Chapter 5: Research Cycle 2

5.1 Introduction

This chapter is an account of the second research cycle of this study where the MCA Online learning environment developed in the first cycle was customised and used in the teaching of a mathematics module for a business and marketing course. The WebCT delivery platform was used to present the customised MCA Online learning environment. Using a blended learning approach students were taught on-campus where face-to-face teaching was complemented with online activities. In Section 5.2 of this chapter I have presented the context of the second cycle of this study in terms of the description of the course, the profile of students attempting the course and the mathematics teacher’s approach towards teaching the business mathematics module. Section 5.3 provides details of the conjectures related to this cycle of research and the process of designing the WebCT website for the course. This section also shows how the MCA Online resources were built into this new website for the module. In Section 5.4 I have given a detailed account of the enactment stage describing the mathematics lessons taught in terms of teaching and assessment methods and reflections on the use of online activities during the lesson. Given the nature and scope of descriptions provided in this chapter, the analysis phase of this research cycle is presented as a separate chapter (Chapter 6).

Evidence from the experience of designing and implementing the MCA Online website during the first research cycle indicated that a generic open ended online learning environment to support mathematics learning had limited appeal to students enrolled in mainstream vocational courses. We discovered that in order for students to make effective use of online resources in their learning these resources had to be situated in the context of specific vocational content.

In addition, mainstream TAFE mathematics teachers also appeared to be slow in responding to online developments and how online resources could impact their teaching practice. During the first research cycle many mathematics teachers were unsure about the skills and effort needed in implementing web-supported teaching.
Furthermore, during the first cycle of the study we found out that the design of the MCA website did not allow us to track students’ use and as a consequence we were unable to confirm if students were actually accessing and using the online resources. Limited classroom observation and postings records on the discussion board were the only sources of any empirical evidence for students’ engagement with the online environment.

Based on the observations and findings from the first cycle that led us to conclude that the online learning environment needed to be closely aligned to the vocational course content in order to engage students and teachers in its use, and enhance and support mathematics learning effectively. Consequently, the second cycle of this study focussed on an in-situ implementation where online learning could be customised to suit a particular vocational context and our conjectures about design and learning could be explored with the help of a systematic process of data collection and analysis.

5.2 Context

During the development of MCA Online website in the first cycle of this study I had come into contact with a number of mathematics teachers from mainstream vocational courses. These teachers provided useful information, support and trial sites for the implementation of the MCA Online website and the induction module during the first cycle. Cathy (a pseudonym), who had been teaching mathematics modules for the business and international trade courses and had also been involved in the development of the MCA Online website as an advisory group member, showed an interest in using this website with her mathematics class. One of her mathematics classes had previously participated in the induction training for the MCA Online website during the first cycle, but she had noted that her students did not show interest in using the MCA Online website mainly due to the generic nature of the content on the website.

From her experience of teaching the Introduction to Business Mathematics module for a number of years Cathy claimed that customising learning activities and resources
available from the MCA online website to suit the context of her course could benefit her class in two ways. Firstly, by including online activities in her teaching she would be able to make mathematics learning more interesting, relevant and appealing to students who love to work on computers. Secondly, by having access to learning activities and resources available from the MCA Online website students would be able to brush up on important basic skills necessary for doing her mathematics module. Although the prerequisite entry qualification for this course was listed as completion of a Year 12 secondary school certificate, students with little or no mathematics education were also able to gain admission to the course. Cathy was in charge of teaching mathematics modules to a number of groups studying business and marketing courses in the TAFE division and she was concerned about the drop out rate from mathematics classes. Cathy and I shared these concerns and were aware of the potential usefulness of the MCA online website for these students but results of the trials in the first research cycle had shown that students needed to see the relevance of online activities in the context of their course. They were not prepared to use the online learning environment to seek support and brush up their skills independently.

Studies have shown that open ended access to innovative learning environments or tools is not enough to engage learners and important contextual preconditions need to be taken into account to ensure effective use by learners (Hoadley, 2004; Hsi, 1998). Emerging research on online learning in the VET sector indicated that mixed mode learning or blended online learning appeared to be increasingly favoured by the teachers and learners (R. Brown, 2003; Fisher, 2003; Franklin & Peat, 2001) in contrast with totally online delivery, where despite a large number of modules being available in the online format, the uptake of online learning remained relatively small (Hill et al., 2003).

5.2.1 The VET Course

The selected mathematics module was part of a diploma course in international trade offered by the Department of Management and Marketing. Like most other business courses, the Diploma in Marketing (International Trade) course was also based on industry endorsed competency standards ensuring that vocational education and
training received by students was up-to-date and relevant to the world of work. Typically students completing Year 12 or Victorian Certificate in Education (VCE) studies would enrol in a 2-year full time advanced diploma course in international trade. It being a 3-stage course, students had a choice to study for a Certificate IV, which required only stage 1 completion, or a Diploma, which required stage 1 and 2 completion or an advanced diploma, which required stage 1, 2 and 3 completion. A typical one-year study consisted of studying 12 modules spread over two semesters. Modules studied during first year included:

Table 5.1
List of modules for the first year of Diploma in Marketing (International Trade) course

<table>
<thead>
<tr>
<th>Module Name</th>
<th>Nominal Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Accounting for non-accountants</td>
<td>51-68</td>
</tr>
<tr>
<td>2. Economics for business</td>
<td>51-68</td>
</tr>
<tr>
<td>3. Occupational Health and Safety</td>
<td>15</td>
</tr>
<tr>
<td>4. International Economic Geography</td>
<td>51</td>
</tr>
<tr>
<td>5. International Business</td>
<td>51</td>
</tr>
<tr>
<td>6. The Marketing Concept</td>
<td>51-68</td>
</tr>
<tr>
<td>7. Introduction to Business Maths</td>
<td>30</td>
</tr>
<tr>
<td>8. Cross Cultural Familiarisation</td>
<td>10</td>
</tr>
<tr>
<td>10. Import and Export Business Procedures</td>
<td>60</td>
</tr>
<tr>
<td>11. Permits and Controls in International Trade</td>
<td>40</td>
</tr>
<tr>
<td>12. International Trade Finance</td>
<td>40</td>
</tr>
</tbody>
</table>

In addition to core modules listed above students also completed a range of computing and writing modules during the year including Advanced Operations Word Processing, Advanced Operations Spreadsheets, Business and Presentation Graphics, Writing Skills for Work, Writing Workplace Documents, Negotiating Skills, Writing in Plain English, Computer Operations, Database Fundamentals, Spreadsheet Fundamentals, Word processing introduction, Electronic Mail and Introduction to the Internet. The computing applications modules aimed at ensuring that students developed appropriate skills to use information and communication technologies for
the relevant industry. In terms of assessment, modules comprising this course are assessed using a competency-based model relying on criterion-referenced assessment. As a common practice most VET courses are required to follow a competency based assessment system (Maxwell, 1997). In this context learning outcomes and criteria for assessment are specified for a particular content and students’ performance is assessed against this criteria. When students’ performance is demonstrated to have met the established criteria, he or she is deemed to be competent in the required competency. This assessment regime works well for most workplace skills based assessment without the need of differentiating between relative performances of learners on any quantitative scale. However, in areas of content based learning, such as mathematics, some training providers have continued to use both competency based assessment as well as graded scores to differentiate between average and high achieving students (Maxwell, 1997).

The Introduction to Business Mathematics module was also required to follow a competency based training and assessment design. With the main objective of providing the learner with the knowledge and skills to apply mathematical techniques to a variety of business applications and decisions, the learning outcomes for the module consisted of six statements about students’ performance:

- Perform with the aid of a calculator, or computer, percentage adjustments to common commercial situations including those requiring algebraic manipulation of formulae
- Explain the concepts of time value of money and be able to perform calculations involving simple interest
- Distinguish between simple and compound interest and perform calculations involving compound interest
- Define an annuity, list examples of a simple annuity and apply the annuity formulae to solve practical problems
- Calculate depreciation rates using the straight-line, reducing balance (diminishing-value), and units-of-production methods
- Plot and interpret straight-line graphs, apply them to business decision-making and discuss the significant features of non-linear graphs.

A closer examination of assessment criteria listed under each learning outcome reveals a clear picture of the mathematical knowledge and skills being desired during this module. The practical and skill focussed orientation of learning is also clearly evident from statements such as, “calculate simple interest using the equation \( I = PRT \)” or “solve problems involving transposing of the compound interest formula to find the present value, the interest rate and the number of time periods”. It is easy to notice from these and similar statements listed that the main emphasis of the course is towards developing practical mathematical skills and manipulation of formulas to calculate the value of desired variables. An analysis of words used to describe required actions (Table 5.2) reveals that out of 30 assessment criteria listed under these learning outcomes only 3 required students to engage with evaluating and communicating mathematics (discuss, describe, examine). In terms of using technology for learning mathematics, the module in its first learning outcome suggested that students needed to “perform with the aid of a calculator, or computer, percentage adjustments to common commercial situation”. Other learning outcomes had no mention of technology use but it was implicit that calculators could be freely used to carry out these calculations.

<table>
<thead>
<tr>
<th>Word</th>
<th>Frequency</th>
<th>Word</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discuss/Describe/Examine</td>
<td>3</td>
<td>Define</td>
<td>2</td>
</tr>
<tr>
<td>Calculate/Compute</td>
<td>8</td>
<td>Manipulate</td>
<td>1</td>
</tr>
<tr>
<td>Solve</td>
<td>4</td>
<td>Distinguish</td>
<td>2</td>
</tr>
<tr>
<td>Prepare</td>
<td>2</td>
<td>Estimate</td>
<td>1</td>
</tr>
<tr>
<td>Apply</td>
<td>2</td>
<td>Compare</td>
<td>1</td>
</tr>
<tr>
<td>Operate</td>
<td>1</td>
<td>List</td>
<td>1</td>
</tr>
<tr>
<td>Use</td>
<td>1</td>
<td>Plot</td>
<td>1</td>
</tr>
</tbody>
</table>
The module followed an assessment process comprising of two components. One component was made up of six ungraded assessments conducted during the semester and the other component was made up of a graded final test paper. In order to pass the module students needed to obtain an ungraded pass in all six assessments spread through the 15-week semester. The final test was used as a summative assessment and offered a graded result ranging from a pass to a high distinction. Students who missed any of the six assessments could still pass the module if they took the final test and passed. The typical features of the course are summarised in Table 5.3.

Table 5.3
*Typical Features of the Course*

- 30 modules studied over 2 years full time
- Each module ranges between 30-50 hours in duration
- A typical module has 5-6 learning outcomes and each learning outcome is specified by a set of performance assessment criteria
- Students need to demonstrate competence in each learning outcome to successfully complete the subject
- Assessment is ongoing and needs to cover performance elements detailed for each learning outcome
- Performance in final examination or a major assignment may be used for final assessment grade
- If a student can demonstrate competence for each learning outcome during ongoing assessment, he/she does not need to take the final examination to obtain an ungraded pass in the subject
- A student who may not have demonstrated competence for a given learning outcome during ongoing assessments may still demonstrate competence in the final examination and pass the subject with a grade.

Fitzsimons (2003) points out that while competency based training encourages the assessment process to demonstrate student’s performance in a practical sense, in the case of mathematical techniques and skills, assessment under classroom situations
often boils down to testing of “carefully rehearsed academic routines”. She argues that it is very difficult to judge a student as ‘competent’ in mathematics and suggests that this type of assessment fails to provide any assurance that “the student will know how to or wish to choose and use the appropriate technique when the need arises” (p 211). As a person responsible for ensuring fairness, quality and authenticity of assessment for the module, Cathy was aware of the challenges in terms of requirements of competency based assessment and appropriateness of assessment design and process from the perspective of learning context. We discussed the issue of assessment in several meetings and decided to use the opportunities offered by the MCA Online learning environment to incorporate greater authenticity in assessment tasks. These assessment tasks are described in greater detail in Section 5.4 under topic headings later in this chapter.

