# Automating the Marking of an Excel Assignment: The Initial Foray, Results and Future Use

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**Abstract**

When class sizes are large there is sometimes the temptation to use forms of assessment that have lower workload associated with the marking process. This is especially so when higher education institutions are under pressure to increase class sizes for economic reasons.

This paper presents how a spreadsheet assignment was used in a large first year information systems course, and how software was written to automate the marking process.

A literature review is presented that covers issues relating to the use of technology to solve educational problems; some of the issues created by large classes; the characteristics of effective learning; the importance of feedback for learning; automated marking systems and parallels that existing in software testing methodologies and IT Auditing.

The assignment requirements are presented along with an description of how the software works and the results of using the software to automate the marking of the assignment across three semesters. The results show a significant saving of time (in excess of 80%) in the second and third semester when much of the software could be re-used and a modest saving of time in the first semester of its use.

The experiment was successful and included other results and conclusions of interest which were the: enhanced consistency of marking; presence of some personalised feedback that was generated for the students; enhanced timeliness of feedback to the students and that the overall process could be used as an example to the students in a following course where parallels can be drawn with approaches to testing software and IT Auditing.

A similar approach is now being planned for use in assignments in other subject areas including taxation; management accounting; and accounting information systems and could be considered in a number of other subject areas, particularly those that have some quantitative content.

**Keywords**
Assessment, Automated Marking, Information Systems

**Introduction**
This paper has its origin in some of the problems faced when class sizes increase to the point where it becomes attractive to remove assessments that, with smaller classes, are particularly useful in enhancing the learning and achievement of students. One of the barriers to retaining assignments in large classes is the time that it can take to mark the assignments.

The purpose of this paper is to present the results of an initial experiment into developing software to mark spreadsheet assignments in both semesters in a large first year information systems course and to hypothesis how the same approach could be used in other subject areas.

## Approach

The approach adopted for this research is very similar in nature to that of Design Based Research in which (a) the researchers are intimately involved in what is being researched; (b) the research can be used to bring about change in the real world; (c) includes iterative experiments that are adapted and refined as time goes on; and (d) has the potential to generate new theoretical knowledge in the field.

It is highlighted by Barab & Squire (2004) that design-based research requires more than showing that a particular design works, but requires the researcher to generate evidence based claims relating to theoretical issues and further the theoretical knowledge in the field.

A further significant aspect of design-based research highlighted in Barab & Squire (2004) is that the value of a theory lies in its ability to produce change in the real world, with this being related to the idea that theories are not judged by their claims to be true, but by how they work in the real world (Dewey, 1938 as cited in Barab & Squire, 2004). The goal of applied researchers engaged in design research is stated by Barab & Squire (2004) as being to "directly impact practice, while advancing theory that will be of use to others".

"Design-based research involves more than simply describing the design and the conditions under which it changed" (Barab & Squire, 2004). Similarly, diSessa & Cobb (2004) as cited in Barab & Squire (2004) suggest that the designs should be contexts, through which theory can be advanced, and as such will be iterative with the ultimate goal of refining theory to produce "ontological innovations" (diSessa & Cobb, 2004).

The "teaching experiment" approach of Cobb et al (2003) is cited by Barab & Squire (2004) as it relates to the problem of the intervention of the researcher as a participant. In this situation the issues that arise from such an intervention are accounted for and integrated into existing theory, as opposed to the researcher having a "hands off role". Barab & Squire (2004) go on to implore researchers to not remain detached from their research, but to use interventions as "opportunities to examine core theoretical issues and explore learning".

## Literature Review

The literature review that follows covers a number of topics that are related to the development of the software for automatically marking the spreadsheet assignment. Issues relating to the use of technology solve educations problems, along with the issues of large and increasing class sizes are covered.

The characteristics of effective learning are summarised, with special emphasis being placed on the importance of, and the nature of feedback. The nature and some of the issues surrounding the use of automated marking systems are briefly explored.

The literature review concludes with parallels being drawn between the use of automated marking systems and both different testing methodologies and different approaches to IT Auditing.

