Chapter 4: Research Cycle 1

4.1 Introduction

A number of researchers following design based research methodology have pointed out the importance of generating a comprehensive record of the ongoing design process (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003; Hoadley, 2004). They contend that researchers need to provide a detailed account of the context of the study, document the developmental process for the design and intervention and acknowledge their personal agendas or biases that may have an influence over the design and intervention. The first section of this chapter provides details of the personal, institutional and curriculum contexts for this study. It is followed by Section 4.2 which gives a comprehensive overview of the online learning environment and how it was developed. It provides details of the content included in the online learning environment and the rationale behind its design and content selection. Section 4.3 presents the implementation details of the online learning environment. In providing this description, I have drawn on documents, reports, minutes of meetings, emails, discussion postings, personal communication with teachers and classroom observations made during the implementation of the online learning environment. In Section 4.4 reflections from the design and implementation stages of this web-based learning environment are discussed and finally in Section 4.5 a summary of the chapter is presented showing how the findings from this first research cycle led to the next stage of this study.

4.1.1 Institutional Context

This study is located within the TAFE division of a large dual sector university in Australia where more than 20,000 students are enrolled in TAFE courses every year. The university offers a range of higher education and TAFE courses and these are spread over 11 campuses within the metropolitan region. It is the only public tertiary education provider located within a region of more than half a million people characterised by its cultural diversity. A significant proportion of the population of the region comprise of immigrants from non-English speaking backgrounds with a lower
than average participation rate in tertiary education (Wheelahan, 2001). The student population of the university reflects the demographic profile of the region.

The University offers a range of educational pathways to students interested in articulating from TAFE certificate and diploma courses to higher education degrees but high attrition rates at both higher education and TAFE level courses are common and remain a constant challenge. Studies have reported that during the past ten years around 25% students have been dropping out from their courses during their first year of enrolment in higher education courses (Gabb, Milne, & Cao, 2006, p. 2). Although developing a clear understanding of this attrition rate is complex and multi-dimensional, the University has shown a recognition of the need to support students and teachers in dealing with the issue of attrition from courses (Milne, Glaisher, & Keating, 2006; Wheelahan, 2001). The university’s student learning support and concurrent assistance programs are geared towards ensuring that students enrolled in TAFE and HE courses are able to meet their academic requirements successfully. This research also emerged from one such initiative from the TAFE division that aimed at enhancing mathematics learning and extending mathematics support to students who could have been at risk due to their poor numeracy and mathematics skills.

The TAFE division of the university where I worked offered courses in the Certificate(s) of General Education for Adults (CGEA) and youth and mature age students studied subjects like General Mathematics, Reading and Writing, English Grammar and Computer Skills either in a part time or a full time mode. The unit also included a concurrent assistance program that aimed at providing academic support to students enrolled in mainstream TAFE certificate and diploma courses. This academic support included helping students with their mathematics and English language skills. The concurrent assistance activity involved several forms of teaching including team teaching with the vocational teacher as a partner, running special workshops, group tutoring and one to one tutoring.

A significant change occurred when my unit received additional funding to establish a separate Mathematics Learning Centre (MLC) to assist TAFE students with their mathematics needs. A team of three mathematics teachers including myself took the
responsibility of the development of this MLC. We assembled and developed a range of resources for hands-on learning activities, print based practice sheets, and problem solving tasks and computer based mathematics programs. The introduction of MLC and its success with students sowed the seeds for this design-based research project. The new project sought to extend the access and usefulness of the MLC by creating an online learning environment. The intention was to develop an online environment modelled on the best practice concept of a physical mathematics learning centre to offer access and support for mathematics learning through an interactive online learning environment. The impetus towards developing an online environment was also influenced by policy initiatives in the TAFE sector that encouraged and supported flexible delivery and online learning (Office of Post Compulsory Education Training and Employment, 2000).

4.1.2 Personal Context

As a mathematics and science teacher I have been working in the field of education for the past 25 years. During this period I have worked in the secondary, TAFE and teacher education sectors. Over the past fifteen years I have been involved with general education programs for adults and was responsible for developing and teaching mathematics and science modules for the general education for adults programs. During this time I have also worked with the concurrent assistance program where I offered learning support in science and mathematics to students from trade, science, engineering and business courses.

During my work in the TAFE sector I have taken a keen interest in the use of computers in numeracy and mathematics teaching. I was responsible for setting up the first computer lab for adult education students in my department. The period of nineties was a boom time in terms of introduction of computers in educational settings. I was interested in the Internet and arranged to bring Internet connection to our computer lab via dial up connections and designed the first website for my department. This experience allowed me to develop technical and design skills for publishing on the Internet. I was also able to find a number of freeware mathematics programs from the Internet for our computer lab. These programs allowed me to introduce computer-based learning in mathematics. Some of these programs were
basic skills practice programs but allowed adult learners to learn to use computers and practice their maths skills in basic operations.

I was also interested in sharing my experiences and knowledge with other mathematics and literacy teachers and became involved with a number of professional development projects. Working as a coordinator for two national projects I took an active part in professional development of teachers in the use and application of technologies in classroom teaching. During these projects I came in contact with a number of teachers working in the vocational education sector who shared an interest in the applications of technology in learning. These projects also gave me new skills in online design and showed me new tools and web-based resources for learning.