5.2.2 The Students

Two important factors influenced our decision to choose students undertaking the Introduction to Business Mathematics module for our blended learning experiment during this cycle of the study. Firstly, it was the subject coordinator and the teacher for this module, Cathy, who had been part of the MCA Online advisory group during the first cycle of the study and was keen to adopt new technologies in her teaching methods. Secondly, it was the nature and availability of student groups undertaking this module. As a second semester subject for first year Diploma in Marketing (International Trade) two classes of this mathematics module were being run on the same campus and Cathy taught both classes. In addition, during the first semester these students had undertaken a number of introductory computing modules and were familiar with basic computing, email and Internet searching. Students were assigned to individual classes by an enrolment management system and we as teachers and researchers had no influence over allocation of students to particular classes. These students were expected to undertake another mathematics module called business statistics in their second year. The availability of two similar groups (classes) offered us an opportunity to employ a quasi-experimental design and designate one class as a treatment group and the other class as a control group. The treatment group had 24 and the control group had 19 enrolled students at the commencement of the module.
Both groups were similar in composition but statistically student allocation to particular groups was not based on random sampling techniques.

The treatment group consisted of 14 male and 10 female students. These students represented an ethnic mix highlighted by their place of birth as shown in Table 5.4. Eleven of the 24 were born in Australia and the rest were born overseas.

Table 5.4
_Treatment Group Students - Distribution by place of birth_

<table>
<thead>
<tr>
<th>Number of Students</th>
<th>Australia</th>
<th>Vietnam</th>
<th>Hong Kong</th>
<th>Turkey</th>
<th>South Africa</th>
<th>Philippines</th>
<th>Yugoslavia</th>
<th>Ethiopia</th>
<th>Poland</th>
<th>UAE</th>
<th>Thailand</th>
<th>Iran</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start</td>
<td>11</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Finish</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

In terms of Internet access from home 20 students from the treatment group indicated that they had access to the Internet from their home. For most students it was their first enrolment in a post secondary course and 18 of the enrolled students were less than 20 years old. Six students were more than 20 years old including one who was more than 30. Most of these students (22) were recent graduates from secondary schools and had completed their year 12 studies in the last two years.

The control group consisted of 19 enrolled students including 11 male and 8 female students. The control group was smaller in size compared to the treatment group but both Cathy and I did not have any control over the selection of students for either group. Decisions about the allocation of students to particular classes was controlled by enrolment management and course selection officers and depended largely on total number of students seeking to complete the required number of studies for a particular course during the semester. The control group also demonstrated a distribution of diverse ethnic mix as shown in Table 5.5

Table 5.5
_Control Group Students - Distribution by place of birth_
<table>
<thead>
<tr>
<th>Number of Students</th>
<th>Australia</th>
<th>Vietnam</th>
<th>Hong Kong</th>
<th>India</th>
<th>Macau</th>
<th>Chile</th>
<th>Yugoslavia</th>
<th>Pakistan</th>
<th>Peru</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Finish</td>
<td>1</td>
<td>3</td>
<td>-</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
</tbody>
</table>

Most of the students in control group were also recent graduates from secondary schools and had completed their Year 12 studies in the past two years. A total of 15 out of 19 were less than 20 years in age with only four aged between 20 and 30. In the control group, although more students were born overseas compared with the treatment group, a large number of them (15 out of 19) were locally educated and had completed their VCE qualification from Victorian schools. Amongst this group of students 13 students stated that they had Internet access from home. In terms of their diversity, age and educational background both groups appeared to be very similar except for the fact that in the treatment group Australian born students formed the majority grouping and in the control group Vietnamese born students formed the majority grouping.

As far as our design experiment was concerned we were particularly interested in the characteristics of the students in the group selected to be the treatment group and were keen to engage them in a blended online learning environment in mathematics. From an educational perspective, the treatment group with a diverse ethnic mix and a majority Australian born students reflected the larger population of VET courses more closely than the control group. With a greater proportion of treatment group students having access to the Internet from home and having completed their pre-requisite qualifications in the last two years, this group appeared to be more prepared for using an online learning environment in mathematics.

### 5.2.3 The Teacher

Successful integration of technology in classroom teaching practice requires a significant contribution and commitment from the teacher. Research has shown that a teacher’s skills, attitude and motivation plays a crucial role in the success of
technology based intervention in classroom learning (Brennan, 2003; Cashion & Palmieri, 2002; Norton & Cooper, 2001). As an experienced mathematics teacher Cathy had been teaching mathematics modules in the department for a number of years and had developed a bank of resources to teach relevant topics. She was also active in developing her own computer skills by participating in a number of professional development programs conducted by the institution. During my association with her for the development of the MCA Online website, where she acted as an advisory committee member, I found her to be a cautious but willing participant in implementing new technologies in classroom practice. She demonstrated a keen interest in learning new skills and maintained an open and sceptical position about the effectiveness of particular technological interventions in achieving learning and curriculum goals.

Cathy was also quick to notice the potential of web based learning in attracting and retaining interest and attention of her first year diploma class students who were mostly young and enthusiastic about technology. In recognition of Cathy’s interest in emerging technologies her department had nominated her to participate in a State funded professional development project. This project provided her a new laptop and opportunities for professional development. So, when the prospect of using a blended learning environment with her mathematics classes emerged, she was quite willing and enthusiastic about implementing it with her group of students.

5.3 Conjectures and Design

The MCA Online website developed during the first cycle of this study served as a base for the design of the module website on WebCT in the second cycle. The experience of trialling the MCA induction module in a number of settings during the first cycle provided us valuable insights into the design, usability and effectiveness of our online learning environment in supporting mathematics learning in mainstream vocational courses. The experience led us to draw tentative theories from our initial conjectures and helped in drawing new conjectures for the second cycle of the study.
An important assumption made during the design of MCA Online website was that if we provided easily accessible discipline specific online resources in mathematics from our website students from mainstream TAFE courses would be able to make use of these resources with some guidance from their teachers and exchange of messages on the discussion board. However, during trials it turned out that merely making useful resources available from a website was not enough to gain students’ sustained attention and the use of these resources in their learning. The MCA Online website provided mainly general mathematics content via its learning units and any discipline specific content was limited to course guides and archives of past examination papers and solutions. We realised that it was essential to establish a link between vocational course content and the online learning environment before expecting students to invest their time in learning online.

Consequently, one of the main conjectures for the design and enactment of the second cycle of study focussed on the blended learning environment. We stipulated that student learning in mathematics can be supported more effectively if we presented the vocational course content in a blended learning format where face to face classroom teaching was supported by resources and activities located in an online learning environment. The blended learning format offered more opportunities to the subject teacher to integrate online resources and activities in learning and assessment tasks. It offered students an extension of their classroom in an online platform where it was accessible to them round the clock and contained additional resources for practise and brushing up work.

Mathematics teachers are generally slow to adopt new technologies in their teaching practice (Kaput & Thompson, 1994; Vale, 2004) and seem to have as a lingering cynicism towards effectiveness of technology in learning (personal observation spanning over 25 years). This cycle of the study offered an opportunity to include a quasi-experimental design and prompted us to make conjectures about the effect of the online learning environment on students’ attitude and performance in mathematics.

In relations to students’ attitude towards mathematics our first conjecture was that at the start of the course both control and treatment group students would show very
similar attitude towards mathematics and there is likely to be no significant difference between the two groups.

We expected that the use of online learning environment in a blended learning format would make a positive effect on students’ attitude towards mathematics and consequently our second conjecture in relation to attitude towards mathematics was that there will be a clear improvement in treatment groups’ attitude towards mathematics in comparison with the control group.

Achievement in mathematics was assessed at the start of the module using a general mathematics ability test (Appendix 3.2). Both treatment and control groups were given the pre-test in general mathematics ability during the first week of the course. The purpose of this test was to establish if the two groups differed significantly in their mathematics ability at the start of the blended learning program with the treatment group. Our first conjecture in relation to students’ achievement in mathematics was that at the start of the course the mathematics achievement scores of both groups would be very similar and there will be no significant difference between the two groups when their pre-test achievement scores are compared.

The mathematics achievement of both groups was once again compared at the end of the semester using their final test scores (post-test). This test was different in content and difficulty from the pre-test and aimed at testing students’ knowledge and skills on the subject matter learned during the course. Since students in the treatment group were using additional online learning resources and activities in a blended learning format we expected them to perform better. As a result our second conjecture in relation to students’ achievement in mathematics was that the treatment group students would have significantly higher post-test achievement scores when compared with the control group.

Another conjecture during this cycle of the study related to the use of online resources from the real world in authentic learning activities with the students. Mathematics taught using traditional methods and resources has been criticised for being disconnected with the real world experiences and pen and paper based calculations are unable to make connections to authentic activities taking place in the real world.
outside classrooms (Ainley, Pratt, & Hansen, 2006). Cathy had been teaching using these traditional resources and had been keen to make her learning tasks more authentic. She had used examples from newspaper cuttings to make her mathematics problems reflect real life experiences. With the help of web access available from the classroom Cathy seemed keen to explore the possibilities of using “live” data from authentic sources in solving mathematics problems with her blended learning group. Research has shown that the mathematics used in workplaces is highly context dependent and increasingly workplace mathematical practices are relying on the use of technology (Noss, Hoyles, Bakker, & Kent, 2005; Zevenbergen & Zevenbergen, 2004). As mathematics teachers we wanted students to become familiar with workplace contexts and the use of technology in solving mathematics problems. Our conjecture in this regard stipulated that the use of online tools and authentic data from the Internet would affect students’ attitude towards mathematics positively and their engagement with class activities and mathematics would be enhanced.

Our conjecture related to students’ access and participation in the module was that when course materials and learning tasks are accessible in a more flexible way students’ would be able to access learning even outside face-to-face class times and this would lead to improved learning and retention of students because those students who are unable to attend particular face-to-face sessions would be able to continue with the module and participate in learning activities.

Another important conjecture leading from the first cycle of this study was that the use of online communication tools in an asynchronous mode would lead to increased peer-to-peer and teacher to student support. It was anticipated that continual and extended use of discussion board communication would lead to the development of a community of practice that is able to solve problems using this new medium of communication to share knowledge and information.

5.3.1 Design of a blended learning environment

The approach adopted in blending face-to-face to learning with an online learning environment emerged from the cycle one work on designing and trialling the MCA Online website with a number of student groups. Review of our first cycle trials
clearly indicated that merely designing a useful online resource for learning mathematics was not enough to engage students in a sustained way to support their learning. Most students needed to see an explicit relevance between their course work and the use of online learning environment. First year youthful learners despite their acknowledged weakness in mathematics were reluctant to take on any additional load of mathematics work that did not relate directly with their immediate course requirements. Recent literature on strategies to support student learning also tends to favour an embedded approach over developing generic learning support resources (Dixon et al., 2005). Using a blended learning environment to support learning resonates closely with the embedded approach where learning support is provided with close cooperation and collaboration with the subject teacher and often extends over the full length of a semester. Recent research also indicates that blended learning where instructors led training is mixed with e-learning methods is being favoured by teachers as a teaching and learning strategy (Booth et al., 2003; R. Brown, 2003; Fisher, 2003; Franklin & Peat, 2001).