*Using Technology to Solve Educational Problems*

In a study conducted by Draper & Brown (2004) it was highlighted that there are a range of empirical indications supporting the concept that learning benefits are more dependent on putting the pedagogy as the focus as opposed to the technology. In a prior study by Draper (1998) it was highlighted that those introductions of technologies that did increase the quality of learning were those that identified a deficiency or a problem in a teaching and learning scenario and then sought to use technology to address the particular problem. An implication flowing from this identified in Draper & Brown (2004) was that researchers should look at the teaching practices around them to try and identify the weakest aspects of them, and then seek to discover how technologies can be used to address them.

*Large Classes*

This section summarises some of the issues of student-lecturer feedback and student engagement in large lectures.

The "2 Sigma Problem" that was identified in Bloom (1984) relates to high student staff ratios and the less effective learning that can take place as a consequence, with this including less personalised feedback on assessments. A range of studies including Greenaway & Haynes (2003), Barr (2004) and Curtis & Matthewman (2005) have cited the financial pressure on institutions as being one driving factor behind the increasing class sizes.

*Characteristics of Effective Learning*

Two areas of relevance to this particular scenario were identified as being the importance of structuring what the students were doing so that learning could take place. This included the particular activities and tasks that the students and the conditions needed for learning to be effective.

The inclusion of authentic learning activities was highlighted in Herrington, Reeves and Oliver (2006). A model was developed that included a number of design principles: including real world relevance; requiring students to define the tasks they need to accomplish; tasks that need investigating over a period of time; opportunities to examine the tasks from different perspectives; opportunities to collaborate and reflect; potential integration across different subject areas; seamless integration with assessment; creation of products and artefacts that are useful in their own right; and diversity of outcomes.

A model set out by Goodyear (2002) that synthesised other literature relating to the characteristics of effective learning is briefly summarised in Table 1.

| **Characteristic of Effective Learning** | **Brief Description** |
|---|---|
| Active | Learning includes a combination of cognitive activity and psychomotor activities, with the combination of these contributing to create personalised learning that is more meaningful to the learner |
| Cumulative | Utilising previous learning is significant in enabling learners to make sense of new information; create links between old and new ideas and to enhance existing knowledge |
| Individual | All learners are different in the way they learn and in the past experiences they bring to each new learning experience |
| Self-Regulated | At advanced levels learners can have an awareness of how they learn best and as a consequence can organise aspects of their own learning, in particular how the learning fits into different contexts |
| Goal Oriented | Learners need to see why they are doing what they are doing and how it contributes to some sort of overall goal |

*Table 1 – Summary of Characteristics of Effective Learning (Goodyear, 2002)*

*Importance of Feedback*

In the literature review conducted by Nelson & Hauck (2008) a number of factors that promote effective learning in the classroom were identified including active learning, providing feedback, increasing attention span and motivation, with all of these being seen as being particularly challenging in large lectures as cited in Beatty (2004) and for Net Generation learners as cited in Robinson & Ritzko (2006). The importance of feedback was also highlighted as cited in Bangert-Downs, Kulik, Kulik & Morgan (1991) with the timing of the feedback being seen as especially important as cited in Azevedo & Bernard (1995) and Kulik & Kulik (1988).

The importance of feedback is highlighted in Debuse, Lawley and Shibl (2007), particularly as it relates to achievement in assessment (Black & William, 1998; Hattie, 1987; Higgins, Hartley & Skelton, 2002). Debuse et al (2007) also highlight the work of Allen, Montgomery, Tubman, Frazier & Escovar (2003) and

Hyland (2000) where the giving of personalised feedback is identified as being a factor in improving student motivation.

The importance of the timeliness of feedback is also highlighted in James, McInnis and Delvin (2002), and Wiggins (1997), with the consistency of feedback being identified in Holmes and Smith (2003).

*Automated Marking*

Factors driving recent trends in automated marking were cited by Clark & Baillie-de Byl (2007) and included the desire to reduce staff workloads (Dalziel, 2000; Jacobsen & Kremer, 2000; Jefferies & Constable, 2000; Pain & Heron, 2003; Peat, Franklin et al., 2001) and a desire to provide more timely feedback for students (Dalziel, 2001; Jefferies & Constable, 2000; Merat & Chung, 1997; Sheard & Carbone, 2000; Woit & Mason, 2000).

Particular benefits of automated marking identified in Clark & Baillie-de Byl (2007) included improved marking consistency; eliminating the manual handling of results; and the potential to automate correction of marking errors across large numbers of assessments.

