AUTOMATED MARKING OF INDIVIDUALISED SPREADSHEET ASSIGNMENTS: THE IMPACT OF DIFFERENT FORMATIVE SELF-ASSESSMENT OPTIONS

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Automated Marking of Individualised Spreadsheet Assignments: the Impact of Different Formative Self-Assessment Options

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Abstract

This paper reports on the effects of providing students with the ability to self-assess individualized spreadsheet assignments prior to submission for formal assessment. Quality learning outcomes are achieved when students adopt deep approaches to learning. Learning environments designed to align assessment to learning objectives and learning activities encourage these approaches (Biggs 1999, Ramsden 2003). A crucial part of any learning or assessment activity is the degree to which students receive timely and effective feedback. This paper responds to Higgins' (2002) observation on the lack of research on feedback, particularly in relation to the use of spreadsheets in learning and assessment activities.

Computer-assisted assessment at traditional universities like the University of Sydney has been limited to multiple choice quizzes, tests completed on paper and scanned, and in recent years, tests completed online. When used for summative assessment, feedback to students is often too late to be effective, limited to a single word or number, or in the case of final exams, non-existent. Some academics may make past exams and tests available to the next semester cohort. A few go further and provide model answers that allow formative self-assessment. However, more immediate and more elaborate feedback is possible with the proliferation of web-based learning management systems like WebCT and Blackboard, which contain an online quiz/test option, and user-friendly programs like WebMCQ and QuestionMark, which allow a greater degree of sophistication in formulating questions.

Accounting concepts are one area where students need to understand how different elements are calculated and interact. For example, the interaction of different assumptions for *sales price* and *quantity sold* when forecasting net present value need to be carefully considered if one is making a business case to a financier. Spreadsheet assignments are a good way to learn such concepts but they are an assessment nightmare either because of validity problems (the potential for cheating using the *cell copy* function) or because of marking time (if students are allowed individual choice in application topic).

Implicitly recognising the benefit to student learning of practice and immediate feedback, students at the University of Sydney have been given spreadsheet assignments for nearly ten years. The spreadsheet assignments allow automatic self-assessment prior to submission for formal marking. Three variations are on trial: limitless self-assessments; a limited known number of self-assessments; and self-assessment only after all parts of the assignment have been attempted. Student perceptions of the self-assessment options are drawn from pre- and post-course surveys, student focus groups and unsolicited comments within the online discussion forum. Effects on participating academic and support staff, including load, are gauged by interviews. Academics seeking ways to improve learning by improving feedback, without an increasing load, will find this research of interest.
Keywords assessment, feedback, spreadsheet

1. Introduction

Quality learning outcomes are achieved when students adopt deep approaches to learning. This is encouraged by designing learning environments that align assessment to learning objectives and learning activities (Biggs 1999, Ramsden 2003). A crucial part of any learning or assessment activity is the degree to which students receive timely and effective feedback. In the last decade there has been an increasing interest in harnessing technology to deliver learning and assessment activities that simultaneously assist students' learning and improve academic productivity in the face of ever increasing class sizes and diminishing resources for the higher education sector.

This paper reports on the effects of providing students with the ability to self-assess individualized spreadsheet assignments prior to submission for formal assessment. This paper adds to the growing research interest in formative assessment feedback noted by Higgins, Hartley and Skelton (2002). It focuses on the use of spreadsheets as a computer assisted tool for supporting learning and assessment activities, and for providing feedback via a number of formative self-assessment options.

Section 2 provides a brief review of the relevant literature. Section 3 is an overview of the assignment marking system and context. Section 4 describes the research method, section 5 the results and some discussion, with concluding remarks provided in section 6.

2. Relevant literature

There is ample research to support the notion that assessment is crucial to learning. Ramsden (1992, 2003) suggests that assessment defines the curriculum. Biggs (1999) shows that a strong alignment of assessment with learning objectives, resources and activities is a key strategy to ensure quality outcomes. However, Prosser & Trigwell (1999) found that teachers were more likely to design and support subjects that encourage students to take a deep approach to learning if they view teaching as helping students change their conceptions of reality rather than as simply transmitting information to them. To what extent can computer technology assist learning assessment?

There appears ample evidence, such as Russell's (1999) review of 355 research reports, that technology in itself is no guarantee of improved learning. Any improvements in learning outcomes are significantly dependent on how educational technology tools are used. For example, in their national review of educational innovation in Australian higher education, Alexander & McKenzie (1998) show that innovative learning technology introduced without changes to assessment was less likely to realise the expected improvement in learning outcomes. Thus we would expect successful teachers to make explicit and strong decisions about feedback and technology, two important elements in assessment, if they are to encourage students to take a deep approach to learning.