In order to create a blended learning environment for the treatment group we faced two tasks – develop an online environment for the module and design appropriate learning activities that make use of the online environment to complement face-to-face teaching sessions. As our first task we focussed on developing a new online environment which used relevant learning objects already created for the MCA Online website. We wanted to use an online platform that allowed access to only registered users and kept track of users access to different areas of the online environment. A powerful online learning management platform, WebCT, was available to us through our institution and served our purpose for the design of a blended learning environment. WebCT offered an online space where learning content can be organised and access to students can be regulated via login procedures. It also allowed administrators of online courses access to logs of students’ use of particular resources from the online course. The WebCT also provided tools for one-to-one and one-to-many asynchronous communication via a message board and email facilities. While WebCT provided a course management tool for the online environment it also imposed certain restrictions in terms of design and content layout. Researchers have noted the limitations of platforms like WebCT and Blackboard in allowing freedom to course designers (Oliver, 2004).
As I had previous experience of using WebCT and instructional design I offered to organise a course website on WebCT and obtained instructor access for Cathy and designer access for myself. These access levels in online course administration allowed us to follow students’ data regarding access to course content and communication via email and message board. Cathy and I had several meetings and worked collaboratively in developing the WebCT home page for the module. These sessions proved useful for me in developing a better understanding of the course content and assessment requirements of the module and at the same time were helpful professional development sessions for Cathy in terms of gaining new skills in using WebCT and developing online resources.

The module home page on WebCT was completed before the teaching sessions started and consisted of module outline, weekly plan, resource page, exercises page, message board, mail box, calendar and subject evaluation sections (Figure 5.1). The module outline contained a list of learning outcomes and how the module outcomes will be assessed. The weekly plan section provided a breakdown of weekly lessons and topic to be covered each week.

![WebCT Home Page for Business Mathematics](image)

*Figure 5.1. The WebCT home page for the business mathematics.*
The exercises page and the resource page links provided access to course content and supporting resources. The exercises page allowed the teacher to post weekly learning activities and related exercises before every scheduled lesson. This page served as a repository of all class handouts and learning activities collection. This section grew with time and all lessons from previous weeks remained available to students (Figure 5.2).

![Class Exercises section of module website](image)

Figure 5.2. Class Exercises section of module website.

The resource page section contained topical listing of online resources supporting each topic for the module (Figure 5.3). Many of the resources listed in this section were borrowed from the MCA Online website and gave students a direct and easy access from their WebCT home page. Four types of resources including units, quiz, archive and tools carefully selected for each topic were listed as hypertext links from this page.

Links presented as Units provided direct access to MCA Online learning unit. For example on the topic of algebra students had direct links to learning units on *Working with like and unlike terms*, *Transposing equations* and *Directed numbers*. Students requiring brush up practice on basic algebra techniques could be directed to these units for self paced learning. These units offered static learning content as described in Section 4.2.3 of the previous chapter. Another type of resource presented to
students was Quiz. The quiz link contained interactive learning activities appropriate for a selected topic. For example Algebra Transposition Quiz provided a java based interactive exercise from the A+ Maths website (Aplusmath.com, 1999) where learners could follow a step-by-step solution to randomly generated algebra equations. These interactive practice quizzes were selected to give students a chance to practice and review their skills and techniques. The interactive activities were self-correcting and provided both intrinsic and extrinsic automated feedback (Mihalca, 2005).

Figure 5.3. The Resource Page section of module website.

The third type of resource presented to students was the Archive links. These links provided access to a collection of frequently asked questions and answers by expert teachers on a particular topic of mathematics. The purpose of these links was to introduce the students to online communities of mathematics teachers and learners so that they could seek assistance from these sources when faced with problem solving situations related to mathematics.

The fourth type of link, Tools, were online calculators commonly used for calculating various business related calculations such as currency conversion, interest rate calculation, depreciation calculation etc. Many of these tools were originally located
on the MCA Online website and were sourced directly from commercial websites such as banks and related financial websites. The use of these online calculators as a resource for this module was two fold. At one level these automated calculators allowed students to get answers to their problems and verify their answers obtained by pen and paper manual methods and at the other level they provided students with a taste of the tools and resources business and marketing professionals use on a day to day basis. The use of online calculators posed a tension and dilemma for Cathy and me because the course assessment and final tests were to use mostly pen and paper methods and use of online calculators were not expected to help students learn traditional methods of solving mathematics problems. However Cathy was supportive of the idea that online calculators are important tools being used in the industry increasingly and it was of value to our students to become familiar with them and learn to use them. The online calculators also offered opportunities for exploratory learning and problem solving because these tools could do the calculations quickly and show the results instantly (Bransford, Brown, & Cocking, 1999). She also agreed to include some learning activities in which online calculator use would be required and students would be encouraged to check their pen and paper calculation results with results obtained by online calculators.

Another important section of the module home page on WebCT was the Message Board section. This section allowed students access to a bulletin board where messages by students and teacher can be posted. This section of the home page also expanded with time as the module progressed. The message board allowed students to post messages and by default these messages were identified with the sender’s name automatically appearing in the header of the mail. However, the sender had a choice to make their posting anonymous if they so wished by selecting the anonymous option in the message composition window. The ‘track students’ feature of WebCT in the administrator mode allowed me to view the summary of each user’s mailing history in terms of original posts, articles read and follow up posts. This feature helped in tracking students’ online access and message board use during the course.

In order to keep track of messages pertaining to particular mathematics topics the message board contained a folder for each topic and original postings and replies to messages pertaining to that topic were stored in that topic folder (Figure 5.4).
In addition to the message board students had access to a dedicated email section as well. This section allowed students to have private email with other students of the class and to contact the teacher by email. The WebCT email allowed the teacher and students to communicate with each other on an individual level.

![Figure 5.4. The Message Board section of the module website.](image)

A number of sections of the module home page including the Exercises Page and the Resource Page were continuously revised and updated during the course of the semester. New exercises and resources were added to these sections on a weekly basis and sometimes during the teaching session as per student needs. While designing the WebCT home page for the module Cathy and I became increasingly aware of the need for redesigning learning and assessment activities to make effective use of opportunities offered by the online resources (Oliver, 2004). But Cathy had to deal with a pedagogical dilemma. On the one hand she had to remain faithful to the traditional classroom practise and the learning outcomes and assessment guidelines provided in the course outline and on the other hand she could see the advantages of modifying her teaching and assessment practice to allow students’ experiences of using new technologies to enhance their learning. She was prepared to take calculated risks and agreed to include online activities as part of weekly assessment for the
topics of Algebra and Depreciation. However, the final assessment test for both control and treatment group students had to be the same paper based test.

The design of the WebCT home page for the module served as an anchor for blended learning with the treatment group. In the blended learning sessions with the treatment group face-to-face teacher led sessions were complemented with online activities via the module home page.

### 5.4 Enactment Stage 2

This section provides an account of how the newly designed WebCT home page was blended with face-to-face teaching for the treatment group class. It draws on class observation notes, personal reflection and WebCT data to present a picture of teaching sessions conducted with the treatment group and identify factors and issues affecting participation and learning of mathematics in this class. I also observed the control group sessions and have drawn comparisons where necessary to highlight differences resulting from the use of online learning environment with the treatment group.

With the help of the timetabling officer Cathy arranged for her mathematics class to be scheduled in a multipurpose room. This multipurpose room had a rectangular shape and networked Pentium computers were available on benches along three sides of the room (Figure 5.5). The room had tables and chairs arranged in the centre to allow for teacher led classroom sessions. In the front of the room a large whiteboard hung on the wall alongside a projection screen for overhead transparencies. Cathy and I shared a large teacher’s desk at the front of the room. A door at the end of the back row served for passage to this room allowing late students to quietly join the class while the teacher continued with her teaching. There were 18 computers along the wall and swivel chairs allowed students to float between central tables and computers on the side bench.
Figure 5.5. A sketch of the multipurpose room where mathematics classes with the treatment and control groups were held.
These networked computers had fast cable connection to the Internet and students had a choice to use either the Netscape or the Internet explorer browser. The computers also had Microsoft Office applications such as Word, Excel and PowerPoint installed on all computers. We had set the default home page for the Internet as the university’s WebCT home page to enable students to log in to their module home page easily. The login procedure required students to type first four letter of their last name followed by last four digits of their student ID as their user ID and their student number as their password for WebCT. After setting up the module on WebCT, I provided a list of treatment group students to WebCT administration for setting up student accounts for this module. Once the WebCT module was in place and students’ accounts were created we were ready to start the blended learning experiment.

According to time tabling arrangements the control group class was scheduled for a 2-hour session in the morning from 9:00 to 11:00, and the treatment group class started from 11:10 to 1:10. The ten-minute gap between two classes allowed for a switch over time and a short break for teacher. Cathy would come prepared for both classes in the morning and stay in the room until lunch. I was present with Cathy during both control and treatment group classes, however, during the final four weeks I did not feel the need to observe the control group class as most of the routine in the control group class was repetitious and did not appear to be relevant to the need of this study.

### 5.4.1 Session 1: Introduction to WebCT

The first session was devoted to introductions, housekeeping tasks related to the module and an introduction to the WebCT component of the module. During this session Cathy gave a general overview of the subject and the assessment requirements and explained to the class my role as a participant teacher and researcher. She informed the class that I would be present during the class for making observations and assisting in learning activities. Students were informed about their role and requirements as research participants and explained how confidentiality and ethical considerations would be adhered to during the research. They were also provided with a printed information sheet about the research (Appendix 5.1). Students from both control and experiment group classes completed and signed a consent form for participating in this research (Appendix 5.2).
Cathy and I explained the blended learning approach being adopted for the treatment group class and asked students to clarify any concerns at this stage. All students appeared excited about the online component and only one student expressed some concern about his lack of computer skills. All students present during this session completed an Aiken Mathematics Attitude Test and took a pre-test on mathematics achievement. The pre-test on mathematics achievement was labelled as General Mathematics General Ability Information Sheet and comprised of ten questions taken from a secondary school mathematics course (Appendix 3.2). The purpose of the pre-tests on attitude and achievement was to determine if the control and treatment groups differed significantly at the start of the module. After initial housekeeping and pre-tests on attitude and achievement we decided to introduce the module home page to the class. We wanted to make sure that students were able to use the online environment and had developed some familiarity with it before actual lessons had started. It was also necessary to find out if there were any hiccups or issues in terms of students’ access to the WebCT home page. We asked the class to move to computers and log in to their module home page. It was their first experience with using the WebCT system. We had prepared a step-by-step instruction sheet for logging on to module home page on WebCT as the first task for students. This task was followed by second task that required students to post a message on the Message Board. Students were given printed copies of instructions to complete these tasks. We were available to circulate and assist students who needed help. Students worked in pairs and helped each other in logging onto WebCT and posting messages. There was an excitement about reading what others had written about themselves. This activity served as an icebreaker for the class and students began chatting to each other and appeared excited about using the online environment for posting messages. A sample of these messages is shown in Figure 5.6.

Message No. 5
Posted by Jacob
Hey guys,
My name is Jacob and despite not doing math for about 7 years now, I’m excited to attack this module. I lived in Japan for a couple of years and am doing the course with the view to working with a company who deals with Japan. I don’t have particular interest in football therefore follow no team, sorry.
Email is xxxxx@hotmail.com

Message No. 6
Posted by Donna
Initial formalities and WebCT activities consumed most of the first session for the treatment group and towards the end Cathy indicated that our first topic on mathematics would be algebra equations. She also handed out a printed exercise sheet to students and asked them to attempt it at home and bring it to class the following week.

5.4.2 Topic 1: Algebra

Algebraic transposition of equations to find an unknown quantity has been considered necessary for solving problems relating to various financial calculations in the marketing and business industry. Two full sessions and one half session were devoted to learning about algebraic equations and how to solve them. At the start of the session Cathy wrote a number of simple algebra equations with one unknown quantity and solved these on the white board to demonstrate the procedure of “doing the same thing on both sides” of an equation. She invited students to guess the next step and a number of students responded to her prompts by suggesting correct answers. Some of the questions solved on the white-board included questions like:

\[ x + 6 = 14 \]
\[ 3x + 10 = 40 \]
\[ x/2 - 5 = 15 \]

After spending some time on modelling and coaching the step-by-step method of solving simple equations Cathy presented word problems for simple equations to the class. An overhead transparency was placed on the projector so that the class could
see the problems. Students were asked to assist in developing algebraic equations for
these worded problems and then explain the steps involved in solving the equation.
Observation notes from this session show that many students worked out solutions of
these problems in their heads but were having difficulties in transforming word
problems into algebraic equations. Typical word problems solved in this session
included questions like:

I earn twice as much as my sister. If our combined income is $90,000 how
much does my sister earn? How much do I earn?