In introducing their study Debuse, Lawley & Shibl (2007) highlight the importance of feedback as being influential on student performance and in doing so cite the work of Black & William (1998), Hattie (1987), Higgins, Hartley & Skelton (2002) and Thurmond et al (2002).

Debuse et al (2007) go on to highlight that feedback needs to have a range of qualities to connect with students and hence impact on their achievement (Higgins et al, 2002), but with growing workloads and student numbers it can prove to be difficult to provide feedback of high quality (Higgins et al, 2002).

The need to find a way to provide high quality feedback in a timely fashion was one of the main motivations of the study by Debuse et al (2007).

*Parallels with Testing Methodologies*

The approach taken to the automatic marking of the assessment has parallels with the concepts of black-box testing and white-box testing as described by Shi (2010). Black-box testing is outlined as being whether the system produces the right outputs for a particular set of inputs, whereas white-box testing is described as testing whether the internal processes are functioning correctly and efficiently. This study cited the work of Myers (2004) who recommended the use of white-box testing and black-box testing for software functionalities.

Myers (2004) outlined white-box testing as including statement coverage, decision coverage, condition coverage, decision-condition coverage and multiple-condition coverage. Myers (2004) then went on to outline how the most important black-box testing was made up of Equivalence-Classes Partitioning, Boundary-Value Analysis, Cause-Effect Graphing and Error Guessing.

*Parallels with Aspects of IT Auditing*

The concepts of auditing around the computer and auditing through the computer in IT Auditing are outlined in Bodnar & Hopwood (2001). The concept of auditing around the computer as described in Bodnar & Hopwood (2001) is similar in concept to that of black-

box testing (Shi, 2010; Myers, 2004) in that inputs are entered into a system and the outputs are checked to see if they are what was expected. The concept of auditing through the computer as described in Bodnar & Hopwood (2001) is similar in concept to that of white-box testing (Shi, 2010; Myers, 2004) in that the focus is on the how the system processes data and/or transactions internally.

*Summary of Literature Review*

Important aspects to emerge from the literature review that relate specifically to this study that includes an intervention of technology needs to be addressing a problem as opposed to being "a solution in search of a problem". The issue of giving good feedback to students in large classes while enabling effective learning is a problem.

The key objectives and drivers of other studies relating to the use of automatic marking systems appear to be consistent with the problem that is being addressed in this study including the need to reduce staff workload; improve the quality and timeliness of feedback to students; and improve the consistency of marking.

The parallels drawn with different testing methodologies and different approaches to IT Auditing are helpful in understanding some of the nature of automatic marking systems.

## The Problem

There are typically more than 300-350 students enrolled in INFO123 (Information Systems and Technology) at the University of Canterbury in the first semester of each year, and 500-600 students in the second semester of each year. Prior to 2010 the use of Excel was assessed using two relatively straight forward lab tests, and mainly as a consequence of the high number of students enrolled the lab tests were reasonably short (25-30 minutes). As a consequence of this, the tests were not particularly in depth and did not really require the students to be involved in any significant problem solving.

There had been a desire to use an assignment in place of one of the lab tests so that (a) the students would have more opportunity to problem solve and (b) the students would be better prepared for what has traditionally been the more advanced of the two lab tests. It was also thought that this would work towards making learning of students more effective, particularly when it comes to learning being active, self-regulated and goal-oriented as per the model for effective learning developed by Goodyear (2002).

One of the stumbling blocks had been seen as being the time that would be needed to mark the assignment, particularly with INFO123 becoming part of the compulsory core of the Bachelor of Commerce from the start of the 2010 year and the increased number of enrolments as a direct consequence of this.

This increase in marking workload is significant, particularly given the importance of the students receiving feedback on the assignment (Black & William, 1998; Hattie, 1987; Higgins, Hartley & Skelton, 2002). Debuse et al (2007), and the importance of feedback being timely as per Azevedo & Bernard (1995) and Kulik & Kulik (1988). Another important aspect of the feedback is the need for it to be personalised as opposed to being generic to the entire class as per Allen et al (2003) and Hyland (2000).

## The Experiment

This section outlines the background of the introduction of the development of the automated marking system; the assignment that was automatically marked using the software that was developed; and the software that was developed as the solution.