Drawing on experience from these projects and working with fellow mathematics teachers I began to explore the possibilities of using online resources in the mathematics classroom. At first I was interested in downloading simple maths programs on skills practice and problem solving but soon discovered java and javascript based interactive online mathematics activities. The interactive online activities provided me an opportunity to explore computer-based problem solving with my mathematics classes. By mid 1999, the successful development of the Mathematics Learning Centre, the introduction of internet in computer labs, the discovery of various online learning resources and communication tools, and the availability of necessary skills for developing an online learning environment seems to have emerged as converging factors for me to initiate a project for developing an online learning environment and conduct a systematic study of the development and use of this new medium as a design research project.

4.1.3 Curriculum Context
Mathematics curriculum in the TAFE sector can be divided into three types. First there is the Adult, Community and Further Education (ACFE) based mathematics curricula that conform to the frameworks of Certificates of General Education for Adults (CGEA). This mathematics curricula bears resemblance to mathematics taught in secondary schools but methodology is strongly influenced by adult learning principles (Knowles, 1980). Mature age and youth learners can move from Certificate
I mathematics to Certificate III mathematics in a developmental pathway. There is a strong network of adult numeracy and mathematics teachers within Australia and globally and mathematics teachers from this area have access to professional development and research from the field (FitzSimons, 2003). Second, there is an adult VCE mathematics that is year 11 and 12 mathematics for those who wish to gain a VCE certification from the Victorian Curriculum and Assessment Authority (VCAA). The adult VCE mathematics follows the same mathematics curriculum and assessment as any secondary school year 11 or 12 student. Teachers teaching VCE mathematics are specialised mathematics teachers with a strong mathematical background. The third type of mathematics is the one taught in vocational and trade courses. The VET mathematics curricula is strongly influenced by the particular industry sector of the vocational training and follows a competency based assessment. VET mathematics is the least theorised and very little research or professional development opportunities are available to mathematics teachers from the VET sector (FitzSimons, 2002).
4.2 Development of MCA Online Environment

The development of an online learning environment to support mathematics learning at the TAFE level was a major project and required institutional support, funding and skilled teachers. Having played an active role in establishing computer based learning activities at the Mathematics Learning Centre at my department and with ten years of experience in teaching mathematics to adult learners, I coined the idea of developing an innovative online learning environment and encouraged two of my fellow mathematics teachers to come on board for setting up this project. A number of government and institute level initiatives such as Australian National Training Authority’s Flexible Learning Framework (ANTA, 1998), Victorian Flexible Learning Strategy for TAFE (Office of Post Compulsory Education Training and Employment, 2000) and the learning and teaching strategy of my university provided a contextual backdrop and our department was able to gain funding from Victorian Open Training Services to carry out this project. The funding enabled time release for two mathematics teachers to work on the project one day a week for a period of one semester. It also enabled me to be assigned to the project on a full time basis for a period of one semester and coordinate the planning and development of the whole website.

Immediately prior to embarking on this project I had completed a research project (Wilson & Javed, 1998) where I explored the use of the Internet and web resources by literacy and numeracy teachers. This work allowed me to develop a broad understanding of issues related to online design and learning and encouraged me to embark on a research project to explore how an online learning environment can be developed and used to support mathematics learning. So, for me, the Maths Concurrent Assistance (MCA) Online project involved not only an innovative online design project, but also an evolving design based research which focussed on articulating and refining tentative theories regarding the development, use and effectiveness of an online learning environment in supporting TAFE students mathematics learning.

The first stage of the project was the planning stage. During this stage we identified the desired objectives and personnel for the project. Two of my colleagues and I
formed the core of the team and began the planning and development work for the project. Our head of department took the role of a project manager and acted as a critical friend during the project. An advisory group consisting of nine members from the field of vocational education met three times during the project and advised the development of the project. At this stage we took stock of our individual strengths and weaknesses in terms of skills required for the project. Research has shown that developing good online resources requires considerable skills and expertise on the part of teacher as a designer (Cashion & Palmieri, 2002; Ward & Newlands, 1998).

The two mathematics teachers brought considerable experience of teaching secondary and TAFE mathematics to the project and were working with students seeking mathematics assistance via our Mathematics Learning Centre. But they did not have any online design skills and used computers for word processing, email and web browsing purposes only. I came to this project with considerable skills in computer use and web design. In addition to teaching mathematics, I was also a teacher of computing skills and according to the classification developed during Literacy Learning through Technology (LLTT) project (Wilson & Javed, 1998, p. 15), my skills would have fallen under the ‘developer’ category. The project employed a graphic designer for a short period to help with developing graphics for the website. Two Information Technology experts were part of the advisory group and were available for any assistance. The two mathematics teachers and myself carried out the bulk of the content and site development and I played a lead role in guiding the design and assisting with writing mathematics units for the web.

4.2.1 Conjectures and Design

The design and development of the online environment, MCA Online (Javed, Canty, & Samarawickrama, 2000), was guided by a number of conjectures about the design. These conjectures were informed by teachers’ personal experiences and an informed survey of literature on computer assisted mathematics learning (Bransford, Brown, & Cocking, 1999; Kaput & Thompson, 1994; McCoy, 1996).

Our first conjecture was concerned with navigational scaffolding for students. Our design wanted to use existing web based interactive learning objects on selected
mathematics activities in a hypertext-linked environment. The problem of giving web addresses or expecting students to follow a link to a given website to find a learning object/activity often leads to frustrating searches and has the potential to lead students to diversions and time-wasting web browsing (Gerber & Shuell, 1998; Smith & Ferguson, 2005). In our design we decided to use navigational scaffolding so that from our online learning environment for a particular mathematics unit learners had direct links to learning objects located on the Internet. Through this approach we hoped to keep the student focused on a particular learning path and avoid distractions resulting from browsing external websites.