A banana is 5 cents more expensive than an apple. Six bananas and four
apples cost a total of $4.00. How much does a banana cost? How much does
an apple cost?

After solving a number of word problems on the white board Cathy handed out an
exercise sheet and asked students to solve the questions in their notebooks. Both
Cathy and I circulated and assisted students in solving the questions. Students’
individual work in solving questions from the exercise sheet revealed to us that nearly
half the class had problems with transposition of equations and some had difficulty
with working out order of operations correctly.

![Figure 5.7: I = PRT triangle.](image)

Later during the session Cathy explained how to use a triangle to help transposition
for the unknown in I = PRT equation. As shown in Figure 5.7, Cathy drew a thick line
underneath the term I and explained that if you wanted to figure out the expression for
calculating T, then I will be divided by P and R. Using the diagram, she was able
to provide a visual mnemonic to students to be able to transpose the given expression for
calculating the value of different variables.
In the second half of this session we asked students to move to computers and attempt online activities on the topic of algebra. Cathy and I had planned two online activities to enhance students learning in algebra. In one activity interactive practice on solving simple equations was offered to students to reinforce the method learned in the face-to-face session. Students were given printed information on how to access this activity from their module home page on WebCT (Figure 5.8). The activity presented students randomly generated simple equations with one unknown quantity and required students to input the answer in the response box. Students’ response was corrected automatically. Incorrect answers generated a response that displayed the correct working and solution for the problem. In this way a student was able to see steps required to solve the problem. The activity interface also displayed correctly answered questions as a fraction of total number of questions attempted. This self-correcting online activity was well received by students and they used pen and paper to solve the question before entering their response on the screen. Students also helped each other in navigating on the activity website and some students worked in pairs to solve the problems.

**Online Algebra Task 1**

1. Log on to your course home page at http://webct.ceds.vu.edu.au using your user ID and password.
2. Go to the Resource Page and click on the link Algebra Transposition Quiz
3. Select Multiplication and Addition by placing a tick for that choice and click start button at the bottom of the flashcard page.
4. Solve the problems and try at least 10 questions online.
5. Check your score. Is it 100%? Well done.

*Figure 5.8. Online Algebra Task 1.*

The second activity (Figure 5.9) was a creative task in which students had to think and generate a word problem from their everyday experience. There were two reasons for including this activity in the lesson. On the one hand it was designed with the view that writing word problems can serve as a powerful tool for learning algorithms (Fennell & Ammon, 1985; Golembo, 2000). On the other hand it served as a context for using the discussion board where students could see each other’s work and attempt solving problems posed by other students.
Students attempted the first online activity during the class but ran out of time to attempt the task of writing a word problem and posting it on the message board. We reminded the class to attempt this problem from their home before next week’s session. An analysis of students’ posting and the use of discussion board by students is presented in Chapter 6, Section 6.3.2.

The second session on the topic of algebra started with Cathy reviewing some of the work done in previous week’s session and introducing the concept of a normal pay rate and weekend loading. Because many students were working in part time and casual jobs they were already familiar with the notion of holiday loading. Cathy used their familiarity to launch into developing an algebraic formula to calculate pay involving holiday loading. Cathy modelled the solution for one problem on the white board showing the procedure of using x as a variable to express the relationship in an algebraic equation form. She used prompts to seek responses from students in building up the solution in a step-by-step format. Her interaction with students involved both triadic dialogue and funnelling techniques and led students’ thinking towards a preferred solution path (Herbel-Eisenmann & Breyfogle, 2005). The students took notes in their notebooks and later referred to their notes while attempting to solve new problems. Later, Cathy introduced some problems where two algebraic expressions were required to solve the problem. She modelled the elimination method of solving simultaneous equations on the white board using examples from the exercise sheet. Following the modelling of solutions on the whiteboard students were given an algebra exercise sheet containing five word problems and asked to devise appropriate algebraic equations to solve these problems. Classroom observation of students’ work suggested that most students needed

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**Online Algebra Task 2**

In this task you have to write a worded problem similar to the ones given to you on your exercise sheet. This could be an age problem or a shopping problem or something similar. Use your own numbers to try the problem yourself.

Post your algebra worded problem on the Message Board in the algebra topic folder.

Cheers for now.

Figure 5.9. Online Algebra Task 2.
assistance with the task of writing an equation based on a worded real life context such as the problem given below:

A job pays $x per hour (normal rate). On Saturdays it pays time-and-a-half of the normal rate.

a. How much would you earn during a week when you worked 3 hours on Saturday and 20 hours at the normal rate? Express your answer in terms of $x$.

b. If the normal rate of pay was $12 per hour how much did you earn?

Cathy decided to spend some more time on working with worded problems and used questions from the previous exercise to help students see how to express a relationship described in a worded context as an algebra equation with the use of $x$ as a variable. Observations of the class also revealed that academically more able students of the class were able to work out the answers for simpler worded problems in their head and appeared reluctant to use an algebra equation to solve something that could be worked out mentally.

Later in the session students were asked to complete the online task of writing a worded algebra problem based on their everyday experience. This task was given to students in the previous week but, contrary to our expectation, students did not post any questions on the discussion board. However, during this session when we reminded students about the task, they promptly obliged and a flurry of activity took place where students helped each other in constructing and posting a message with their questions.

Classroom observation of students’ written work also revealed that many students had forgotten their order of operations number skills and needed to re-learn and practice this skill. I discussed this with Cathy and we came up with the idea of using an online task in which students could practice skills required in solving order of operations problems. This quiz was similar to the transposition quiz and students could work at their own pace while receiving automated feedback on their attempts.
This session concluded with students returning to their seats and working on word problems from their exercise sheet. Some students stayed back at the computers to continue to work on interactive algebra exercises. Cathy and I went around the class to students working on worded algebra problems and helped them with understanding the steps involved in solving these problems. Before finishing the class Cathy informed the group that there would be an assessment test on the topic of algebra in the following week.

The algebra assessment activity consisted of two tasks and was completed during the first half of the third session on algebra. It consisted of an online task followed by a paper-based task on solving word problems in algebra. The online activity asked students to complete an interactive quiz on transposing equations where they had to complete at least ten questions within ten minutes. The online quiz was auto corrected and the final score of the quiz was displayed as a percentage score. This auto corrected score at the end of ten minutes was noted as student’s mark for the quiz. Following the interactive quiz students were asked to complete a paper and pencil assessment task on worded algebra problems. Students were asked to solve five problems in half an hour. Two sets of printed assessment sheets were used containing similar questions so that students sitting next to each other may not copy each other’s work during the assessment session. A final score for the assessment task was obtained by combining the scores from the quiz and the paper based task. The remaining time after the assessment task was used by Cathy to introduce the next topic: percentages. The three sessions described above and illustrated in Figure 5.10 reflect a pattern of teaching that was repeated for topics such a percentages, interest, depreciation and linear graphs in the following weeks.
5.4.2.1 Reflections and Interpretations

My reflections and interpretations from these sessions are based on personal observations in the classroom, records of online participation available from WebCT designer access, students’ journal entries and interview sessions with selected students.

Observations from sessions covering the first topic of the module provide a glimpse of technological and pedagogical issues affecting the use of online learning in mathematics in a blended learning format and how we responded to these challenges in order to create an effective learning environment. On the technological front the first few sessions with the online group showed that most students were familiar with using computers and Internet but mature age students in the class had less experience of working with computers. The first problem faced by students was with logging on to course home page. The main problem was caused by the fact that after the first login the system opened a new window on the computer screen and asked students to change their password for security purposes. This was an unexpected and unfamiliar process. Students were surprised that when they logged in for the first time with their initial passwords they were being asked to change that password. Perhaps, it was due to lack of online experience with security sensitive websites. However, it was a once
only process and later login procedure by students did not require them to change their password again.

Another technological issue that came up during the first session with WebCT use was that at least four computer screens froze while attempting the login process. It caused frustration in students, as they were not able to find out why their computers were not working properly while others did. It was discovered that because of a policy of not to switch off computers at the end of the day, some computers experienced a memory allocation problem and behaved erratically. This problem was easily resolved by restarting the affected computer.

Additionally, at least three students during first session had problems with their login details. It was discovered during login process that the spellings of their names were misspelt on the WebCT system and as a result when they used the combination of their name and student ID as required by the system, they could not login. This problem was resolved in the following week by sending an email to WebCT administration for correcting the names on the system. Research has shown that the teacher’s ability to resolve technical issues quickly is critical in the success of online supported learning and we took note of addressing student’s access issues as a priority (Bonk, Kirkley, Hara, & Dennen, 2001). While some problems were resolved at the classroom level, problems related to incorrect user names and passwords had to be referred to the IT department for follow up.

At the class management level observations reveal that students’ attendance pattern was a cause for concern. Although 24 students had registered to do this subject only 14 showed up for class during the first week. Attendance increased to 20 students in second week but dropped back to 14 in the third. I observed that during these sessions, some students turned up late and missed the first part of the session. The problem of students’ attendance was similar in the control group class where out of 19 students registered for the course only 9 showed up for the first session, followed by 15 and 11 in the second and third sessions. An overview of classroom attendance is shown graphically in Figure 5.11.
Interestingly, out of 11 students interviewed from this course five indicated that either they were not sure or had changed their course preference from the previous year which tends to indicate that many students enrolling in this course did not have a clear direction about their educational goals. Attrition from vocational education courses is a well known problem in the field and in recent years our institute had been particularly concerned at the rate of attrition from its VET courses (Gabb, Milne, & Cao, 2006; Keith & Javed, 2004; Misko, 2000).

In terms of classroom management issues another interesting observation made during these sessions was that while most students showed an increased level of motivation in working with online activities, some students found easy diversions on the internet and during one session at least five students while working on WebCT tasks were noticed to have opened other browser windows for reading personal emails or chatting with friends on the internet. Considering that this demonstrated the confidence and multitasking skills of students, we ignored this distraction in the first stance but reiterated that while on computers students must focus on completing their online activity before being side tracked.

Observation of students’ work during the first session indicated that students were familiar with simple algebra equations but most showed difficulties in working with equations where fractions were involved. Students were able to follow Cathy’s
modelling of the solution process by doing the same thing to both sides of an equation but there was little or no discussion on why these steps resulted in the correct solution. This was more clearly evident when students were presented with the word problem tasks and simple word problems were answered by students without the use of any algebra equations. Students were able to use mental maths to work out solutions for simpler algebra word problems. At this point students were exposed to more complex equations where mental solution was not easy and the need for using the algorithm was justified. Cathy’s modelling of the solution process on the white board drew on ideas proposed by cognitive apprenticeship (J. S. Brown, Collins, & Duguid, 1989; Collins, Brown, & Newman, 1989). The theory of cognitive apprenticeship holds that masters of a skill often fail to recognise the importance of the implicit processes involved in carrying out complex skills when they are teaching novices. In her teaching Cathy carefully explained and illustrated tacit processes involved in solving algebra expression using a variety of examples and allowing students to observe, clarify and enact these processes through practice questions.

Student participation in online activities during the class session required a transition from face to face teacher directed instruction to computer-based learning. The idea of using the second half of a two-hour session for online activities meant that we were able to introduce the topic and have some paper based work done before moving to computers. We were also able to identify more able students from weaker students who required more attention. Not everyone was equally enthusiastic about using computers in a mathematics class and at least one female student did not like the idea of using computers to do mathematics. She was however happy to use her calculator. The idea of students working in pairs worked well because students were able to help each other out with technology issues and less enthusiastic students were able to play at least an observer role in watching how their partners worked with mathematics problems on the computer.