*Background*

It was decided to introduce the assignment for semester one, and to design the assignment so that software could be written to automate the marking of the assignment. This would speed up the marking and therefore the timelines of the feedback as per Azevedo & Bernard (1995) and Kulik & Kulik (1988). A further aim of the writing of the software was that it would provide some personalised comments to the students based on standard errors that could be made in the assignment as per Allen et al (2003) and Hyland (2000).

*The Assignment*

Across the three semesters that are covered by this study there were six different types of questions used in the assignment, with these being shown in Table 2.

| Type | Description |
|---|---|
| 1 | Students were required to (a) import data from Access into Excel; (b) write a formula using absolute references and nest IF statements to calculate discounts and (c) utilise an input area on the worksheet. A screen shot of the starting template is shown in Figure 1 |
| 2 | Students were required to place a filter on rows that had been imported from an Access database |
| 3 | Students were required to create a pivot table based on data that had been imported from an Access database |
| 4 | Students were required to create a chart based on some of the data |
| 5 | Students were required to use the PMT function to calculate regular loan repayments and total interest paid for a loan. The model needed to be flexible enough to allow for the amount of the loan; the term of the loan; the interest rate; and the frequency of payments to be changed. A screen shot of the starting template for this question is shown in Figure 2 |
| 6 | Students were required to use Lookup functions to find the exchange rates for a number of different currencies to work out the New Zealand value of a basket of money that was in different currencies; and then work out how many of a particular product could be purchased and how much money would be left over. Part of this involved the use of TRUNC and ROUND functions. A screenshot of the starting template for this question is shown in Figure 3 |

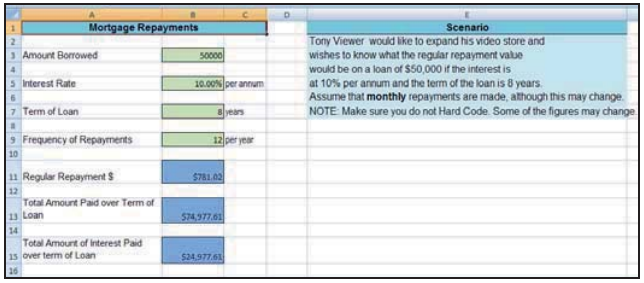
*Table 2 – Description of Question Types Used in Assignment*

In each case the software was looking at whether the different parts of the students' spreadsheets were producing the correct outputs for a range of inputs as per black-box testing (Shi, 2010); and whether the formulae that were used were appropriate including

such techniques as absolute referencing as per white-box testing (Shi, 2010).