Our second conjecture related to the issue of use of interactive learning objects. In this context interactivity referred to the ability of the online learning object to allow users to manipulate data input and observe its effect on the outcome. The Internet offers a range of JavaScript and java applet based learning objects that allow users to interact with the system to generate solutions. Loong (2001) has identified three types of interactive mathematics objects on the internet but in our design we were concerned with using the interactive objects that provided feedback to users and were exploratory in nature. The type of interactivity generated through these objects is unique to computer-based systems only and cannot be achieved in paper based learning activities. Studies have shown that interactive tasks with immediate feedback enable the online medium to engage students’ attention for longer than usual (Laurillard, 1997). We were not interested in the game play type of interactivity, as it was not expected to appeal to adult learners. Our assumption here was that the interactive online activities on our website need to help in building students’ understanding and use of mathematical concepts.

The third conjecture that affected the design of the online learning environment was related to the use of communication tools. One of the key aspects of face-to-face teaching is the live teacher-student interaction and this class dynamism is unable to be reproduced in the online environment (Smith & Ferguson, 2005). However, research has shown that the availability of communication tools such as email, discussion board and live chat can be used to create effective online learning communities (Salmon, 2000). The Mathematics Learning Centre (MLC) provided students direct contact with teachers where they were able to bring their mathematics problems to
seek guidance from a teacher in the MLC. The teacher guided the student in a face-to-face meeting with the aim of providing the student a support that would not only solve the student’s immediate concerns but also lead him or her towards becoming an independent learner. The online environment provided the opportunity to extend the student’s access to the teacher’s guidance by means of synchronous and asynchronous communication.

By creating and using an online message board we expected that students would be able to post their questions in an asynchronous mode and teachers would be able to respond to students’ postings. In this way, we were aiming to promote a culture where other students could also respond to questions and comments posted by students. In addition to the message board, the online environment design also incorporated an online live tutorial tool. This online tutorial tool was built to allow students to log on to the tutorial site at specified times and chat with a mathematics teacher in the online mode. Drexel University’s Ask Dr Math (2000) online forum provided a good example of building a community of practice by using asynchronous tools of an online discussion board. Using the communication tools of discussion board and live chat, the MCA online design assumed that TAFE students seeking support in mathematics could also be trained to use the synchronous and asynchronous mediums for their learning needs. However, it is useful to note that the live chat option was a novel experience and very few teachers and students had used this medium for learning mathematics.

Another important conjecture that played a significant role in the design and content of the online environment was that if we provided discipline specific resources from engineering, science, business, VCE and general education areas, students and mathematics teachers from these disciplines would be more inclined to direct their students to this online learning environment and also use this website as a reference with their regular face-to-face classes. This assumption led us to design sections of the MCA Online that were devoted to particular discipline areas and contained archives of questions and answers from past examinations, recommended book lists, module details and links to MCA Online learning units particularly relevant to that discipline. We anticipated that teachers and learners would readily use a web design that suited
the needs of students enrolled in mathematics modules and offered access to learning in a flexible format.

4.2.2 Design framework, planning and construction

Kuutti (1996) suggests that technology based design needs to balance three levels: automating routines, developing understanding and fostering communication/creativity. A number of contemporary researchers have also highlighted interactivity and connectivity as important and useful elements of online learning environments (Alexander, 2001; Laurillard, 1997; Loong, Barnes, & White, 2002). Our design of the mathematics online learning environment was guided by our desire to make both interactivity and connectivity available to learners.

It is important to note that the intention of our proposed online environment was not concerned with distance education or learning remotely with the use of technology without direct assistance from teachers. Our goal was to offer an online environment that could extend the access and opportunities for students in classroom based learning and encourage teachers in incorporating new technologies in mathematics teaching. It aimed at expanding teacher’s zones of promoted action (ZPA) and free movement (ZFA) (Goos, 2006).

The planning for the design of MCA online website started with the conjecture that if we created an online environment that offered content that engaged students without challenging their attention threshold and offered spaces for social interaction, we would be able to increase their involvement with mathematics learning beyond classroom contact. Studies have shown that interactive tasks with immediate feedback enable the online medium to engage students’ attention for longer than usual (Laurillard, 1997).

The MCA Online development process included planning and designing for the mathematics content provided in the online environment; planning and designing for the interactivity using external website links and java based resources; and planning and designing for the communication tools to be provided to users of this online environment.
4.2.3 Learning Units

Planning and designing for the mathematical content provided in the online environment was influenced by our conjecture that we should make available learning content that would be appropriate for the needs of students enrolling in engineering, science, business, VCE and general mathematics courses in the TAFE sector. Although working with students coming from different disciplines and using our Maths Learning centre (MLC) we had developed a fairly good idea of what areas of mathematics students needed help with, we decided to ask six teachers from vocational programs and VCE to list mathematics topics that would be most helpful in building students concepts and skills in mathematics. In addition, we collected data from students of three vocational mathematics classes using a questionnaire for Maths Students’ Survey (Appendix 4.1). The survey aimed at identifying the kinds of mathematics problems students experienced in their courses. It asked three questions: 1. What maths module(s) are you studying this semester, 2. What maths are you having problems with? (Give names of topics or examples of questions.), 3. Did you have any problems with your school maths? (If yes, name the topic).