In the typical assessment cycle of a modern university, computers can assist assessment in nine possible steps:

1. **Computers can assist in assigning assessment tasks**. They can be used to deliver the task and its related marking criteria via a course management system or by email. The task should be accompanied by clear requirements (such as deadlines), strong links to relevant learning outcomes and marking guidelines, so that expectations for the standard of work and effort are clear. Student motivation and approaches to learning are linked to clear standards and goals.
2. **Computers can assist during the period of completion of an assessment for clarification**. Academics can use email or even better, a public discussion board to continually clarify students' conceptions of what is required. Additional strategies could include providing exemplars of quality work from past student cohorts.
3. **Computers can assist in the completion of the assessment task**. While sophisticated proprietary software programs such as CAD can be used, increasingly academics are exploring new ways of using worldware programs, such as library databases, web-supported search engines and course management systems. Worldware enables simple reusability of complex teaching and learning activities like anonymous asynchronous online debates or role play simulations (e.g. Freeman & Capper, 1998)

4. **Computers can be used to deliver formative feedback**. Statements like 'don't be discouraged if you have spent at least two weeks gathering data as this will ensure your results are more meaningful' motivate students to keep going. Students can be encouraged with more specific statements to reflect on their progress, for example, 'you should have completed stage 2 by now and got a result between 10% and 12% for your discount rate if you want to complete the assessment task on time'. Feedback can be delivered manually as a broadcast announcement, automatically programmed on an individualized basis (like the quiz function on Blackboard), or delivered as a formative step in the submission process (e.g. 'the answer is 11.6% for the discount rate for your spreadsheet question'). Any of these methods will encourage students to sustain their efforts.
5. **Computers can assist assessment in the submission process**. Electronic submission methods include "anytime anyplace" submission systems like a digital dropbox in a course management system, or email attachment to a centralized submission account, or simply submission of a computer disk. The attractions of the former include the delivery of a time and date stamp receipt.
6. **Computers can assist assessment in the marking process.** Historically this was restricted to scanning paper sheets completed by students undertaking multiple choice and true/false questions under invigilated exam conditions. In the worst case, manual data entry of student responses was required. Both these cases require human intervention to check for data entry error. Fortunately, in recent years other summative assessment systems have become computerised, allowing data entry accuracy to be the sole responsibility of the student. More sophisticated systems include specific assessment programs like QuestionMark or WebMCQ. Academics can easily use the quiz feature on course management systems like Blackboard to provide feedback responses. Proprietary code scripted to work automatically within web environments is typically out of the reach of the average academic, however, incorporating Visual Basic within individualized Excel spreadsheet assignments can achieve the same result. The use of worldware products ensures that such a solution is not out of the reach of the average academic. Recently, artificial intelligence systems have been developed around free-response answers on open-ended questions. Vantage (2003) boasts that 'IntelliMetric achieves levels of scoring accuracy that equal or exceed expert graders".
7. **Computers can assist assessment in the generation of feedback.** Higgins et al (2002) posit that larger class sizes have meant the demise of written feedback to students. Despite student expectations of feedback as a right, the feedback received was minimal and, in 40% of cases, the handwriting was hard to read. As a result, students rarely spent more that five 10-15 minutes reading and reflecting on the comments. Computers can help address this problem. The simplest options include generating generalized feedback or model answers into a course website to allow students to self-select the appropriate feedback. Several software programs are available to assist markers

provide customised feedback more efficiently. Mindtrail and MarkIt are two programs that encourage academics to generate knowledge trees related to marking criteria from which standardized feedback comments can be chosen and further customised for each student's assignment.

8. **Computers can assist assessment in the feedback delivery process**. Students can be provided with more efficient or more effective access to their feedback aided by computers. Examples include feedback files emailed to a student or made available on a web or network server, or simply posted back to the Gradebook in a course management system.
9. **Computers can assist assessment in the diagnostic, audit and evaluation process**. Multiple choice questions can be analysed for poor wording, or lack of detractors, and improved for future usage. Results from human markers can be analysed to identify weaknesses or inaccuracies.