During the first online activity on algebra transposition, once students had become familiar with the screen layout and navigation, they seemed to enjoy the practice where feedback was instant and they could monitor their progress. Delors, In'am, & Roberto (1998) point out that using the new technologies is also a way of combating under achievement because people who experience difficulties under the traditional
system are sometimes better motivated when they come to use them and are thus better able to show where their talents lie. I noticed that students’ motivation had increased during the interactive online activity; perhaps it was because many students were able to experience success in solving equations using the technology. An entry from my class observation of these sessions reads:

This task proved a success in online learning as most students seemed to enjoy their participation and success in learning the task. Many students used pen and paper to help them solve the questions and self-scoring as a positive experience for most. One student later reported that she liked this site and task very much and at home she helped her sister to practice algebra equations using this page. It appears that self-assessment part of online maths learning is welcomed by most students.

[Observation notes: Thursday 16 August 01]

The second online activity on algebra required students to post word problems on the discussion board. This activity generated more interest than the interactive quiz because it allowed students to express their creative side. Both Cathy and I were concerned that students were having particular difficulties in transforming worded problems into algebraic expressions. By giving them an opportunity to compose worded problems we hoped to give students the experience of seeing the connection between the language of a worded problem and the mathematics expression for it in the form of an algebraic equation. This strategy has been used in the school sector and reported to have shown that students who practise writing worded problems on algorithms appear to have a greater sense and understanding of the meaning behind an algorithm (Fennell & Ammon, 1985; Golembo, 2000).

Students’ participation in composing worded problems and posting them on the online discussion board was very encouraging. All 14 students present during the session posted questions and 44 postings from students were recorded. Many students attempted to correct each other’s postings and also posted attempted solutions for questions composed by other students. Out of the 44 messages, 20 were generated by three male students who were among high achieving students from the class. In contrast with the interactive quiz activity where students with low confidence in
mathematics also took an active part, the activity of posting questions on the
discussion board and solving questions posted by others generated less interest by
lower achieving students. Most messages were posted by students who felt confident
about their mathematical ability and others contributed only in a token form by
responding to the task set by teacher.

Cathy’s use of collaborative and creative learning tasks and mixing them with teacher
led instruction shows a pragmatic approach to teaching mathematics where both
social constructivist and cognitive apprenticeship models could be applied to achieve
desirable outcomes for students. While the first online activity on algebraic
transposition could be conceived as using the technology as a servant where it was
used as a supplementary tool to amplify cognitive processes, the second online
activity of constructing and posting worded problems on the discussion board can be
seen as using the technology as a partner in facilitating understanding (Goos,
Galbraith, Renshaw, & Geiger, 2003).

5.4.2.2 Assessment
The assessment for the online group consisted of an online task where students were
asked to use an interactive equation quiz to solve a minimum of ten problems. This
task was followed by a paper-based task where students were required to solve two
algebra questions including one worded problem. Three different versions of this
paper-based assessment were used so that students sitting next to each other may not
confer and copy each other’s answers. One version of this paper is shown in Figure
5.12. Both treatment and control group students completed similar paper based tests
but the treatment group was also given the online quiz as the first part of the test.

Algebra Test

Question 1 (1+3 marks)
Solve for x
(a) \( x - 8 = 23 \)
(b) \( \frac{3x + 5}{2} = 6 \)

Question 2 (6 marks)
Last week porterhouse steak was $4.00 more expensive (per kg) than lamb chops. If 2kg of
porterhouse steak and 3kg of lamb chops cost $47.75
(a) What was the price of porterhouse (per kg)?
(b) What was the price of lamb chops (per kg)?
Treatment group students appear to have done very well on the online quiz task. In the given period of ten minutes at least four students were able to do more than 30 questions whereas on average students completed 18 questions. The online quiz questions were auto-corrected by the computer but students were unable to change their incorrect responses and their quiz score reflected how many questions were answered incorrectly. Based on quiz results the treatment group received a mean score of 84% with a median score of 86%. Since the control group did not take part in online quiz it is not possible to compare the results of the treatment group with control group on the measure of online quiz performance.

However, the same paper based test was given to both groups and it is possible to compare their performance on the paper-based test. As shown in Table 5.6 mean and median scores of treatment group on the paper-based test is lower than mean and median scores of control group. This may appear to show that control group students on average performed better than treatment group students on paper based testing in algebra. Nonetheless, it is also worth noting that based on performance of both groups on question number one on the test, which was an algorithm based equation solving question, it will become clear that 64% students in treatment group had correct answers compared with 46% of the control group. It may be assumed that students practice with online algebra tasks had contributed to their performance in solving algebra transposition problems favourably compared with traditional methods used with the control group.

<table>
<thead>
<tr>
<th></th>
<th>Online Test</th>
<th>Paper Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Students</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean Score%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median Score%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean Score%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median Score%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correct Question 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correct Question 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5.6
Comparison of Algebra Test Scores
<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>22</th>
<th>84.3</th>
<th>85.6</th>
<th>42.3</th>
<th>40</th>
<th>64</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group</td>
<td>13</td>
<td>NA</td>
<td>NA</td>
<td>50</td>
<td>60</td>
<td>46</td>
<td>31</td>
</tr>
</tbody>
</table>

The number of students participating in online quiz testing may also have affected assessment comparison because during this session two new students had arrived for the treatment group class for the first time. As can be seen from the students’ attendance pattern (Figure 5.11), during the fourth week the largest attendance was recorded. So, it appears that the presence of new students in the treatment group who had not taken part in class activities prior to the assessment may have impacted on the comparisons unfavourably for the treatment group. It is also evident from the attendance graph (Figure 5.11) that fluctuations in attendance were more prominent in the treatment group class compared with the control group.

Results from the pen and paper test on algebra also indicate that treatment group students performed poorly on the worded algebra question (question 2) and it may suggest that the online activity of writing algebra questions with the treatment group may have impacted negatively on students’ performance. Only 14% students from the treatment group could answer this question correctly compared with 31% from the treatment group. There are two explanations possible for this. One is that, students in the treatment group were distracted by online activities and as a consequence could not get enough pen and paper practice for solving word problems on simultaneous equations. The second explanation could be that new students taking the algebra test did not learn the topic like other students who were in the class from the start. In fact only three students from the treatment group and four from the control group answered the word problem involving simultaneous equations correctly on the test.

### 5.4.3 Topic 2: Percentages

The topic of percentages aimed to cover the second learning outcome from the module and focussed on developing students’ proficiency in working with percentages. Calculations involving percentages are a key skill in business and marketing calculations. Two sessions were devoted to this topic and were designed to cover aspects such as calculations of commissions, discount, wages, profit and loss.
and the Goods and Services Tax (GST). The first session on percentages started immediately after the assessment test on algebra was completed during week four. The assessment task took about 30 minutes and the remaining 90 minutes were given to learning percentages.

Cathy started the topic with revision of concepts related to percentages. She introduced the topic with examples of percentages in everyday use such as calculations involving GST and sales promotions. She used the whiteboard to show equivalence of percentages with fractions and gave examples of how percentages can also be expressed as decimal numbers. The emphasis during this lesson was placed on learning applications of percentages in everyday business operations and a basic understanding of number skills associated with the use of fractions and decimals was assumed. Using a cognitive apprenticeship approach Cathy modelled solution processes of various percentage problems on the whiteboard. Her exposition involved students’ active participation in building a solution. She prompted students to think about how a problem can be solved and asked them to suggest the next step and funnelling their responses to lead their thinking to a desired path (Herbel-Eisenmann & Breyfogle, 2005). Students who were less willing to speak up were encouraged to respond by Cathy addressing them by name and seeking a response.

A casual observer could easily misjudge Cathy’s teaching approach as classical direct instruction, a teaching method often criticised by researchers as not actively involving students and failing to challenge students to think at higher levels of synthesis, analysis and evaluation (Handal, 2003). One of the basic tenets of direct instruction expects teachers to use scripted lesson plans (Engelmann & Carnine, 1991). In her teaching Cathy led the teaching session with the authority of a teacher but her script was not pre-determined and her teaching approach allowed for exploration of ideas by students. She placed special attention to the associative stage of learning (Anderson, 1983) to ensure that students’ misunderstandings on key concepts can be clarified and corrected. In fact during the session her teaching style was able to create a transition from teacher directed learning to cooperative and exploratory learning. Typical examples of problems involving percentage calculations modelled during the lesson included questions like:
Jan works for a fixed amount of $250 per week plus 1.75% of the sales price of all items sold. Find the total income for the week if the total sales price of all items sold was:

(a) $35,000  (b) $125,000  (c) $385,000  (d) $53,250

A product that is listed for $59.98 is discounted down to $56. What is the rate of discount given?

A store wishes to get rid of its old stock of fridges that retail for $1200, so it marks them down by 28%. You go to that store and you tell the salesman that you are prepared to buy a fridge provided you receive a further 10% discount if you pay cash. How much should you pay if the salesman agrees to the 10% cash discount?

The online activities for the topic of percentages were introduced during the second session. The first part of this session was spent doing paper-based questions involving percentage calculations and Cathy used the whiteboard to model solution processes. Students worked in pairs to discuss each question and interpreted the descriptive questions to work out what calculations are desired and what methods can be used for calculations. The first online activity on percentages aimed to introduce students to the archives of Ask Dr Math questions and answers on the Internet as shown in Figure 5.13.

### Online Task 1

In financial circles there is a popular method of working out how long will it take your money to double at a given interest rate. It is known as the 'Rule of 70'. Find out more about this rule of 70 from your course Resource Page via the link 'Interest Problem Q and A' under the Percentage section.

**Problem:** Can you work out how long it will take to double $5000 at the interest rate of 9% p.a.

Figure 5.13. Online Task 1 on the topic on percentages.

Students were given a task of locating particular information related to percentage calculations and interest rate. The purpose of this task was to expose the vast array of information on common math problems available from the Internet. Our intention was
to train the students to access Internet based knowledge sources in problem solving involving mathematics.

The second online activity on the topic of percentages included an exploration of an online home loan calculator (Figure 5.14). This activity was designed to encourage students to explore the relationship between the interest rate and the loan repayment amounts and principal over a period of time. Students were expected to manipulate different variables in an online calculator to model different scenarios and analyse the output in terms of financial decision-making.

### Online Task 2

To answer the following questions you will need to go to the Home Loan Calculator link from the Resource Page. The Commonwealth Home Loan calculator offers 3 types of loan calculations. Select appropriate calculations to carry out the following tasks. Once your calculations are done post your answers on the Message board.

1. You wish to borrow 100,000 dollars for an owner-occupier home loan at the basic variable rate from the commonwealth bank. Your loan term is 20 years and you wish to make fortnightly repayments. How much will be your repayments per fortnight?

2. In the above loan if you decide to pay $100 extra per fortnight how will this affect your loan repayment term and how much interest will you save?

3. You earn $40,000 p.a. and you are allowed to use one third of your wages in loan repayments. At the current basic variable rate from commonwealth bank how much money can you borrow if your term of loan is 20 years.

*Figure 5.14. Online task 2 on the topic of percentages.*

The two online tasks on the topic of percentages aimed to extend students’ understanding of percentage based calculations using a constructivist paradigm. Here the activities were attempting to incorporate technology in the role of a ‘re-organiser’ of learning rather than ‘amplifier’ where technology would play a subservient role of simply creating efficiency in calculations (Goos, Galbraith, Renshaw, & Geiger, 2003). Unlike the algebra online tasks where the focus was on developing students’ proficiency in manipulating simple equations during percentage online tasks the emphasis was on providing opportunities for deeper understanding through problem solving and exploration. The percentage online activities were not aimed at providing skills practice for error reduction and automation.
During our use of online activities for percentages we were aware of the positive impact of technology use when it is used in exploring and problem solving (Tarr, Uekawa, Mittag, & Lennex, 2000). We paid special attention to give students an opportunity to explore the technology for non-routine learning such as finding out different ways for estimating percentages and interest calculations and exploring the relationship between loan amount, loan period, interest rate and the effect of extra payments on interest savings. At the end of this activity many students were astonished to see the effect of compound interest over a 25-year period as the interest paid exceeded the amount of original loan.