In response to this survey, common topics listed by students and teachers included algebra, fractions, decimals, percentages and unit conversions. Some students also listed topics such as calculus and differential equations but we limited our goal to providing supporting learning units in only pre-requisite mathematics skills and broadly focused on mathematics of up to year 10 and Certificates of General Education of Adults (CGEA) levels. After discussions with project team and advisory committee, we decided to develop learning units on 12 topics. These topics included Algebra, Numbers, Fractions, Decimals, Percentages, Indices, Measurement, Trigonometry, Statistics, Geometry, Probability and Graphs (Figure 4.1). Each topic or learning unit was further divided into three or more subunits. The purpose of these learning units was to provide a basic understanding of mathematical concepts and techniques associated with these topics.
The learning content and activities within each subunit of a topic were developed with a view of adult learning principles (Knowles, 1980) and used the design and interactivity elements of the web to offer a learning experience not possible with print based resources. Each subunit (Figure 4.2) started with an *Examples* section where the basic concept was explained in simple language using a number of examples. Procedures for finding solutions for the example problems were elaborated and explained in a meta-talk along with the mathematical solution. The purpose of this meta-talk was to scaffold learners’ conceptual thinking in the absence of a face-to-face teacher talk. The *Examples* section was followed by a *Have a go* section where learners were prompted to attempt a couple of problems, but complete solutions to these problems were available to them as a hyperlink.

A third and final section of a subunit labelled as *Practice questions* contained a number of problems at various difficulty levels and learners were expected to solve them on their own. These sections of a subunit described above were similar to the content found in a typical mathematics textbook, except that the examples were described with adult learners in mind and used meta-talk to describe procedural learning of mathematical tasks.
While working on the content development of a subunit we were aware of the limitations of presenting text book like content on the web and made sure that the *examples, have a go and practice questions* sections of a particular learning unit were aptly supported by interactive online activities where learners could develop and practice their skills and have the opportunities to extend their conceptual learning.

### 4.2.4 Interactive Online Activities

The interactive online activities for learning units were selectively drawn from external websites. Some activities were particularly suited to skills practice where learners were able to attempt computer generated questions and monitor the accuracy of their responses. These activities provided learners opportunities for self paced auto corrected skills practice work. For example the learning unit on the topics of fractions provided a number of interactive skills practice activities including *Practise fractions inequalities* (Figure 4.3), *Practise reducing fractions*, *Practise fractions multiplication* and *Practise fractions simplifying*. These JavaScript based interactive activities originating from *aplusmath* website (Aplusmath.com, 1999) offered learners practice questions where learners were expected to provide a response either by selecting from a number of options as in *Practise fractions inequalities* or by typing in their answer as in *Practise fractions multiplications*. The automated feedback to
learners’ responses offered the correct solution and kept a count of correct and incorrect scores.

Another type of interactive activity allowed learners to observe the solution of a randomly generated problem in a step-by-step method. Learners had to click on a button to move to the next step. For example in the learning unit for Algebra Interactive Maths Practice link offered a range of JavaScript based activities on solving linear equations and factorisation (Figure 4.4).

Figure 4.3. A drill and practice type interactive activity from Learning Unit on Fractions. Source: http://www.aplusmath.com.

Figure 4.4. An interactive activity from Algebra Unit showing a step-by-step computer generated solution. [Reproduced with permission from Robert Bunge of Cyber School Services.]
We also used interactive activities where learners could input their own problems in fill-in forms and observe a step-by-step solution generated by a Common Gateway Interface (CGI) programming based automated math-solver program. These automated math-solvers used sophisticated programming to simulate a solution accompanied by explanations of each step undertaken. The interactive tools allowed learners to try their own problems to test if their solutions were similar to the ones provided by the math-solver program (Figure 4.5 and 4.6).

*Figure 4.5. An automated maths problem solver for simple algebra equations. Source: http://www.webmath.com/solver.html.*
We were also able to incorporate Java applet based exploratory interactive activities from the web into our learning units for selected topics. These exploratory activities allowed learners to manipulate a simulated activity and explore abstract relationships and concepts. For instance, an exploratory interactive activity connected to the learning unit for trigonometry provided learners with the opportunity to explore the relationship between the ratios of base, height and hypotenuse in a right angle triangle and use it to explain the ratios of sine, cosine and tangent (Figure 4.7).

![Sine and Cosine](http://catcode.com/trig/trig05.html)

*Figure 4.7. An interactive exploratory activity. Source: http://catcode.com/trig/trig05.html.*

In this activity clever use of java applet programming allowed learners to vary the size of an angle between two sticks by dragging them apart. The applet showed how changing the size of the angle between two sides of a right-angled triangle affects the ratio of sides. Computer based interactive activities that allow learners to control and manipulate the learning environment and explore it to develop a deeper understanding of the concept being presented have consistently been favoured in educational instructional design and in mathematics education research (Ainley & Pratt, 2006; CTGV, 1992; Goos, Stillman, & Vale, 2007; Jonassen, 2000; Street & Goodman, 1998).
The use of interactive activities also allowed us to incorporate authentic and real data into learning activities. The Internet has allowed various financial companies to develop and offer online tools for various numerical calculations such as home loan calculations, depreciation calculations, currency conversions, measurement unit conversions etc. Often these online tools are buried in layers of the organization’s website. In the MCA online design we provided access to these tools as direct links from relevant learning unit pages. For example, from the learning unit page for the topic of Interest calculations, we provided a direct link to learners to be able to open a home loan calculator provided by a leading Australian bank.

4.2.5 Message Board and Chat

The flexibility and ease of exchanging ideas and information provided by an online communication medium was also an important element of our design plan. One of the main advantages of Internet over other forms of electronic content such as CD ROM based educational software is its distinct ability to provide access to both synchronous and asynchronous forms of communication. Email, discussion boards and chat are familiar forms of communication tools for the Internet. In designing the MCA online learning environment we were aiming to create opportunities of both teacher- learner communication as well as learner- learner communication. We also wanted to build a facility which would allow dedicated real time online chat where regular online chat sessions led by a mathematics teacher can offer assistance to learners who were located remotely or were unable to access our MLC facility during its operating hours.