In recent years there has been increased interest in reusable learning objects and worldware solutions which promise wide adoption possibilities and economies of scale. The attraction of worldware solutions is that they are generally available on the standard desktop computer and thus make innovation more achievable. This research project focuses on worldware-type assessment solutions rather than proprietary ones. In particular we are interested in formative self-assessment feedback as described in points 6, 7 and 8 above.

Computer-assisted assessment at traditional universities has been limited to multiple choice quizzes, tests completed on paper and scanned, and in recent years, tests completed online. When used for summative assessment, feedback to students is often too late, limited to a single word or number or, in the case of final exams, non-existent. The next most common worldware solution is automated self-assessment of multiple-choice questions for formative feedback. There has been considerable research showing significant improvements in the efficiency of these programs, however, such gains can come at a cost. For example, multiple choice questions can be difficult and time-consuming to write well, especially for testing higher learning outcomes like analytical and problem solving skills. Multiple-choice question cannot test important graduate attributes such as the ability to collaborate and communicate. Even after considerable design effort and success in testing lower levels of learning, biases may still be inherent. For example students assessed in a language other than their native tongue are susceptible to nuances and subtle differences in language, which are difficult to identify.

This paper explores an alternative worldware formative self-assessment solution. Implicitly recognising the benefit to student learning of practice and immediate feedback, students at the University of Sydney have been given spreadsheet assignments for nearly ten years. The spreadsheet assignments allow automatic self-assessment prior to submission for formal marking, thus allowing opportunities for improvement beyond points 6, 7 and 8 to include

point 4. They can be used in a wide range of disciplines where calculations and interactions between variables are crucial knowledge for professionals.

Accounting concepts are one area where students need to understand how different parts are calculated and how they interact. For example, the interaction of different assumptions for *sales price* and *quantity sold* when forecasting net present value need to be carefully considered if one is making a business case to a financier. Spreadsheet assignments are a good way to learn such concepts but they are an assessment nightmare either because of validity problems (the potential for cheating using the *cell copy* function) or because of marking time (if students are allowed individual choice in application topic).

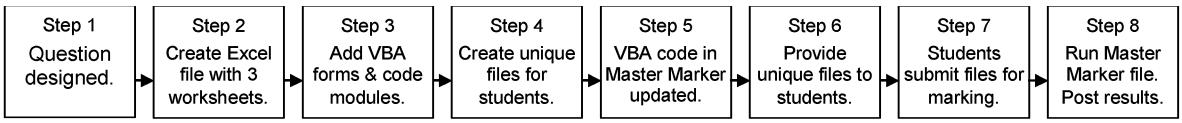
The three variations of self assessment researched are: limitless self-assessments; a limited known number of self-assessments; and self-assessment only after all parts of the assignment have been attempted. The main expected benefits are improved student attitudes to learning, resulting in a positive effect on student learning, and improved productivity for teaching staff

3. Assignment marking system and context

The assignment marking system has been used in the University of Sydney's Faculty of Economics & Business for over 10 years. This system was developed chiefly as a response to the challenge of assessing large numbers of student accounting assignments in an economical and timely manner. A secondary outcome of the assignment system was improved personal computer skills and spreadsheet expertise, which are essential skills in today's business environment.

The eight steps to generate individualised spreadsheets for both formative self assessment and summative assessment are depicted in Figure 1.

Figure 1. Development steps for self-assessable individualised spreadsheets



1. Instructor designs assignment question with sample data and entry cells requiring answers with suggested solutions input as proper spreadsheet formula. Creates master assignment template file from this information.
2. Adds two worksheets to file, one to display self-assessment results to the student and another to record self-assessment activity for the instructor. Both of these sheets are hidden with the self-assessment sheet being displayed to the student upon request.

