plan		
v	I don't really make a plan, I just start writing		
vi	I tend to go back and re-read and revise my essay quite a lot		

8. Please click the statements that apply for you:

i   I type faster than I handwrite
ii I type more slowly than I handwrite
iii I type and handwrite at about the same speed
iv I type pretty accurately with few errors
v   I make errors but correct them quickly as part of typing
vi My typing often contains errors

9. For you, what are the main differences between handwriting and typing an exam essay?
<text response>

Biographies

Andrew Fluck is a teacher educator at the University of Tasmania. He has an interest in curriculum transformation through the use of computers; developed an eExam system for students to use their own computers in high stakes assessment; and serves on the executive of Working Group 3.3 (research into educational applications of information technologies) for IFIP/UNESCO. See more at http://www.educ.utas.edu.au/users/afluck/.

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