Figure 4.8. The message board entry web page.
Our university had a site licence for a commercially available online communication platform known as WebBoard. This communication platform allowed both synchronous and asynchronous communication to take place from the same interface but in our design we planned to keep the chat system separate from the message board area. By keeping the chat system accessible from a separate web page we made it simpler for students to access the chat facility.

The asynchronous feature was accessible from a message board link from the MCA online home page. It was accessible to all visitors to the MCA online website with a guest account access without the need of a user ID or password (Figure 4.8). However, only registered users could post new messages and reply to previously posted messages. The message board link took users to a message board web page (Figure 4.9). This web page provided information about how to use this message board and links for guest access, registered users access and a direct link to registration form for new users.
An online chat facility was provided using a separate link from the main home page. This chat facility was labelled as online tutorials. The online tutorial button was linked to a web page with details about how to use the live online tutorials facility (Figure 4.10). A help page to show users how to use this chat program showed screenshots with instructions. This page had a “join live tutorial” link that opened a separate chat window when clicked. Announcements about the live chat sessions were posted on the message board and a link to these announcements was provided on the live tutorial web page. This java applet based synchronous chat program was limited to text-based communication only and sharing of graphics or drawing of line images was not possible.

In addition to learning units, interactive activities and communication facilities the MCA Online website also provided a toolbox and a glossary sections. The toolbox section contained resources commonly needed in mathematics learning. A JavaScript based online scientific calculator and a units conversion calculator was included in the toolbox along with quick reference pages on commonly used mathematics formulas and symbols. The toolbox also included links to basic mathematics, statistics, calculus and financial terms glossaries. The main purpose of the toolbox section was to provide self-help mathematics tools to learners.
The MCA online website also included discipline specific resources for Business, Engineering, VCE and general mathematics in four separate sections on the website. Each section was directly accessible from the homepage of the MCA online website and contained resources such as module details, archives of past question papers and solutions, booklist and links to a selection of learning units relevant to that particular discipline. As the initial purpose of MCA online website was to provide learning support to students undertaking vocational and general mathematics courses, we included in our design many useful resources sought by students undertaking mathematics modules from these disciplines. The project team contacted teachers from various departments and collected module information, course notes and past test papers. Digital copies of these resources were created by word-processing and scanning.

4.2.6 Issues and Concerns

As a designer, I was aware of the problems associated with website links that go out of date and users receive an error message when they try to use the link. Firstly, we tried to develop most of our content locally and relied on external links only for live data, simulations and java based interactive content that was beyond our skills and scope to produce. In order to overcome the ‘broken links problem’ I took the initiative to seek permissions from original authors of selected JavaScript programs to allow me to host their scripts on my local web server. In this way I managed to design some online tools and activities such as the scientific calculator or the interactive algebra exercises without the risk of broken web links. Also, regular checks were made to ensure that all links from the MCA Online website were current and active.

Finding and reviewing websites with online mathematics activities was an important task for the project team and we shared our findings and reviewed useful sites for possible inclusion to relevant sections of the MCA Online website. This review and revise cycle was an essential step for keeping external online links working and ensured regular updating of broken web links from the MCA Online website. For example one of the websites hosted by Webmath.com was taken over by a commercial company and links to online activities located on this website were lost due to authentication requirements of the commercial company. We were
disappointed to lose free access to these online activities and responded by replacing these links with new links from our directory of reviewed websites.

One of the major challenges in creating a website for mathematics learning was the difficulty of writing mathematical symbols and expressions. Although Microsoft Equation Editor offered a solution for writing common mathematical terms in a word processing document, it was not possible to copy and paste these mathematical expressions into a web page editor. As mathematics symbols and expressions were not supported by HTML code, it was not possible to present mathematical expressions on the web using text or ASCII codes. The only solution available at the time was insertion of mathematical expressions as a graphical element on the web page. We acquired the MathType software that allowed writing of mathematics expressions and saved them as GIF images. These GIF images of mathematical expressions could be embedded in a web document with some tweaking required for text and image alignment on the page. In this way, the MCA Online was able to overcome the difficulty of writing mathematics for the web with the use of MathType software.

4.3 Enactment

The successful design and construction of the MCA Online website was a significant achievement for the project team and added a new dimension to the operations of our department’s Maths Learning Centre (MLC). After an initial phase of testing, proof-reading and editing the new learning environment was put to immediate use with students attending the MLC. During the first semester of 2000, in order to introduce this new learning environment to mathematics teachers and their classes in the TAFE, I developed a module (manual) that explained different features of the MCA Online and provided simple exercises to introduce the learning environment to learners (see Appendix 4.2).

In the following semester the MCA online environment was piloted with a number of classes and feedback from students and teachers was collected. This process led to further refinement of the product (MCA Online website) and identification of issues related to the use of such an environment to support mathematics learning. In addition to the introduction of the MCA Online website to the vocational mathematics classes
as a supporting resource, I implemented it in my CGEA certificate II class in a blended learning format and noted the pros and cons of implementing it as an integrated learning resource with the traditional curriculum. In the following sections I will describe how the MCA online implementation in three different modes led to its continuous refinement and tested the conjectures held at the beginning of the development of this learning environment.