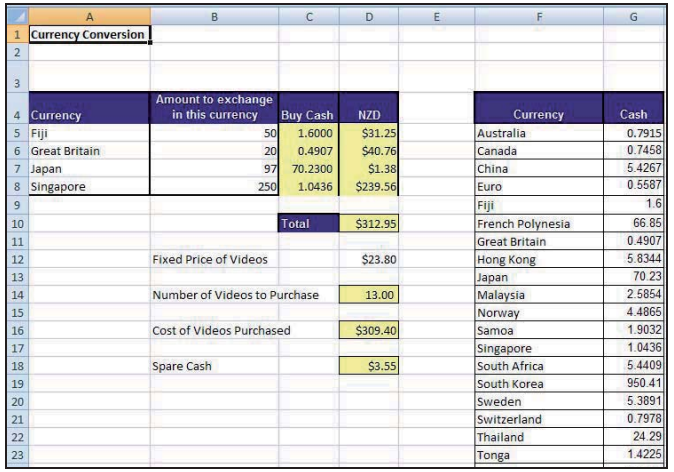
| | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Input area | | | Output Area | | | | | |
| 2 | 1 | 5% | | Total Videos Sold | | 110 | | | |
| 3 | 2 | 10% | | Total Order | | $1,387.00 | | | |
| 4 | 4 | 20% | | Updated Total | | $1,121.05 | | | |
| 5 | | | | | | | | | |
| 6 | Book ID | Author Name | Title | Year | Price | Quantity Bought | Total Order | Discount | Updated Total |
| 7 | 1 | Scott, Tony | Top Gun | 1986 | $5.00 | 1 | $5.00 | $0.25 | $4.75 |
| 8 | 2 | Donaldson, Roger | Cocktail | 1988 | $7.00 | 2 | $14.00 | $1.40 | $12.60 |
| 9 | 3 | Scott, Ridley | Gladiator | 2000 | $12.00 | 3 | $36.00 | $3.60 | $32.40 |
| 10 | 4 | Crowe, Cameron | Jerry Maguire | 1996 | $7.00 | 4 | $28.00 | $5.60 | $22.40 |
| 11 | 5 | Cameron, James | Avatar | 2009 | $18.00 | 5 | $90.00 | $18.00 | $72.00 |
| 12 | 6 | Jackson, Peter | The Lovely Bones | 2009 | $18.00 | 6 | $108.00 | $21.60 | $86.40 |
| 13 | 7 | Reitman, Jason | Up in the Air | 2009 | $18.00 | 7 | $126.00 | $25.20 | $100.80 |
| 14 | 8 | Anderson, Wes | The Fantastic Mr. Fox | 2009 | $18.00 | 8 | $144.00 | $28.80 | $115.20 |
| 15 | 9 | Becker, Walt | Old Dogs | 2009 | $18.00 | 9 | $162.00 | $32.40 | $129.60 |
| 16 | 10 | Kershner, Irvin | The Empire Strikes Back | 1980 | $5.00 | 10 | $50.00 | $10.00 | $40.00 |
| 17 | 11 | Dominik, Andrew | Chopper | 2000 | $12.00 | 1 | $12.00 | $0.60 | $11.40 |
| 18 | 12 | Luhrmann, Baz | Moulin Rouge | 2001 | $12.00 | 2 | $24.00 | $2.40 | $21.60 |
| 19 | 13 | Kleiser, Randal | Greese | 1978 | $5.00 | 3 | $15.00 | $1.50 | $13.50 |
| 20 | 14 | Jonze, Frank | Where the Wild Things Are | 2009 | $18.00 | 4 | $72.00 | $14.40 | $57.60 |
| 21 | 15 | Becker, Walk | Wild Hogs | 2007 | $12.00 | 5 | $60.00 | $12.00 | $48.00 |
| 22 | 16 | Stanton, Andrew | Wall-E | 2007 | $15.00 | 6 | $90.00 | $18.00 | $72.00 |
| 23 | 17 | Stanton, Andrew | Finding Nimo | 2003 | $10.00 | 7 | $70.00 | $14.00 | $56.00 |
| 24 | 18 | Stanton, Andrew | A Bug's Life | 1998 | $7.00 | 8 | $56.00 | $11.20 | $44.80 |
| 25 | 19 | Donner, Richard | Leathal Weapon | 1987 | $5.00 | 9 | $45.00 | $9.00 | $36.00 |

*Figure 1 – Screenshot of Discount Calculation Question*



| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | Mortgage Repayments | | | | Scenario |
| 2 | | | | | Tony Viewer would like to expand his video store and |
| 3 | Amount Borrowed | 50000 | | | wishes to know what the regular repayment value |
| 4 | | | | | would be on a loan of $50,000 if the interest is |
| 5 | Interest Rate | 10.00% | per annum | | at 10% per annum and the term of the loan is 8 years. |
| 6 | | | | | Assume that **monthly** repayments are made, although this may change. |
| 7 | Term of Loan | 8 | years | | NOTE: Make sure you do not Hard Code. Some of the figures may change. |
| 8 | | | | | |
| 9 | Frequency of Repayments | 12 | per year | | |
| 10 | | | | | |
| 11 | Regular Repayment $ | $781.02 | | | |
| 12 | | | | | |
| 13 | Total Amount Paid over Term of Loan | $74,977.61 | | | |
| 14 | | | | | |
| 15 | Total Amount of Interest Paid over term of Loan | $24,977.61 | | | |
| 16 | | | | | |