Cathy also asked students to visit the MCA Online unit on percentages (Figure 5.15), which they could easily find from their course resource page on WebCT. It helped students in revising their basic skills and knowledge on the topic of percentages. This unit from the MCA Online website was particularly useful for students who needed to learn and practice how to express percentages as decimals and fractions. The percentages unit consisted of topics related to meaning of percentages, everyday use of percentages, calculators for percentages and percentage error. Students were shown how they could use the activities available from the MCA Online unit in a self-paced

Figure 5.15. The MCA Online website unit on percentages.
way to help them learn about percentages. I observed that the mature age students from the class were particularly interested in exploring this site.

After the online activities were completed students were asked to reflect on their experience of working on these activities with particular focus on exploring the Ask Dr Math archive and experimenting with an online home loan calculator. Students were asked to post their answers and reflections on the discussion board and encouraged to comment on their experience of using these activities. Students who had completed their online tasks early returned back to their desks and continued to work on the percentage exercise sheet (Appendix 5.3). Cathy informed students that solutions to the exercise sheet on percentage calculations were posted on the course home page and students could use this answer sheet to self-correct their work.

5.4.3.1 Reflections and Interpretations

During the lessons on the topic of percentages both treatment and control group student attendance varied significantly. In the treatment group during first session on percentages 22 students were in attendance but in the following two sessions the numbers dropped to 15. The attendance pattern was similar in the control group where 13 students attended the first session but in subsequent sessions the numbers declined to 11 and 9 respectively. Although attendance fluctuated unpredictably a core group of regular students emerged in both groups and continued with the subject for the rest of the module. Initially, I was concerned that if it was something to do with my research design that might have caused this pattern in attendance but talking to Cathy and other teachers confirmed that the drop out in numbers was a normal occurrence and reflected on the nature of first year diploma students who were not sure if they had enrolled in the right course. Callan (2005) points out the three major reasons for VET students leaving a course without completing any subjects. These are perceived poor quality of the teaching staff, the content of the course not matching students' needs and the course not being able to fit into the demands of their job. Most of the students who dropped out from the class had attended less than 50% of the classes. Teaching style or poor performance in assessment does not seem to be the likely cause of dropouts because most of those who dropped out had successfully passed their first assessment task.
Technology issues for the treatment group were resolved for the most part and all students had become familiar with the process of accessing the module home page on WebCT. One student reported that he was unable to access the module home page from his home computer due to browser problems but managed to access it from a friend’s home. Another female student reported that she had found the site to be very useful and accessing it from her home allowed her to help her sister with learning maths. From students’ journal logs it was noted that three students were heavy users of the Internet and reported that they spent 15 to 20 hours per week on the Internet. The rest of the students reported usage between 1 to 10 hours. Researching for assignments on the Internet was the main usage reported by students. Other online activities reported in their journal by students were emailing, chatting, downloading, looking up news and playing games. Learning mathematics on the web was a new experience for students and they were unfamiliar with websites on topics of mathematics.

The online tasks during this topic were exploratory in nature and students’ participation in these tasks was quite active and engaged. The tasks allowed students to work in pairs or small groups and this allowed students to help and guide each other in their use of the computer and Internet. Classroom observation of activities in both treatment and control groups during this topic revealed that there was more active peer learning happening in the treatment group class compared with the control group class where students worked mostly individually on printed worksheets.

While working with websites on mathematics topics students confronted two kinds of problems. Students were unfamiliar with the symbols used on the Internet to communicate mathematics and required explanations of the ASCII equivalents of common mathematical operations such as division, square, square root, indices notations etc. In addition, despite their good skills in using computers and the Internet, many students were unsure of how to work with interactive online systems such as financial calculators. Use of online financial calculators required some prior knowledge of variables such as loan amount, loan term, owner-occupier and investment interest rates etc. Once students were familiar with the terms their confidence grew in using the tool and it lead to deeper exploration and discovery of
patterns related to the home loan problem. They appeared more engaged with the task while working with authentic industry tools such as the online loan calculator. Students were quite surprised to find that banks charged so much interest to home lenders and how extra repayments can affect the loan term and interest paid. The online simulation of the mathematical model appeared to be a very powerful tool for learning.

In terms of out of class access and use of online learning on the module there was little if any independent activity by students. Only three messages were recorded on the topic of percentages in which students simply posted answers they had searched and located on the Internet. Students also did not make use of online resources from outside class and their Internet access to the module home page was mainly from campus-based computers. It appears that students were very selective about what online activities they would engage with. If the assessment for the topic did not require them to work with an online task, most ignored the activity when they were given a choice. As a result, in comparison with the Algebra online activities, the sessions on percentages generated less visible activity online. Although the nature of online activities for this topic was more closely aligned to the constructivist learning paradigm, students’ practical orientation in relation to the assessment task meant that online exploration of the topic remained confined largely to classroom based access and use.

5.4.3.2 Assessment

The assessment for the topic of percentage was conducted during the first part of session three on the topic of percentages. The assessment comprised of four questions from an everyday business context and students had to carry out percentage calculations. Two sets of the tests were prepared comprising similar questions and students sitting next to each other were given different versions of the test. Students were allowed to use calculators for these calculations.

**Percentage Test**

1. A computer has a list price of $5670, but it is sold for $4896. What is the rate of discount offered?
2. An item is sold for $188 (This price includes GST). How much is the GST paid on the item?
3. Last year Peter received an income of $44,000. His income is calculated on a retainer plus commission of 5% on all sales. If his sales for the year were $300,000 what was his retainer?
4. How much would you sell a product with a cost to you $168 and a 33% mark-up?
The assessment did not include any online activity and students were not penalised for not participating in online activities or discussion board postings. Prior to the assessment on percentages students were told that the test on percentages will be a paper-based test and online activities did not constitute assessment for the topic. While the control group class was given two sessions of face-to-face learning with the help of pen and paper exercises and class discussion, the treatment group class had both face-to-face learning with the help of pen and paper exercises and online activities. Students had access to online resources to practice percentage skills and explore archive of questions and answers on the topic of percentages. For assessment purposes on this topic both control and treatment group classes were given the same paper based test on percentages.

Cathy and I were aware of the constraints imposed by competency-based curricula and for comparison purposes we kept the assessment for control and treatment group as similar as possible. As we progressed along the blended learning path we became increasingly aware of the fact that the use of technology was not playing a neutral role in assisting learning of content but it was shaping the content at the same time (Goos, Galbraith, Renshaw, & Geiger, 2003; Hoyles, Noss, & Kent, 2004).

<table>
<thead>
<tr>
<th>No of Students</th>
<th>Treatment Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Score</td>
<td>71.7</td>
<td>51.4</td>
</tr>
<tr>
<td>Median Score</td>
<td>75</td>
<td>62.5</td>
</tr>
</tbody>
</table>

Comparison of assessment test scores between treatment and control group classes (Table 5.8) shows that the treatment group performed slightly better than the control.
group. It was a little bit of a surprise to us because both Cathy and I were concerned that we had spent less time with the treatment group class with respect to paper based learning and that they may not perform as well in comparison with the control group. In addition to showing better scores on the assessment task the treatment group class appeared to be more friendly and social where students interacted with each other during their class work. The cohesiveness of the treatment group could be partly attributed to the blended learning format that allowed for greater interaction between students.

5.4.4 Topic 3: Interest

Although some problems based on interest rate calculations and GST calculations were covered during the percentages topic simple and compound interest concepts were treated as a separate topic and covered during two sessions immediately after students had done work on the topic of percentages. Interest rate based calculations are considered to be an important part of business and marketing industry and our module clearly stipulated that students should be able to “distinguish between simple and compound interest and perform calculations involving compound interest”.

The first session on simple and compound interest topic started with a short review of percentage concepts and an explanation of how to represent percentage as a fraction and as a decimal number. Cathy’s approach to this topic was similar to previous topics and started with teacher directed activities and gradually blended into a cooperative and problem solving session. She used modelling and coaching strategies to facilitate cognitive and associative stages of learning (Anderson, 1983) and introduced online activities as an anchor for exploratory learning with problems involving real life contexts (Bransford, 1990). Typical problems in print based exercises given to students included questions like:

1. Find the amount of interest earned on a principal of:
   - $5000 at 3.5% per annum over 3 years
   - $8,600 at 5%p.a. over 4 years and 3 months
   - $15,000 at 6%p.a. over 2 years and 6 months
$6,700 at 2.5\% p.a. over 3 years and 9 months

2. How much interest would you earn if you invest $3,500 for 3 years at 8\% p.a. compounded quarterly?

These print based problems were designed to help students practice using the compound interest calculation formula derived earlier in the session on the whiteboard. Students were permitted to use calculators but were instructed to estimate their answers first. After the initial session focusing on declarative and functioning knowledge on calculations of simple and compound interest, Cathy moved the class to the online activities session where students were expected to use the course website to carry out tasks involving interest rates problem.

Cathy introduced the online compound interest calculator and asked the class to try solving questions from the printed exercise sheet using the online calculator (Figure 5.17). As some students had already solved these problems using pen and paper, they were keen to see if the online calculator would give them the same answer. A typical display of solution provided by online compound interest calculator showed a detailed working of compound interest calculation showing both the long table method that

![Figure 5.17. Compound interest calculation input screen 1.](source: www.webmath.com)
included step by step working out for each period as well as calculation using the compound interest formula as a short cut (Figure 5.17).

Students used data from questions provided in the exercise sheet to test the online compound interest calculator. Once a problem was entered correctly, the online computing tool provided a detailed solution as shown in Figures 5.18 and 5.19.

The simulation of compound interest calculations using the powerful online tool provided by Webmath website helped students verify their own solutions as well as clarify their thinking regarding how the shortcut formula for compound interest calculation works.

Figure 5.18. Compound interest calculation output screen 2 part 1. Source: www.webmath.com.
Following introduction to the online calculator for compound interest calculations, Cathy extended the range of questions to include scenarios from real life situations and asked students to solve and comment upon possible solutions. Students had to select from a range on online calculators to choose the appropriate calculator for their problem. In this way students were able to work on compound interest problems from a range of contexts. First, Cathy modelled the solution of a typical compound interest problem on the white board and demonstrated how the shortcut formula can be derived from step by step calculations in a lengthy solution. Then students were asked to practice the formula on questions from the exercise sheet.

In one online task (Figure 5.20) students were asked to explore the compound interest calculations using an online tool that reproduced the modelling shown earlier by Cathy on the whiteboard.

**Online Task 1**

*Let us suppose you are 20 years old and wish to retire at the 65 as a millionaire. What amount of money would you have to deposit at a rate of 10 per cent in order for this one deposit to make you a millionaire?*

1. Log on to your course home page
2. Click on the Resource Page from your Course Home Page
3. Locate and click on the Compound Interest Calculator link under the Percentages section.
4. Read instructions on how to use this calculator to work out the above problem.

Also, solve the following problems using the same calculator:

a. At what interest rate your money will double if you deposited $5000 for 6 years.

b. What will be the value of your money in 5 years if you deposited $10000 at the compound interest rate of 7% per annum?

*Figure 5.20. Online task 1 on the topic of interest.*
In another online task students were asked to work with real time data provided by the Internet and calculate the value of an investment calculation in a foreign currency (Figure 5.21).

**Online Task 2**

You are planning to invest $20000 in an investment in Thailand. The investment guarantees a return of 12% compounding annually.

Use the Currency converter link and compound interest calculator links from your Resource page to estimate the value of your investment in Thai Baht at the end of a five year investment.

Record your answer on a piece of paper and show to your teacher.