4.3.1 MCA Online in the Maths Learning Centre

The Maths Learning Centre (MLC) operated within my department as a drop in centre. During morning hours the MLC was used as a classroom to teach regular mathematics classes to general education students and during afternoons it served as a drop in centre for all other students. Usually, students from VCE, business and engineering branches would drop in with their problems in mathematics, or sometimes teachers from these departments would recommend a student who would seek help from the MLC on a regular basis. A mathematics teacher was always available in the MLC but at times, it became difficult to attend to the needs of several students at the same time. The MLC teachers prepared relevant practice work and used mathematics worksheets to keep students engaged so that their time could be used more efficiently in helping all students.

The MLC also had five networked computers and these computers served students computing needs in mathematics. The computers had programs such as Microsoft Excel, Maths Blaster, Measuring Up, Geometer’s Sketchpad and many freeware skills practice mathematics programs downloaded from the Internet. Once the MCA online website was launched, these computers were set to open the MCA online website as their default home page. The availability of the MCA online website in the MLC helped in two ways. It helped teachers working in the Centre by providing them instant access to worked examples, exercises and activities that could be easily printed and given to students for extension work. Secondly, it served as an important learning resource for students especially with the interactive auto-correcting exercises. Students waiting for assistance or needing extra practice were directed to these online exercises to allow the MLC teacher to share their time with more students. With the
help of auto-correcting practice exercises students required less direct teacher attention.

As the MLC was the first educational setting where the MCA Online website was being used, it served as a field-testing ground for the refinement of the new learning environment. It allowed for a closer scrutiny of the MCA online content and links and errors noticed were rectified on a regular basis. The MLC procedures allowed for documentation of students particular use of MLC facilities and teachers were able to record any errors or difficulties experienced with the online learning environment. Observations of students and teachers using the MCA online website showed that users with little or no experience of computer usage found it difficult to navigate their way around and often did not see that there was more content available on the screen and required their use of the scrolling bar. Many students were unfamiliar with the use of websites as interactive learning interfaces and required teacher guidance to show them how different buttons and selections worked in the online environment. Students also had to learn equivalent ASCII keys for writing mathematics expressions and symbols on the screen. Another important advantage of using MCA online website in the MLC was that many new and useful links were added to the online learning environment. The use of MCA online within the MLC program helped in identifying new links and revising existing links according to the needs of students. As far as the design of the learning environment was concerned the structure of learning units contained a static part in terms of Examples, Have a go and Practice questions sections where learning content could not be changed, but the links to relevant websites belonging to individual learning units could be continuously revised according to needs of students, discovery of new online tools and activities, and links becoming outdated. One feature of the MCA Online website that remained unused during its use in the MLC was its communication feature. It appears that because the website was not included in the classroom learning in a structured way, the students did not feel the relevance or the need for using the message board or the chat facility.

4.3.2 MCA Online use promoted with a module

After introducing the MCA Online environment in the MLC we moved to extend its usage beyond MLC and planned to use a pro-active strategy to promote this online
learning environment in mainstream vocational mathematics courses. We knew that it was important to familiarise teachers and students with this new learning environment before they would be interested in trying a new and computer based medium of concurrent support and learning. After consultations with mathematics teachers and program managers of interested departments it was proposed that if we developed a short non credit module to introduce the MCA online services and resources, general and vocational mathematics teachers will be willing to recommend their students to take this non credit flexible delivery module to help them improve their mathematics. We also knew that when the online learning medium is introduced in a structured way, we would be able to test our conjectures with more confidence and evaluate its use. Consequently, a short module was written to serve as an induction manual and contained activities and exercises to familiarise learners to various tools and resources available from the MCA online website (Appendix 4.2). The design of the module was based on an assumption that when teachers and students have become familiar with using the MCA Online tools and resources they would be more willing to explore the MCA Online website to seek assistance with their course related mathematics needs. With this purpose in mind the module was divided into four sections – communicating online, working with maths problems, using tools and references and using online symbols. The module aimed to achieve the following learning outcomes:

- Communicate using MCA online Message Board
- Identify appropriate paths for solving problems at MCA Online
- Find and use relevant maths tools and resources
- Become familiar with online maths symbols and expressions

The Communicating Online section of the module focussed on message board activities and explained the process for registering as a new user, reading and posting messages and joining for a live chat. The section contained online activities where learners were given step-by-step instructions for completing a given task such as posting a new message on the message board. The section on Working with Maths Problems explained the contents and structure of a learning unit and how links to online resources from the web offered practice activities for a selected learning unit. This section also contained hands-on activities where learners had to complete a given task
of following a learning unit to understand basic maths concepts and locate answers to
selected problems at the Ask Dr Math archives of questions and answers. The third
section of the module concentrated on Using Tools and Resources and explained how
to use online calculators and glossaries. Four different activities guided learners how
to use different online tools for maths calculations. The final section of the module
focussed on Using Online Symbols provided learners with an overview of symbols
used in writing mathematics in an online environment. This section also contained
activities where learners had to carry out mathematical calculations and write symbols
and expressions in an online form.

During the second semester of 2000, 140 students enrolled in Electronic Engineering,
Business and Marketing, Women’s Education, Language Studies and Adult Basic
Education programs participated in this flexible delivery module which aimed at
equipping them with the necessary skills to use the MCA Online learning
environment to support their course related mathematics learning needs. With
assistance from mathematics teachers from these departments I conducted workshops
to introduce the MCA online website using selected activities from the induction
module. A copy of the induction module was given to each participant and they were
advised to go through all activities contained therein in their own time. These face-to-
face workshops allowed learners to become familiar with the MCA online
environment and the module expected students to complete a number of tasks in their
own time during the next few weeks. We especially wanted students to use our
communication system to seek mathematics help and share their learning. The
conduct of these MCA Online workshops was also aimed at providing a professional
development opportunity to teachers and build their confidence in using new learning
technologies to enhance their class room based teaching and ally the fear that
increased use of online technology is intended to replace traditional class room
contact with students. The workshops were conducted as a team effort with the class
mathematics teacher and allowed him/her to observe and participate in MCA online
learning activities.