*Figure 2 – Screenshot of Loan Repayment Question*



| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 1 | Currency Conversion | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |
| 4 | Currency | Amount to exchange in this currency | Buy Cash | NZD | | Currency | Cash |
| 5 | Fiji | 50 | 1.6000 | $31.25 | | Australia | 0.7915 |
| 6 | Great Britain | 20 | 0.4907 | $40.76 | | Canada | 0.7458 |
| 7 | Japan | 97 | 70.2300 | $1.38 | | China | 5.4267 |
| 8 | Singapore | 250 | 1.0436 | $239.56 | | Euro | 0.5587 |
| 9 | | | | | | Fiji | 1.6 |
| 10 | | | Total | $312.95 | | French Polynesia | 66.85 |
| 11 | | | | | | Great Britain | 0.4907 |
| 12 | | Fixed Price of Videos | | $23.80 | | Hong Kong | 5.8344 |
| 13 | | | | | | Japan | 70.23 |
| 14 | | Number of Videos to Purchase | | 13.00 | | Malaysia | 2.5854 |
| 15 | | | | | | Norway | 4.4865 |
| 16 | | Cost of Videos Purchased | | $309.40 | | Samoa | 1.9032 |
| 17 | | | | | | Singapore | 1.0436 |
| 18 | | Spare Cash | | $3.55 | | South Africa | 5.4409 |
| 19 | | | | | | South Korea | 950.41 |
| 20 | | | | | | Sweden | 5.3891 |
| 21 | | | | | | Switzerland | 0.7978 |
| 22 | | | | | | Thailand | 24.29 |
| 23 | | | | | | Tonga | 1.4225 |

*Figure 3 – Screenshot of Foreign Currency Question*

*The Solution*

The students were required to download a starting template for the assignment from the learning management system (Moodle) and when they had completed the assignment they were required to upload the file to Moodle. Some of the instructions in the assignment included that they should not change the names of any of the worksheets and that some of the formulae were to be entered into specific cells. The assignments were typically due at 5pm on a Friday evening.

When marking, all of the assignments were downloaded from Moodle, the students' userID was added to the front of all of the filenames followed by the underscore character. For example, the filename for a student

whose userID was "abc123" would begin with "abc123_". This is shown in Figure 4.

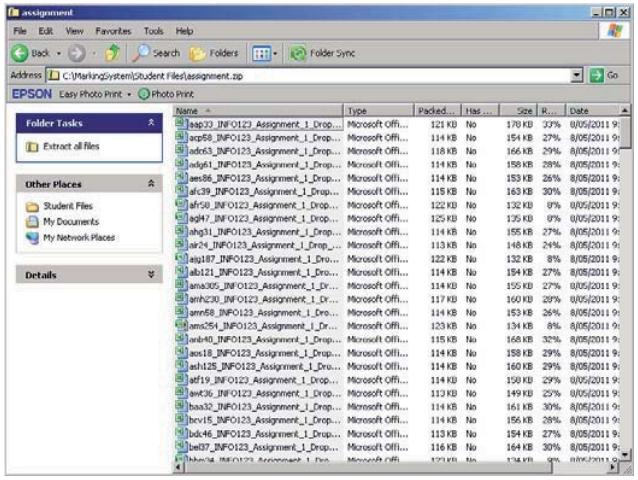


*Figure 4 – Assignments Downloaded from Moodle*

The software was written so that when each file was opened, a new worksheet was inserted at the front of the workbook so that it could be used as a feedback sheet for that particular student. A screen shot of a blank version of this is shown in Figure 5 with a screen shot of a completed version being shown in Figure 6.

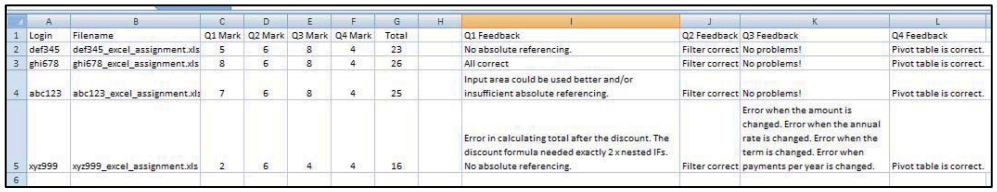
| | A | B | C | D |
|---|---|---|---|---|
| 1 | **Marking Sheet for INFO123 Excel Assignment** | | | |
| 2 | | | | |
| 3 | **Question** | **Max Mark** | **Your Mark** | |
| 4 | **Q1 - General Use** | 0 | | |
| 5 | **Q2 - Filter** | 0 | | |
| 6 | **Q3 - Chart** | 0 | | |
| 7 | **Q4 - PMT Function** | 0 | | |
| 8 | **Q5 - Pivot Table** | 0 | | |
| 9 | **Q6 - Vlookup etc** | 0 | | |
| 10 | | | | |
| 11 | | 0 | | |