3. VBA code is added to the master assignment template file [1], three forms and seven modules. Each of the three forms is standard for all assignments and can therefore be imported into the master assignment template directly. Of the seven VBA code modules, four are standard for all assignments and three require customisation for the individual assignment. The modules requiring changes provide the code that changes the question data to allow for testing of proper formula use. The code compares the student's entry cell outputs to the correct outputs with the changed data. At this point the master assignment file should be provided to a discipline expert for rigorous checking.
4. Individualised student files are created with the unique assignment creation file. This file simply contains a list of student names and numbers. The creation file's VBA code performs a four step procedure for each student on this list. It opens the master assignment template file and pastes the current student's name and student number to a visible location and the student number to a hidden, protected location. The student file is individualised further with the input and hiding of a random number (up to 10) of rows and columns. This randomisation of the location of an assignment's data and entry cells makes it extremely difficult to use the cell copy function from another student's assignment file. The question data may also be randomised. Finally the assignment template file is saved using a combination of the assignment number and the student number as the file name.
5. Formal assessment of submitted assignments is performed by a master marking file containing a number of VBA code modules to perform the marking and a worksheet with a list of students and recorded marks. The master marking file has several standard modules (no changes required) which open submitted files, record marks and move assessed files. A new assignment file requires the addition of a module for changing the question data (same code as used in the master assignment file) and marking code for assessing the accuracy of the student's entries. This marking code is the same as used in the master assignment file for self-assessment adjusted to record the mark to the marker file rather than to the self-assessment worksheet of the master assignment file.
6. Assignment files are provided to the students on a self-service basis through the faculty student file server with each student having their own subdirectory named with their student number.
7. After downloading from the student file server, assignment files can be completed using Microsoft Excel. The self-assessment option provides instant feedback on the student's work for the entire assignment irrespective of the number of entry cells completed. Upon receiving a self-assessment of 100% (or when the student decides that a lesser mark is good enough) submission for formal assessment is made. Currently students at the University of Sydney use the Blackboard digital drop box for submission of their assignment work. An email system with assignment files sent as attachments has also been

[1] VBA code is not required in this file if the self-assessment option is not made available to students.

effectively used. A requirement of the master marking file (whichever system is used) is that all assignment submissions are located in a single directory.

8. The master marking file is usually run on a daily basis requiring approximately five seconds to open, assess and record the mark for each submitted file. The current system for providing students with formal assessment marks is through a file with student numbers and assignment marks available via Blackboard. In the past assignment marks have been emailed to students with a Perl script. Reinstatement of this personalised delivery of the formal assessment mark is currently being explored.[2]

4. Method

Research data was gathered from multiple stakeholders affected by the assignment marking system during the first half of 2003. The system was used in three subjects at the University of Sydney – 1,100 first-year Financial Accounting (Acct1001) students, 600 second-year Management Accounting (Act2002) students, and 200 post-graduate Management Accounting (Acct5002) students.

Survey data on student learning expectations and experience was collected for the first year Financial Accounting students.[3] A pre-course survey was administered in tutorials to over 900 students. The post-course survey was conducted by tutors with 230 surveys being completed.[4]

Data on use of the assignments' self-assessment option was collected for students in each of the three units of study through an automatic recording feature built into the assignment files. Each time a student used the self-assessment option the day/time and assessment mark were recorded on a hidden sheet of the assignment file. Use of the assignment self-assessment option was analysed for 8,600 assignment submissions and 89,000 self-assessments requests over the three units of study.

A detailed analysis of the number, timing and frequency of self-assessments was conducted. Differing use of the self-assessment feature was analysed for the three different self-assessment options available to students.

Further student information was gathered from tutor-conducted focus groups and analysis of unsolicited comments on the course Blackboard discussion board. Data from other stakeholders was gathered from interviews with participating academics, IT staff and teaching & learning specialists.

5.

[2] The problem being that Outlook email security introduced as a result of the Melissa virus prevents sending emails programmatically from within Excel.

[3] Administrative problems prevented data collection from the other students.

[4] Further administrative problems prevented data collection from the other students.

Results

We present the results of our research using a multi-stakeholder perspective. We begin with students, and then examine the effects on staff, department and university.

Effect on students

The effects on students are discussed in three separate ways, namely the survey responses, an analysis of the online discussion board and an analysis of the actual spreadsheet files.

The online discussion board was available for students to clarify their understanding of how the spreadsheets worked and help them understand the concepts to adequately complete the calculation questions contained in the spreadsheets. Most of the comments related to administrative aspects, for example "Where are the files located on the network?" and 'How does the digital drop box work?' There were several questions about how the spreadsheets worked and a few about the underlying concepts being tested by the calculation questions, e.g. "How do I calculate the average inventory?"

Table 1 describes first year students' perceptions prior to using the self-assessment formative spreadsheet assignments.