*Figure 5.21. Online task 2 on the topic of interest.*

The multiple-embodiment approach to teaching (Dienes cited in Biggs & Moore, 1993, p. 226) suggests that concepts are formed through a process of abstraction from concrete experience and the more varied that experience, the more powerful would be the concept that is formed. Our attempt in presenting the concept of compound interest in a variety of face-to-face and online tasks aligns with this multi-embodiment approach.

After completing the online activities in the session students were asked to email their responses to Cathy from their WebCT home page. Later students returned to their desks and worked in pairs and practised solving paper-based questions from the exercise sheet (Appendix 5.4). Cathy and I circulated in the class to clarify and assist students with interpreting the problem from the context and applying relevant mathematical processes.

**5.4.4.1 Reflections and Interpretations**

Observations from sessions covering the topic of simple and compound interest revealed that the treatment group class attendance pattern was settling into a trend
with a core group of students attending the class regularly. They had become familiar with Cathy’s teaching style and the blended learning format involving online activities. Students seemed to have settled into peer groups and helped each other in solving problems. During these sessions more able students from the class began to show active participation and readily volunteered to come up to whiteboard and solve problems for the whole class to see. However, female participants from the class were reluctant to come up to whiteboard and were content with providing verbal responses. Cathy’s approach in solving the problem on the whiteboard with assistance with students conformed with Herbel-Eisenmann & Breyfogle’s (2005) description of funnelling where a series of classroom dialogue between a teacher and students helps students to converge their thinking and understanding towards a predetermined path of thinking.

While this method of teaching appeared effective with more able students, weaker students who had gaps in their understanding of decimals and percentages were finding it difficult to extract information from worded questions to apply it in a given formula for simple and compound interest calculations. More able students assisted these students in class and both Cathy and I circulated to provide one to one attention to students who needed help. At this point we also indicated to students that they could receive additional practice on these topics from online learning resources available from their course home page.

Accessing the course website and working on computers during their mathematics class had become a routine by now and students were able to log on to computers and access the course website without any difficulty. After discovering that some students in class needed extra practice with fractions, decimals and percentages topics two new links were added to the resource page after the first session and students were advised to access these online learning units to brush up their skills.

The use of the online tool for calculating compound interest from the Webmath website proved a successful strategy in clarifying the concept of compound interest as it simulated the calculation for each period as shown in Figures 5.17, 5.18 and 5.19. Students were able to try solutions of a number of problems in a short time and see how a general formula can be developed. The online calculator for compound interest
calculator did the multi step interest calculation in an instant and allowed students to focus their thinking on comparing the results produced by following the long method and the formula based method. It was obvious to us that using pen and paper for long method calculation of compound interest calculations students would have been able to solve hardly one problem during the class but with the online tool for the same calculation it was possible to demonstrate the complete method and give students time to practice and see for themselves how the formula for compound interest calculation is evolved from a long hand calculation. Many students commented during interviews that the pace of teaching was too fast for their liking and they did not have enough time to absorb new concepts. One student commented:

There’s a lot of work and very little time to do it so that’s a bit...Yeah students who don’t do maths, don’t like maths, they should have extra time on it, stay with it, so they can actually understand what they’re doing. [Interview transcript: student – Donna]

The issue of the pace of lessons and time spent on particular topics came up consistently in discussions with students and Cathy. Especially those students who were returning to study after a gap of a few years wished that we spent more time on each topic but course content and design demanded that Cathy covered all the learning outcomes within a given timeframe. This was a dilemma for us and one intention of using online resources in blended format was to make classroom learning more flexible and extend it beyond formal contact hours. We were expecting that with the teacher’s guidance students would be able to make use of opportunities offered by online mathematics units via the MCA website and the course home page. One student summed up his feeling about the pace of teaching as follows:

At the two week period I start to feel confident a little bit in it but all of a sudden I’ve got a test and then I feel like we’re into a new topic and it’s gone...I’m just starting to get interested a little bit, get the feel for the topic then we’re into something different, which I’ve heard of before but can’t remember...Or even two six month units cos...I think it’s important to cover everything, everything that we’ve done. I see the relevance and I see how it works, and I think ‘no you couldn’t really skip that, this is really important’
especially all the depreciation stuff, if you were trying to run a business you’ve got to understand what’s happening in the market. So, do the algebra over four or five weeks cos I found that was just the grounding, and then everything a little bit longer. [Interview transcript: student – Jacob]

During the online session all students showed a keen interest in solving their simple and compound interest problems with the help of online tools and working in pairs proved helpful as students were able to help each other with aspects of technology. Using online tools required that students were able to identify different variables of a problem and use correct entries for input fields. We encouraged them not to accept the computer output blindly. During use of these online tools Cathy and I emphasised the need for estimating answers and applying the criteria of reasonableness to output provided by online tools. After initial trial and error methods students grew in confidence and were able to use the online tools effectively. They also realised that online tools have limitations and as users of these tools they had to work on some problems manually before applying online tools.

Students raised the issue of relevance of online activities to the assessment task, as they were keen to know if they will be assessed using online activities. It was a sticky issue for Cathy. On the one hand she knew that using online activities was encouraging students to engage with the content and helpful in building confidence and motivation but on the other hand she appeared apprehensive about fairness of testing students using online activities when control group students were being tested using standard print based tests. I shared her view regarding fairness and we decided to give only print based tests to both treatment and control groups. Although the treatment group students used the online tools to work on interest problems keenly their subsequent engagement with online resources was limited and only seven students posted their answers to online activity on interest calculations on the WebCT. Others chose to focus on practising paper-based problems in preparation for the test.

5.4.2.4 Assessment
At the end of two weeks of work on the topic of interest students were given a paper based assessment task in the third session. The paper based assessment task comprised of four worded problems including both simple interest and compound
interest problems. As for previous units, two sets of assessment tasks similar in difficulty level were used to ensure that students worked individually and there was no chance of copying from each other. No online activity was included in the assessment and both control and treatment group students completed the same paper based assessment task as shown in Figure 5.22.

<table>
<thead>
<tr>
<th>Assessment Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Find the amount of interest earned if $6250 is invested at 4% p.a. (simple interest) over 6 years.</td>
</tr>
<tr>
<td>2. What principal will amount to $17250 if it is invested for 2 years and 6 months at 6%p.a. (a) simple interest (b) compounded quarterly.</td>
</tr>
<tr>
<td>3. How long will it take a principal of $4500 to double if it is invested at 6%p.a. simple interest?</td>
</tr>
<tr>
<td>4. Find the interest earned if a principal of $7380 is invested at 5%p.a. compounded quarterly.</td>
</tr>
<tr>
<td>5. How long would it take a principal of $6500 to amount to $9621.60 if it is invested at 8%p.a. compounded semi annually?</td>
</tr>
<tr>
<td>6. A principal of $6000 amounts to $7622.94 when invested for 4 years with interest compounded monthly. What is the annual rate of interest?</td>
</tr>
</tbody>
</table>

Figure 5.22. Paper based assessment task on the topic of interest.

Results from the paper based assessment for the topic on simple and compound interest appear to be similar in comparison (Table 5.9). The mean and median scores of control group students were slightly higher (42.86 / 41.67) compared with treatment group mean and median scores (39.29 / 40.70) but overall the two groups showed very little difference in assessment results. It is interesting to note that less than 50% (10) students from the treatment group took this test whereas for the control group students the attendance was nearly 75% with 12 students taking the test.

<table>
<thead>
<tr>
<th>Table 5.9 Comparison of Interest Test Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Students</td>
</tr>
<tr>
<td>Treatment Group</td>
</tr>
<tr>
<td>Control Group</td>
</tr>
</tbody>
</table>
When results of only those students are counted who made it till the end in both groups, it appears that on the topic of interest control group students achieved better scores because five students from this group achieved scores above 75% whereas in treatment group only two students managed 75% or above. It can be argued that this core group of regular students from the control group were able to handle the assessment task on interest with greater success and which may be attributed to their focused work on paper based tasks and greater peer to peer and peer to teacher interaction in the traditional mode of teaching. In contrast the treatment group students who learned new skills in manipulating and working with online tools to solve interest based problems appear to have missed out on mastering paper based skills in solving these problems. Cathy acknowledged this concern at different times during the course that if we ask students to work with online activities it may put them at a disadvantage in paper based assessment because she felt that the nature of the mathematics changes with the medium of instruction and our assessment practice needed to reflect this change (Booth et al., 2003; Oliver, 2004).

5.4.5 Topic 4: Depreciation

The topic of depreciation was introduced after work on percentages and simple and compound interest had already been done with both the control and treatment groups. Learning outcome statements for this topic suggested that students learn about depreciation of asset value and be able to calculate depreciation rates using the straight-line, reducing balance (diminishing-value), and units-of-production methods. Face-to-face teaching session included explanation of relevant concepts and formulas and their application in solving given problems. Similar to previous topics Cathy used a number of examples and solved them on the whiteboard applying cognitive apprenticeship principles and the funnelling technique in leading students’ responses to the desired path of action. The use of straight line and reducing balance methods in calculating depreciation offered Cathy an opportunity to incorporate the use of Excel on computers. Since students had learned Excel as part of their computing modules in the previous semester students readily agreed to work on Excel and apply their skills in solving mathematics problems. Typical problems given to students included questions like:
Using the straight line method of depreciation, for an asset with an original cost of $12,000 and an estimated life of 10 years
   a. Find the annual amount of depreciation
   b. Find the annual rate of depreciation
   c. Prepare a depreciation schedule for the first 4 years

An asset costing $10,000 has an estimated life of 7 years and is depreciated on a reducing balance method at 13%pa.
   a. What is the asset’s book value at the end of the fifth year?
   b. Prepare a depreciation schedule

After the teacher led session students were given a worksheet (Appendix 5.5) for practice exercises where they could apply the methods shown to them by Cathy in solving problems.

During the online session students were introduced to the Business section of MCA Online website where questions and answers from past papers were explained and solved. Students were also shown the Ask Dr Math archive of questions and answers related to the topic of depreciation. We also used a link to a depreciation online calculator from the Resource Page available at WebCT course website. Students were shown how to use this calculator to solve straight-line method depreciation problems. Later in the session students were given two online tasks. In one task students had to use Excel to prepare a depreciation schedule for given problems. This depreciation schedule had to be saved as an Excel file and sent to Cathy by email. Students were asked to use the WebCT mail option to post their work to Cathy.

In the second online task students had to explore Internet based tools for calculating depreciation problems. It was an investigation task where they had to find appropriate online calculators and test them to see if they were suitable for solving problems given to them in their exercise sheet. It was a problem-solving situation where students had to establish if they could rely on the online calculator selected to give them reliable solutions to their depreciation problems. These online activities were
presented to students as assessment tasks and they were required to email and post their responses on the discussion board of WebCT by the following email.

5.4.5.1 Reflections and Interpretations

During the two lessons devoted to the topic of depreciation attendance for the treatment group was at its lowest for the semester. Control group students also registered their lowest attendance for the second lesson on this topic. Explaining the possible reason for low attendance Cathy suggested that two teachers from the department were leaving for overseas teaching assignments in China and they had given a load of assignments to students to cover their courses before leaving. Students were under stress of meeting deadlines for these assignments forcing them to miss classes. The assessment task for depreciation was done in an online mode where 10 students completed their assessment tasks online. In control group assessment was paper based and eight students took the in-class assessment task.

The treatment group class engagement with online activities was more evident during this topic and this may be directly associated with the fact that they were told that assessment for this topic was going to be in an online format. Eight students posted a total of 18 messages on the discussion board. These messages contained answers to problems students were asked to solve. Interestingly, more than half the postings on discussion board were made outside class hours indicating that students had become more confident in using the course website from their homes and were prepared to use the online tools when it was part of a required task.

In face-to-face sessions students had learned how to use the formula for calculating depreciation by the reducing method. The formula required manipulation of the inverse function on a calculator. Cathy had also shown the use of log tables to solve inverse problems where the period of depreciation years had to be calculated. More able students in the class were able to learn to use the formula quickly but students who had not learned mathematics in their senior secondary years and a couple of mature age students needed assistance from Cathy to solve these problems.