All students participating in the workshops and undertaking the induction module
were asked to respond to a questionnaire (Appendix 4.3) four weeks after the initial
workshop. In addition, classroom observations and postings on the message board
were used to evaluate the pattern of access and usage by students. Any content and design issues such as incorrect answers or broken web links were immediately acted upon to refine the design of the learning environment. The promotion of MCA Online website using an induction module also provided opportunities for teachers to reflect on the content, design and students usage of the MCA Online website. Teachers provided feedback via emails and a response sheet. Comments from the email and response sheets were further clarified in face-to-face informal interviews. The trial of the MCA Online website with mainstream mathematics classes revealed a number of interesting issues in relation to implementing an online learning support and teachers’ attitude and perceptions towards such an innovation.

A primarily logistical issue in using online learning support within classroom-based mathematics was the fact that most mathematics classes were held in traditional classrooms where no networked computers were available. In order to conduct our MCA Online induction workshops we had to arrange and move to a computer laboratory to enable access to the MCA Online website. However, this was only a temporary arrangement and classes reverted to their normal locations after the workshop sessions. Many teachers and students reported that this lack of access to networked computers in mathematics classes could have constrained their use of this new learning environment.

All students enrolled in the university were provided with an email account but many continued to use their hotmail or similar email accounts. The data from students’ questionnaire confirmed that more than 70% of them regularly checked their email. Nearly 30% of these claimed to check their email on a daily basis and at least 40% said that they log on to their email accounts at least once a week. These trends suggested that most students were becoming familiar with online services but may not have access to these services on a regular basis. Many students also revealed that they relied on university computers to access their email accounts. The same trend was noticed on the MCA Online message board service where most students posted messages only from the university computers. Access to network computers at times convenient to students appeared to be a significant factor in the use of the MCA Online environment from outside class hours. From this experience it was clear that
access to network computers is crucial in the success of online-based flexible learning methods.

More than 70% students reported that they found MCA’s resources useful for their mathematics learning needs. Nearly 50% found these resources very useful whereas 30% found them to be sometimes useful (Figure 4.11). About 10% of the students were still undecided. In response to a related item on the questionnaire (item 9 Appendix 4.3) many students reported that they needed more time to use these services to truly assess its usefulness.

![Figure 4.11. Students perception of MCA Online Environment.](image)

![Figure 4.12. Students’ preferred sections of MCA Online Environment.](image)
Students’ approval and willingness to adapt to the new methodology of online facilitated mathematics learning was an encouraging signal showing that students were willing to take advantage of this new learning environment if appropriate access and training structures were put in place to optimise learning opportunities offered via the MCA online environment.

According to students’ responses for the question on what sections of the MCA Online website they were likely to use in future (Figure 4.12), almost 50% students agreed that they would like to use the Message Board, Learning Units and Toolbox sections in future. These responses suggested that electronic communication and feedback were valued parts of online learning environments and students preferred content supported with communication and feedback services.

However, in practice students’ use of the Message Board and Live Chat sessions was limited mainly to in-class use during the workshops and training sessions. Contrary to our expectations, students did not take up the challenge of posting messages to seek assistance and hardly used the message board to post messages. In terms of chat, during the whole semester four invitations to live tutorial sessions via chat were posted on the message board but there was no response to these invitations and no one turned up for online chat. The problems with using chat sessions to conduct mathematics tutoring had become obvious even during the workshop sessions as students found it difficult to articulate mathematics symbols and expressions in a chat environment.

It would be incorrect to assume that students did not have adequate technical skills to participate in online communication because the same students were using email and social chat programs such as MSN Messenger regularly and the university had to place a ban on unauthorized use of chat programs in computer labs. Possible reasons for this lack of use of online communication may lie with issues of access to the Internet and difficulty of writing mathematics on the computer (Gadanidis, Gadanidis, & Schindler, 2003; Smith & Ferguson, 2005). But an equally if not more significant reason could lie in the fact that students had no motivation to use the online communication because their mainstream mathematics subject which counted towards their results had no connection with using the online communication facility.
This lack of activity on the message board and chat sessions indicated that by simply making an online service available to students does not necessarily motivate them to start using it for their needs. Perhaps students needed to see a direct connection between their classroom work, course assessment requirements and the use of online facilities. It became clear that TAFE students generally were not yet prepared to use online facilities to independently seek support in mathematics learning.

Another issue related to the use of MCA online environment was that apart from the message board services the system did not allow any other monitoring of usage. For example there was no electronic monitoring or feedback on students’ usage of sections of the learning environment other than the message board and chat. Informal feedback from teachers and occasional emails provided an indication that students (and teachers) were pleased to have access to this learning environment and made use of many of its learning units sections. For example, an email from a teacher in the electro-technology department confirmed the apparent usefulness of our MCA online environment as he reported that his students were making regular use of the content and links available from the MCA Online website and his own department’s website had made links to MCA Online pages to help students access the contents easily. In an email he wrote:

This is just a short email to give thanks to the people who put together the MCA Online site. We in the Electro-technology have numerous links to your site from our own online material and our students (around 400 a year) use your site extensively and feedback we get from students is always extremely positive with many commenting on how well the site has been put together and how much help it has given them with their maths. It is good to see areas within (university) that have actually done something worthwhile with online material and not simply talk about “investigating the possibilities of doing something with it in the future”.