Table 1 - Pre-Course Survey of Learning Experience & Expectations - Acct1001

Section 1: Background information								
Gender	Male	53%	Female	47%				
Overseas fee-paying:	Yes	29%	No	71%				
Age	<21 yrs	92%	21-25 yrs	7%	>25 yrs	1%		
First language	English	49%	Other	51%				
Disability status	None	94%	Visual	2%	Hearing	1%	Other	3%
Social security benefits	None	86%	Austudy	7%	Other	7%		
Semester working hours	None	37%	1-5 hrs/wk	15%	6-10 hrs/wk	23%	>10 hrs	25%
Home internet facilities	Phone modem	62%	Cable modem	33%	None	5%		
Main access to internet	Uni lab	13%	Home	87%				

Section 2: Previous experience using computer-based and web-based tools anywhere				
	No Experience	A Little Experience	Some Competence	Expert
Spreadsheet	23%	45%	29%	3%
Word processing	2%	11%	63%	24%
Online threaded text discussion forums	43%	34%	18%	5%
Emailing with attachments	7%	20%	43%	30%
PowerPoint	23%	37%	32%	8%

Section 3 – Previous learning experience & expectations at University of Sydney					
	Strongly Disagree	Disagree	Agree	Strongly Agree	No opinion
I expect lectures to be productive for learning	2%	7%	61%	27%	3%
Working with others is a productive way to get feedback & learn	1%	7%	55%	35%	2%
Feedback on my homework, quizzes & assignments is crucial to my learning	1%	2%	34%	60%	3%
Model answers to past exams and quizzes help me gauge my ability	0%	2%	33%	61%	4%
I make a serious attempt with past exams & practice quizzes prior to looking at answers	1%	10%	51%	31%	7%
Practical assignments motivate me to learn	3%	17%	53%	19%	8%
I expect the assignment with self-assessment to be non-threatening for learning	2%	9%	57%	19%	14%
I expect the spreadsheet assignments to be a productive way to learn	3%	10%	59%	17%	11%
I have confidence that the computer will assess my work accurately	4%	17%	50%	14%	15%

Table 1 reveals a number of conditions necessary to achieve a positive role for self-assessable spreadsheet assignments. First, busy students are more likely to want to complete assessment tasks and obtain feedback away from a classroom context. With close to half the surveyed population (48%) working at part-time jobs for over 6 hours per week and most (95%) with home computers and Internet access, the self-assessment options will be popular. Second, we would expect spreadsheet assignments to be an attractive option for students for whom English is a second language, although this is less likely if students are unfamiliar with spreadsheets. With over half (51%) of the students indicating a first language other than English and the majority (68%) with little or no spreadsheet experience, there is no strong reason for expecting students to expect the summative aspect of the spreadsheet assignment to be attractive.

Table 1 also reveals this student group strongly supports feedback for learning (94%). Further analysis indicates that there were statistically significant differences about the benefits of feedback dependent on the student's first language and age. Students speaking English as their first language and younger students regard feedback as being more crucial to their learning. Further chi-square analysis of the importance of feedback revealed no significant difference based on gender or employment status.

Subgroup Analysis of Student's Perception That Feedback is Crucial to Learning: Comparison of various subgroups to the main group of all students (94% who agreed that feedback is crucial to learning)	**Chi-Test for Significance of Difference**
1st language: Agreement down by 3% if 1st language was not English	0.01
Age: Agreement down by 4% for older (>21 years) student	0.05
Gender: Marginally more females agreed	0.51
Paid work (> 6 hours): Marginally more working students agreed	0.47

Table 2 reveals the results of the post-course survey.

Table 2 - Post-Unit Survey of Students Learning Experience Summary - Acct1001

Survey Question	Strongly Disagree	Disagree	Agree	Strongly Agree	No opinion
I found the instruction package and answers to FAQs useful.	6%	22%	47%	7%	18%
The Blackboard Discussion board was useful.	7%	25%	35%	12%	21%
The computer lab supervisor was a useful resource.	8%	27%	21%	10%	34%
Overall (as a package) the resources provided for completing the assignments were adequate.	3%	18%	60%	14%	5%
I had a clear idea of what was expected for the assignments.	7%	28%	45%	17%	3%
The computer assignments motivated me to learn.	8%	25%	44%	16%	7%
The workload required for the computer assignments matched the assessment value.	8%	21%	49%	15%	7%
There was sufficient time to understand and apply background concepts	2%	13%	58%	23%	4%
I completed each assignment in one or two intensive sessions	4%	14%	51%	24%	7%
I completed the assignments in a group to learn from others	26%	40%	20%	6%	8%
I completed the computer assignments away from campus	11%	14%	46%	25%	4%
I used the text and/or lecture notes while completing the assignments.	11%	26%	47%	14%	2%
To do well on the computer assignment was a simple case of repeating work done in class.	5%	18%	57%	14%	6%
I found the spreadsheet assignment with the self-assessment option to be non-threatening for learning.	3%	10%	**46%**	**33%**	8%
The self-assessment options motivated me to keep trying	3%	10%	**41%**	**41%**	5%
I was more motivated when I knew there was a limited number of times I could apply self-assessment	17%	24%	30%	12%	17%
The computer marking program assessed my work accurately	11%	27%	42%	13%	7%
If possible all assignments should provide self-assessment	1%	9%	40%	42%	8%
The computer assignment tested spreadsheet skills more than accounting knowledge / skill	6%	34%	38%	16%	6%
These assignments helped develop accounting problem solving skills	5%	17%	60%	11%	7%
The assignments helped develop my spreadsheet skills	3%	17%	59%	14%	7%
I feel more confident tackling unfamiliar accounting problems because of the computer assignments	7%	26%	45%	9%	13%
I found these assignments to be a productive way to learn	5%	15%	**62%**	**14%**	4%
These assignments were more enjoyable than normal ones	7%	10%	**46%**	**29%**	8%