*Figure 5 – Screenshot of Blank Feedback Sheet*

| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | **Marking Sheet for ACIS123 Excel Assignment** | | | | |
| 2 | | | | | |
| 3 | **Question** | **Max Mark** | **Your Mark** | | |
| 4 | **Q1 - General Use** | 8 | 5 | | |
| 5 | **Q2 - Filter** | 6 | 6 | | |
| 6 | **Q3 - PMT Function** | 8 | 3 | | |
| 7 | **Q4 - Pivot Table** | 4 | 4 | | |
| 8 | | | | | |
| 9 | | | | | |
| 10 | | | | | |
| 11 | | 26 | 18 | 69.23% | |
| 12 | | | | | |
| 13 | **Comments** | | | | |
| 14 | Q1 | No absolute referencing. | | | |
| 15 | Q2 | Filter correct | | | |
| 16 | Q3 | Error with first set of data. Error when the amount is changed. Error when the annual rate is changed. Error when the term is changed. Error when payments per year is changed. | | | |
| 17 | Q4 | Pivot table is correct. | | | |

*Figure 6 – Screenshot of Completed Feedback Sheet*

As the software marked each question, the mark for that question and the comment generated by the software was inserted. When all of the questions for a particular student had been marked, the file was moved into a new folder.



| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Login | Filename | Q1 Mark | Q2 Mark | Q3 Mark | Q4 Mark | Total | | Q1 Feedback | Q2 Feedback | Q3 Feedback | Q4 Feedback |
| 2 | def345 | def345_excel_assignment.xls | 5 | 6 | 8 | 4 | 23 | | No absolute referencing. | Filter correct | No problems! | Pivot table is correct. |
| 3 | ghi678 | ghi678_excel_assignment.xls | 8 | 6 | 8 | 4 | 26 | | All correct | Filter correct | No problems! | Pivot table is correct. |
| 4 | abc123 | abc123_excel_assignment.xls | 7 | 6 | 8 | 4 | 25 | | Input area could be used better and/or insufficient absolute referencing. | Filter correct | No problems! | Pivot table is correct. |
| 5 | xyz999 | xyz999_excel_assignment.xls | 2 | 6 | 4 | 4 | 16 | | Error in calculating total after the discount. The discount formula needed exactly 2 x nested IFs. No absolute referencing. | Filter correct | Error when the amount is changed. Error when the annual rate is changed. Error when the term is changed. Error when payments per year is changed. | Pivot table is correct. |
| 6 | | | | | | | | | | | | |

*Figure 7 – Marking Sheet Generated After All Assignments Marked*

Once all of the assignments were marked, another script was run that created a marking sheet that showed the student userID, marks for each question and the comments that were generated for each question. An example of this spreadsheet is shown in Figure 7. This spreadsheet was then able to be saved as a comma separated value (CSV) test file which was then imported into the gradebook on Moodle.

At the lecture following the marks being uploaded, the lecturers demonstrated what was required in the assignment. One reason for this was to give the students feedback on what was required, and the other reason was to then allow students who had completed aspects of the assignment using different approaches than the software expected to email the lecturers.

In some cases this resulted in the alternative approaches being written into the software as they were seen as being appropriate, and in other cases they weren't. Where the alternative approaches were written into the software, all of the student assignments were marked again.

## Results

The total number of assignments submitted in each of the three semesters, along with how long it would have taken to mark the assignment via traditional means (based on 15 minutes per assignment) is shown in Table 3.

| | **Semester One 2010** | **Semester Two 2010** | **Semester One 2011** |
|---|---|---|---|
| Number of Assignments Submitted | 280 | 507 | 259 |
| **Estimated traditional marking hours (@ 15 mins each)** | **70.00** | **126.75** | **64.75** |

*Table 3 –Estimated Marking Time via Traditional Means*

The amount of development time for the first semester included a significant amount of development compared

with what took place in the second and third semesters as much of the code that had been written could be reused. The total development time; total marking time using the software and the percentage time saving in each of the three semesters is shown in Table 4.