Later, when online calculators were used to solve the same problems students appeared relieved that there is another short cut way to solve these problems.
However, the task of finding a relevant depreciation calculator from a jungle of online calculators to solve financial calculations required students to interpret information provided on the calculators and relate it to the problems they had to solve. One student noted in his interview that the use of online calculators to solve financial calculations provided him a kind of security. In response to a question whether the computer and Internet use in the class made learning of mathematics easier, he pointed out that:

_"A lot of the stuff I can understand in my head but I don’t know how to apply it but to click on the resource page and have those special financial calculators and those special tasks that we can do, solidifies that information in your mind, you see how it works, you do a few more examples and you think ‘even if I get stuck I can always come back here’, and use these to check my answers. It’s a security almost._

[Interview transcript: student - Juang]

Although the use of online calculators to work out depreciation problems appeared to be an easier option, students needed assistance in learning what different input fields on the online calculators meant and how to interpret depreciation problems when using online calculators.

### 5.4.5.2 Assessment

Treatment and control group students completed different assessment tasks for the topic on depreciation. They were given similar problems to solve but while control group students completed a traditional paper based test consisting of four problems, the treatment group students worked on computer based tasks requiring use of Excel and an online task of locating and testing online calculators to solve depreciation problems. By this stage of the module we were beginning to realise that the use of online activities in our blended learning approach was affecting the content and nature of mathematics learned. Using the tools available to them students were feeling the freedom to explore solutions by in-putting different values and seeing their affect on the outcome. We encouraged them to do this as we thought that it helped them understand the relationship between different variables. In contrast to the paper-based solution where students focussed on the process of solving the problem using a given
algorithm, students in the online group were developing more problem-solving skills and developing an understanding of the mathematical concept.

While 88% of the control group and 100% of the treatment group students passed this assessment they used very different methods to solve their problems. The control group students used a formula based approach where they substituted the given values in a given formula and solved the algorithm for the unknown quantity. This method allowed them to focus on the process of substituting values in an algorithm and solving the equation. However, the assessment task given to the treatment group students made use of technology to solve these problems and allowed students to explore the relationship between different variables.

While the assessment task set for the treatment group allowed them to gain the skills of using online tools and explore various calculations for depreciation of assets, we found it challenging to evaluate students responses to this task and award them appropriate grades for the assessment. In a traditional assessment it is rather easy to look at the solution presented by the student and award marks for correct procedures and calculations, but in an online activity the issue of marking an assignment takes a new dimension especially if the activity involves problems solving and exploration. For example, in the online assessment task requiring students to search and locate an online depreciation calculator and use it to solve the problems given in the exercise sheet it was important for students to find and use a calculator that was appropriate for the problem they were attempting to solve. From the assessment point of view, while it was easy for us to check if the students had located an appropriate calculator from their email message in which they had to provide details of the online calculator, the actual use of the online calculator by the student was difficult to assess because the output was in an online format and could not be copied and sent to the teacher via the email message. Students had to copy and paste data from online output, which was difficult to interpret in an email due to formatting problems. As a result, for the assessment of online tasks on depreciation we relied on a set of criteria based on relevance of students’ selection of the online calculator and if the final answer provided by their online calculation was correct for a given problem.
5.4.6 Topic 5: Linear Equations

Linear equation and graphing techniques topics were the final two topics for the module. These topics were taught in the last two sessions and a paper-based assessment on linear equations was conducted in the third week. Graphing techniques were assessed using Excel program and students were asked to submit an assignment on graphing work. The learning outcome required the class to be able to plot and interpret straight-line graphs, apply them to business decision-making and discuss the significant features of non-linear graphs.

Class attendance for both groups had settled by this time and treatment group attendance ranged from 11 to 14 while control group attendance ranged from 6 to 9. The topic was introduced with a drawing of Cartesian plane on the white board and showing how ordered pairs are located on this plane. Cathy used examples from her exercise sheet to demonstrate the method of solving linear equation graphically. The concepts of gradient, y-intercept and the general form of linear equation in terms of \( y = mx + c \) were introduced on the whiteboard using examples for expense and income equations. After some discussion on the application of the graphical methods of solving business problems of income and expense to carry out break-even analysis, students were given an exercise sheet (Appendix 5.6) for practice and practical investigation during the online session of the lesson.

Figure 5.23. Interactive coordinates plotter.
In the online session activities were designed to provide interactive practice of linear graphing using an online simulation. During the face-to-face session Cathy had realised that the class needed some background skills in graphing techniques and working with coordinates. She directed students to a link from their WebCT course resource page. This link opened in a new window and allowed students to key in coordinates and see how these coordinates can be joined to draw lines on a graph (Figure 5.13). Students used the coordinates given to them in the exercise sheet to practice with this interactive online tool. This java based online tool proved very helpful for students who had little or no familiarity with how coordinates are located on a mathematical graph.

After exploring the topic of linear graphing from the resource page links students were given an online activity. This activity asked students to use linear equations derived from income and expense problems to plot a graph. An online tool from Webmath.com was made available through the Resource page (Figure 5.14).

![Online tool for graphing a linear equation. Source: www.webmath.com.](image)

In this online activity students had to input $m$ and $c$ variables for a $y = mx + c$ equation to plot a graph for the equation. The java applet created a graph for the equation instantly and in follow up discussion students were prompted to play a game
where one student would key in an equation to plot the graph and a partner would look at the graph to guess the algebraic expression of the linear equation.

This online tool for linear equation graphing allowed students to choose a range for their x and y axis thus allowing them to draw graphs for equations from realistic business problems where numbers were larger and required larger scale ratios for graphing. After the online session students were asked to work with graph paper and draw graphs for linear equations to solve for breakeven analysis. This activity was followed up in the following session where students worked on break-even analysis problems without the use of online tools. The assessment task for this topic was based on a paper based activity and both control and treatment groups did similar tasks.
5.4.6.1 Reflections and Interpretations

I noticed that there were two groups of students in the class, those who had some familiarity with linear equations and graphical methods mainly due to their prior exposure to these skills in a VCE mathematics course and those who had no familiarity with graphing techniques. Considering this divide of those who know and those who don’t, we searched the Internet for graphing tutorials and located a java based interactive tool. A link to this tool was added to the MCA Online website and the course resource page on WebCT. The use of embedding links to learning resources relevant to a problem-solving task illustrates how online learning environments can be created for anchored instruction (CGTV, 1992).

The interactivity of the online graphing activity made it interesting for students and they took part in the activity keenly. In particular those students who had little or no prior experience of plotting graphs learned the skills of locating x and y coordinates on the graph and had a visual experience of the representation of an equation into as a linear graph. The availability of this online activity to help students understand the process of drawing and interpreting linear graphs shows the usefulness of digital technologies in creating interactivity and multiple representations to advance our understanding of difficult abstract concepts (Goos, Stillman, & Vale, 2007).

During a session when Cathy asked students to work on graph paper I realised that some students in class did not have graph papers with them and Cathy also had not brought any to class. Using the Internet, a number of grid papers for graphing were quickly located and their links were posted on the course home page. Students used this link from their course home page to print off the graph whenever needed. During the second session on linear equations, the computers failed to log on to network and our course website was not accessible. This incident provided an opportunity to Cathy to devote the full session to solve problems on break-even analysis using graphical methods. Students used a pen and paper method to draw graphs for cost and expense equations. One of the difficult parts of graphing for students was use of an appropriate scale for plotting given equations. We noted that the online activities were also limited in allowing students to manipulate scale factors for practise purposes. This led to a trial and error approach by students.
The online tasks for this topic were designed for practise and exploration purposes only. They were not included in assessment for the topic and students had to participate in a paper based test for assessment of linear equations. As there was no requirement to post answers or comments on the discussion board students stayed away from using the discussion board and only two postings were made by students. These related to queries related to other topics and showed that some students had become familiar with using the discussion board from their homes.

5.4.6.2 Assessment

The assessment task for the topic of linear equations was in print based format only. No online activity was included in assessment of this topic and both treatment and control groups completed the same assessment activity. The assessment task required students to solve the following questions using a grid paper provided along with the assessment task (Figure 5.26).

Assessment Task

1. Given the equation \( y = 4x + 8 \); a. state the y intercept, b. state the gradient, c. sketch its graph
2. Solve the following simultaneous equations graphically.
   \[
   \begin{align*}
   y + 2x &= 8 \\
   5y + 2x &= 20
   \end{align*}
   \]
3. The total cost of manufacturing radios is linear. The radios are sold at $150 each. When 10 radios are produced the total cost is $4500.
   a. Sketch the cost graph (on the graph paper supplied)
   b. Use your graph to find the fixed cost
   c. Find the variable cost per radio
   d. State the cost equation
   e. State the income equation
   f. Sketch the income graph (on the same axes as the cost graph)
   g. Use your graph to determine the number of radios that should be produced and sold to break even.

Figure 5.26. Paper based assessment task on the topic of linear equation.

An examination of comparative results from assessment reveals that the two groups achieved very similar results as mean and median scores for two groups were very close (Table 5.10).

Table 5.10

Comparison of Linear Equations Test Scores

<table>
<thead>
<tr>
<th></th>
<th>No. of Students</th>
<th>Mean Score</th>
<th>Median Score</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>11</th>
<th>40.90</th>
<th>50.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Group</td>
<td>7</td>
<td>39.29</td>
<td>50.00</td>
</tr>
</tbody>
</table>

Although the results from the assessment task for the topic shows that there was no difference between treatment and control group performance as measured by print based assessment tasks, it was obvious to Cathy and me that teaching of coordinates and graphing was made much easier to understand with the help of online graphing tools used in the practise activities with the treatment group.

## 5.5 Conclusion

This chapter has reported the details from the second cycle of this research where the online learning environment developed in the first cycle was customised for teaching a business mathematics module in a blended learning format. This second research cycle aimed at designing and implementing a teaching program where classroom learning of mathematics was carefully blended and enhanced with web-based learning activities relevant to the content of the course.

A blended learning approach adapted in the second cycle allowed for online activities to be integrated with pen and paper tasks in lessons. This approach allowed for blending of face-to-face teaching with online resources and activities. It also allowed for blending of teaching methods where traditional teacher led instruction was blended with online learning methods based on tasks and activities using interactive simulations, online tools, discussion board and email. A number of conjectures guided the design of the learning environment in the second cycle. These conjectures were based on the outcomes of the first cycle of this research and included ideas such as that learning in mathematics can be supported more effectively if we present the vocational course content in the face to face mode is supported with resources and activities located in an online learning environment. We also expected that the use of a blended learning approach using would lead to an improvement in students attitude towards mathematics and their performance would be better than those learning through traditional teacher directed instruction only. During this research cycle we hoped that the use of online tools and authentic data from the Internet would have a
positive affect on students participation and engagement in class activities and their mathematics learning would be enhanced. We also anticipated that the use of discussion board as a communication tool during the course would help in peer-to-peer and teacher to student interaction and sharing of knowledge and information.

Observations from classroom implementation of web-based learning activities and analysis of data from WebCT and assessment records reveal a complex picture of students’ participation and engagement with the learning content. They also point towards a range of technical and pedagogical issues the teacher has to deal with when introducing online learning in a mathematics classroom. Observation of classroom practice showed that the teacher’s use of online activities extended and expanded the scope of learning but traditional pen and paper assessment methods were not suited to assessing learning that occurred in the online mode.

The next chapter presents a detailed analysis and interpretation of observations and data obtained during the second cycle of the study to verify our conjectures and to respond to research questions regarding students’ access and use of online environment and their participation in online learning, the affect of blended online learning on students’ attitude and achievement, and how a mathematics teacher’s role is affected by use of an online learning environment in teaching.


Cashion, J., & Palmieri, P. (2002). *The secret is the teacher: the learner's view of online learning*. Adelaide, South Australia: NCVER.