Over three-quarters of the group (76%) indicated they found the computer assignments a productive way to learn while 75% found them more enjoyable than normal assignments. Most respondents (79%) found the self-assessment option to be non-threatening for learning with 82% signifying that the self-assessment option motivated them to keep trying. This is strong support for providing adequate feedback as early as possible in the learning and assessment cycle.

Table 3 describes the results by gender. While female students were somewhat more motivated than male students on a number of attributes, all differences based on gender are insignificant statistically based on the chi-square testing performed.

Table 3 - Post-course survey responses by gender

Survey Question	All Students	Male	Female	Chi-Test
The computer assignments motivated me to learn.	57%	52%	62%	.30
I found the spreadsheet assignment with the self-assessment option to be non-threatening for learning.	76%	76%	75%	.88
The self-assessment options motivated me to keep trying	81%	79%	83%	.57
The computer marking program assessed my work accurately	51%	49%	52%	.79
If possible all assignments should provide self-assessment	86%	86%	87%	.88
I found these assignments to be a productive way to learn	77%	75%	80%	.48
These assignments were more enjoyable than normal ones	79%	75%	83%	.24

Table 4 describes post course survey response by native language. None of the differences are statistically significant. A student's first spoken language appears to not be a factor with respect to students' perceptions of the learning effectiveness of the computer marking system.

Table 4. Post-course survey responses by native language

Survey Question	All Students	English 1st lang	Other 1st lang.	Chi-Test
The computer assignments motivated me to learn.	64%	64%	63%	.89
I found the spreadsheet assignment with the self-assessment option to be non-threatening for learning.	84%	82%	85%	.70
The self-assessment options motivated me to keep trying	87%	91%	83%	.23
The computer marking program assessed my work accurately	54%	53%	55%	.81
If possible all assignments should provide self-assessment	93%	95%	92%	.53
I found these assignments to be a productive way to learn	83%	84%	81%	.65
These assignments were more enjoyable than normal ones	86%	87%	85%	.73

Table 5 describes post course survey response by age. Only one difference was statistically significant at less than 5%, this being that older students had a poorer opinion with regards to the accuracy of the marking system.

Table 5. Post-course survey responses by age

Survey Question	All Students	< 21 years	>= 21 years	Chi-Test
The computer assignments motivated me to learn.	64%	64%	58%	.69
I found the spreadsheet assignment with the self-assessment option to be non-threatening for learning.	84%	84%	83%	.96
The self-assessment options motivated me to keep trying.	87%	86%	93%	.48
The computer marking program assessed my work accurately.	54%	57%	29%	.04
If possible all assignments should have a self-assessment facility.	93%	94%	85%	.21
I found these assignments to be a productive way to learn.	83%	82%	85%	.84
These assignments were more enjoyable than normal ones.	86%	86%	83%	.79

The responses regarding the perceived accuracy of the marking program were somewhat disappointing with approximately half of the students agreeing that their work was assessed accurately. This result can be at least partially explained by an error in the summative assessment marking code that resulted in students receiving a result of 98% while their formative assessment indicated they were 100% correct. This discrepancy was pointed out in the comments section of a number of survey responses with their corresponding disagreement with the accuracy of the marking system.

The free response section of the survey asked students to indicate the "three best things" and "three suggested improvements" for the self-assessable spreadsheet assignments. Following is a representative sample of their comments.