In the first two semesters there were two rounds of feedback from students that resulted in some modifications being made to the software. In these semesters the two rounds of feedback resulted in it taking approximately one week from the assignment being submitted to the results for the assignment being finalised.

| | **Semester One 2010** | **Semester Two 2010** | **Semester One 2011** |
|---|---|---|---|
| Total Development Time (hours) | 50.00 | 10.00 | 6.00 |
| Actual Marking Time (hours) | 9.50 | 7.50 | 5.00 |
| **Total Marking and Development Time (hours)** | **59.50** | **17.50** | **11.00** |
| **Percentage Saving** | **15.0%** | **86.2%** | **83.0%** |

*Table 4 – Development Time and Marking Time Using the Software*

One such modification to the software was in the section of the assignment were the students had been expected to use the TRUNC() function to truncate an amount to zero decimal places – some students had used the INT() function instead. The software was modified so that INT() was an acceptable alternative as it would always produce the same result provide the number being truncated was positive. Some students had used the ROUND() function, and for the particular numbers involved this sometimes produced the correct answer, but was not an acceptable alternative as it would not always be correct.

In the third semester, the assignments were submitted by 5pm on a Friday evening and the first round of results were released by 1pm the following Monday. Students were given feedback in the lecture on the Tuesday morning. There was no feedback from students that resulted in any modifications to the software being needed, and as a consequence the results were confirmed by 5pm on the Wednesday.

In all three semesters there was some surprise expressed by some of the students at the short time it had taken for the assignment to be marked.

**Analysis and Discussion**

The assignment that was created enabled the extent of problem solving through the use of spreadsheets to be increased, with this being consistent with the notion of authentic learning activities (Herrington et al, 2006) and with the importance of learning being active, self-regulated and goal-oriented (Goodyear, 2002).

That the software was not only able to mark the assignment consistently (Clark & Baillie-de Byl, 2007)

but also provide some contextual feedback or personal feedback (Allen et al, 2003; Hyland, 2000) based on what individual students had done indicates that this aspect of the experiment was relatively successful. The consistency of marking with such a large class was significant in that normally the marking would be spread across several staff members.

The need to address staff workloads (Dalziel, 2000; Jacobsen & Kremer, 2000; Jefferies & Constable, 2000; Pain & Heron, 2003; Peat, Franklin et al., 2001) was addressed by the significant reduction in marking time needed, particularly in the second and third semesters as shown in Table 3 and Table 4. This reduction in time also significantly improved the timeliness of the feedback to students (Azevedo & Bernard, 1995; Kulik & Kulik, 1988). Even if there was no overall time saving, the time between submission and feedback could be reduced significantly as the development work could all take place before the assignments were submitted.

The parallels that were drawn with black-box and white-box testing (Shi, 2010; Myers, 2004) and with IT Auditing (Bodnar, 2001) resulted in a second year accounting information systems course that follows INFO123 being able to use the automated marking of the spreadsheet assignment as an example that they had some real-life exposure to.

**Future Development**

The success of this experiment has led to investigating other papers where similar approaches could be tried, with three having been identified the next two-three semesters.

The first of these is ACCT254 which is an introduction to taxation course where assignments involve a heavy workload particularly when students make an early calculation mistake. The aim of an experiment in an assignment in ACCT254 would be to have students make decisions about how to treat a range of transactions based on current tax law and to calculate how much tax is payable. When a student makes a mistake early on in the process the software would adjust for this and be able to check whether the rest of the process had been carried out correctly. Students would also need to specify which tax law cases were relevant to each decision with this potentially being done by allowing the students to select the relevant cases from a list of all cases covered in the paper (the number of which exceeds 100).

The second paper is ACCT222 in which the students are required to perform a number of calculations regarding allocation of overhead costs to departments. Similarly to ACCT254 above, the software would be able to quickly determine whether after an early error in a calculation all later steps had been performed correctly.

The third paper is INFO243 which is an accounting information systems paper. In this paper the students complete assignments using two accounting packages. The marking of the assignments is time consuming when students make errors. A concept being investigated is writing software that interrogates the data that has been entered into the packages and the balances of particular accounts to identify where the actual errors lie.

## Conclusions

The experiment of writing software to automate the marking of the spreadsheet assignment was successful on a number of accounts. These included that:

- There was a significant time saving in marking, particularly when components of the software were able to be reused in later semesters
- The consistency of marking was enhanced
- There was a degree of personalised feedback that was able to be generated for each student
- The timeliness of feedback to the students was significantly improved
- The students in a following paper could relate what was done to the concepts of black-box and white-box testing; and auditing through and around the computer

The extent of the success of the experiment presented in this paper is that similar approaches are being contemplated for three other papers and could be considered for many more in the future.

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