- "Self-assessment helped a lot."
- "Easy to get marks"
- "Results can be checked directly"
- "They should be worth more"
- "Correct the marking so you don't get 98% when self-assessment says 100%"
- "Opportunity to practice"
- "Work at your own pace"
- "Convenient. No paper work"
- "Lack of advice on due date"
- "Not all people have Excel"
- "Less intimidating than normal assignments"
- "Helped cement knowledge learned"

- "Motivated me to improve my computer skills combined with accounting"

Finally we turn to a discussion of how students used the self-assessment facility. This data was collected automatically by the assignment files. The popularity of the self-assessment option is apparent from the data collected with an average of 10.3 self-assessments per assignment (namely 88,969 self-assessments requested for 8,600 assignments submitted over three subjects).

We suggest that self-assessment use may be even higher than recorded due to students subverting the data collection mechanism by making a copy of their assignment file and using the self-assessment option on the copy. This could be the case for all or most of the 1,258 files (15% of total submissions) that were submitted with zero recorded self-assessments. The alternative explanation that these students were uninterested in their assignment mark is less plausible. It is not possible to discover the degree to which the 15% of students with zero self-assessments overlapped with the 17% of students who did not agree that the assignments with the self-assessment option were a non-threatening way to learn.

In any case, self-assessment use was at least as popular as depicted in Graph 1, with students using the self-assessment option six or more times for close to half of the submitted assignments (47%). The popularity of assessing their own work was also strongly reflected in the post-course survey results (82%). The data suggest that this option should be available for all assignments when possible. Of the written comments received from students, accolades for the self-assessment option were by far the most frequent.

Graph 1

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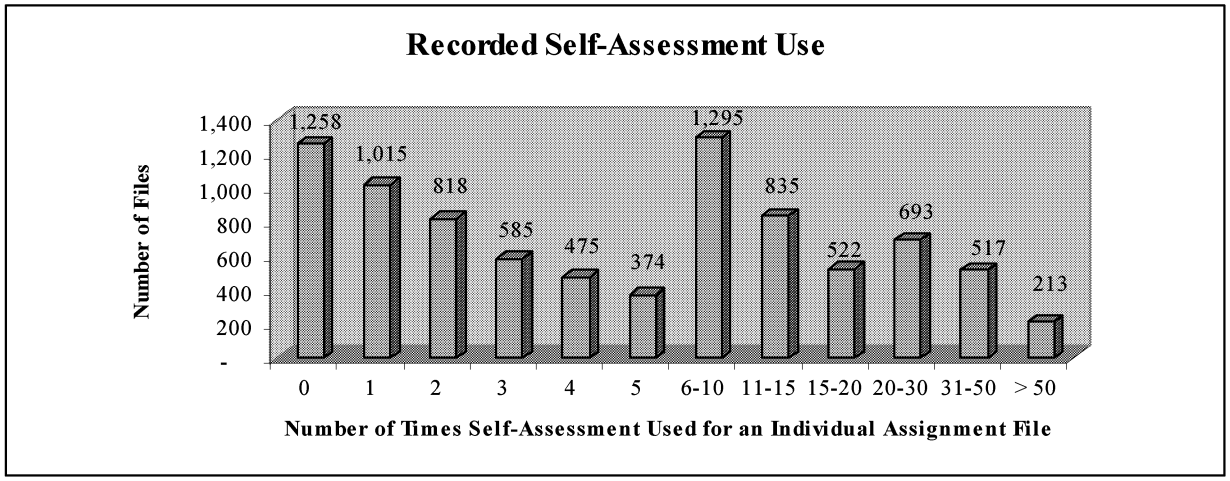

One of the objectives of this research project was to gather evidence with regards to the effect of different types of feedback on student learning and to this end different self-assessment options were developed. The variations of this assignment feature trialled in semester 1 2003 were (1) a limited known number of self-assessments, (2) self-assessment only after all parts of the assignment have been attempted and (3) limitless self-assessments. Table 7 summarises self-assessment use for the three different self-assessment options.

Table 7 – Usage of self-assessment options

Type of Self-Assessment Available	Number of Submissions	Average Number of Self Assessments per Submission	Average Best Self-Assessment per Submission
(1) Limited number of self assessments (max 10) allowed.	**873**	**3.0**	**86%**
(2) All entry cells must be attempted before self assessment allowed.	**442**	**1.9**	**67%**
(3) Unlimited self-assessments	**7,285**	**11.7**	**81%**
All submissions	**8,600**	**10.3**	

It is interesting to note that the average best self-assessment result (86%) was obtained with the limited number of self-assessments alternative. While this alternative was only applied to two assignments, each of the two limited self-assessment assignments (cost allocation for different purposes and support department cost allocation) were of equal or higher difficulty than the other assignments. The difference between the average of 86% for these two assignments and the 81% average for unlimited self-assessment assignments is significant at the .0002 level (student's t-test).

Effects on academic staff

Responses by academic staff to the self-assessable spreadsheet assignments largely relate to the perceived benefits to student learning and to their own productivity.

The lecturer responsible for the first-year Accounting unit using the marking system provided the following comments:

- "Students like the quick feedback."
- "Self-assessment helps them."
- "It's great, I don't have to do any marking."
- "A few students didn't understand how the marking system worked."
- "Some students had problems getting their assignment files."
- "Quite a few students had problems with the Blackboard digital drop box."

The lecturer responsible for the second-year Management Accounting unit using the marking system provided the following comments:

- "I like it because it allows me to force my students to work."
- "It's easily integrated with my other course material."
- "It requires the students to use spreadsheets which they need to know."
-

Effects on department

The effects on the department can be gauged from comments from the faculty teaching and learning specialist as well as the head of department. One of these staff members was the course coordinator in 2002 for the Introductory Accounting unit. The 2002 offering of this unit used the computer marking system in an identical fashion to semester 1 2003 (the subject of this study). As such her comments have great relevance:

- "The students really liked getting the 'formative' feedback so they could correct their answers before they submitted it for 'summative' assessment. They had a very positive effect on students.
- "As the lecturer in charge, I didn't have to worry about the students – you took care of all of the support and marking – fantastic!"

The current Head of School and former Head of Department is very familiar with the computer marking system. His comments focus strongly on the productivity aspect.

- "The benefit of this software is highlighted in an environment where the university is seeking to balance research outcomes with teaching excellence. Clearly the software provides an efficient marking mechanism while freeing up academic's time to pursue better research outcomes and a better understanding of current teaching directions. "

Effects on university

The effects on the university as a stakeholder are twofold. First, there is the effect of the spreadsheet marking system on the IT systems. Interviews conducted with faculty IT staff affected by the marking system revealed a very positive view of the system with comments such as "hardly any problems" and "students seem to like it" from the IT help desk staff. The IT staff member responsible for the faculty Blackboard software indicated his requirements for the marking system to be "less than an hour per month". His other comments included "quick & effective" and "students get results".

The only negative comment about the marking system was received from the network administrator who pointed out the file server storage requirements. Almost 10 gigabytes were used by the marking system in the next to last week of the semester. This usage was approximately evenly split between the server location providing the individualised assignment files to students and a "submitted and marked" folder containing all student assignment submissions.

For the close to 2,000 students using the marking system, server requirements average about 5 megabytes per student. Should storage pose a problem, the marking system's disk storage requirements could easily be reduced in several ways. One simple method would be to remove individualised files from the "self service" location after students have downloaded their assignments. A second way would be to store marked files for a limited time. Currently all submitted files have been stored indefinitely for research purposes and to respond to rare student queries.

6. Conclusion

This research was motivated by a call from Higgins et al (2002) that feedback is under-researched. We report the effects of providing students with the ability to self-assess spreadsheet assignments prior to submission to test the theory that this would improve students' attitudes to learning and opportunities to learn, without increasing the load on academics.

Our first major result was a confirmation of the notion that feedback is a crucial element of the learning process. Strong support for this belief has been obtained from a variety of sources; the pre- and post-course surveys of students, Blackboard discussion comments and the widespread use of the self-assessment option as indicated from the assignments' automatic recording routine.

The second major result comes from the use of the self-assessment option that allowed only a limited number of assessments. The results for the two assignments with this option were significantly better than the results for the other two self-assessment options. This result was achieved despite the fact that these two assignments (in the opinion of the authors) were more difficult than most of the other assignments.

There are major limitations to generalising the results of this research. First, specialist skills in VBA are required to obtain the full benefit of the automatic marking and self-assessment options. Second, the study was limited to Sydney University, so institutions whose students have different attributes may achieve different results.

Future research would do well to examine the effect of individual attributes such as the type of learner while controlling for the assignment difficulty and evaluating the usefulness of different self-assessment options. However, we found the provision of self-assessment feedback improved the attitudes of students to learn various important concepts.

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