Regards,
Program Manager
Formal feedback using a questionnaire (Appendix 4.4) from teachers involved in trialling the MCA Online learning environment indicated that they were impressed by the look and feel of the website. Teachers generally agreed that the instructions were clear, graphics were good and navigation was easy. They found the website easy to manage in terms of moving from one section to another and returning to home page from any location. The teachers did not like the chat facility and found it confusing and limiting for instructional purposes. Most teachers lacked familiarity with the message board postings and the discourse of threaded discussions. In contrast, students demonstrated a better understanding and fluency in the use of both the message board and chat facilities.

Mathematics teachers from the general education courses found that the content of MCA Online was very relevant to their courses and were generally very pleased with the interactive online activities in mathematics. There were comments about adding special features. For example one teacher said that, “I would like more units in ESL maths, perhaps an ESL dictionary”. A VCE teacher commented that, “I would like more depth – extend the trigonometry range”. In vocational areas such as business mathematics, the teachers were keen to offer additional learning opportunities via the MCA Online website but noticed that any sustained use of online services would require more planning of content and assessment strategies. They confirmed that the use of online resources in teaching would make their content more realistic and relevant for students.

During the trials of MCA Online environment it also became evident that teachers were willing to use online learning environments but needed professional development both in terms of technical skills and online teaching and learning strategies. Most TAFE students taking part in MCA Online program were able to access and interact with the online environment but required some guidance in using facilities such as interactive activities and online communication. They also needed instructions and practice in using special symbols to write mathematical expressions on the web.
4.3.3 MCA Online in Classroom

While the MCA Online website was being promoted using a MCA Online induction module, I took a general mathematics class for the CGEA certificate II with a group of 12 students. These students were doing an adult education course and nearly half the class comprised of students in their late teens and had left school early. I took the opportunity to trial the MCA Online environment with this group to explore the issues and possibilities in using it in a blended learning format. I had a 3-hour class per week where I arranged to have a two-hour session in a traditional classroom and moved to a computer lab close by for the final hour. Students would start with a face-to-face session in the morning and do a mathematics topic using pen and paper activities and tasks. After about 90 minutes the class would take a short break and return in the computer lab for the MCA Online supported learning. In previous years I had faced difficulties in keeping the youth members of the class motivated enough to maintain their focus on learning during a 3-hour class. This arrangement of a two-hour traditional and one-hour computer based class aimed at providing them a variety in teaching method.

In a typical class I would start a mathematics topic with a reference to some everyday event and then build the context for learning with the help of students’ responses. This would be followed up with an explanation of the mathematical concept with illustrations and examples. Often the examples would be solved on the whiteboard with students’ responses and feedback leading to the next stage of solution. For example, a topic on calculations and use of percentages may start with issues of discount sales in everyday life and introduce the concept of interest rate calculations. The two-hour class time would be used in reviewing and doing practical problems on the whiteboard and in students’ exercise books. It may be followed up by a group activity using newspapers or some other hands-on problem solving before the class interval. When the group reconvenes in the computer lab, the students would be shown the MCA section on percentages and would do interactive online exercises on calculating discount prices or working on percentage skills. Later students would be asked to investigate the cost of a home loan using an interactive online calculator from a link from the Learning Unit on percentages. Sometimes I used the Message
Board to post the problem to be solved and asked students to post their solutions back using the message board.

In this way, blending classroom learning on a topic with relevant online activities allowed me to extend the learning for both drill and practice and also for experiential learning and problem solving tasks. The continuous use of MCA Online environment during the semester with the same group of students allowed me to make closer observations of students’ use of selected online resources and gain an understanding of issues of teaching and learning mathematics with the help of web-based learning resources.

The experience of using the MCA Online environment in a blended teaching model indicated that student’s participation in learning improves when they use MCA Online with their regular classroom work. In fact, this particular group showed the lowest drop out rate for the year and many times students stayed back in class longer to continue to work on their problems on the computer. Direct links to interactive online activities from the MCA Online website allowed students to navigate easily and address the issue of being lost on the web and not being able to find the site that the teacher wants them to use.

Since the online learning environment did not monitor students’ access and use by an authentication (login) process, it was not possible to know out-of-class use of the website by this group of students. In terms of using the communication system, students used the Message Board more frequently than in the trials using the MCA module but there were very few postings initiated by students. Most postings were in response to the teacher’s problem task. The Online chat facility was not used, as the class did not seem interested in using it to discuss mathematics. This blended model of classroom use of MCA online learning environment showed a positive response from students in terms of their engagement and participation in learning activities. It also encouraged me to explore the affect of using MCA Online environment on students’ understanding and achievement in mathematics more closely. I also became interested in monitoring learners’ engagement with the online medium more closely because it promised to show the details of students’ access and use of the MCA
Online learning environment and how their performance and attitude towards mathematics changed by its use.

### 4.4 Review and Redesign

The implementation of MCA Online website during a period of one year where it was promoted and trialled using a module, embedded in the MLC as a computer based learning resource and blended in a mathematics classroom provided an opportunity to continually refine the content and design. Feedback from students and teachers and observation of classroom use of MCA online website tested our assumptions about the design and use of this environment.

The assumptions about the design of this learning environment and the apparent value of scaffolding students’ learning using links to interactive online activities appeared to be true (Gerber & Shuell, 1998). Data from students’ and teachers’ questionnaires and classroom observations indicated that navigation on the website was clear and easy. Students were able to use external links to interactive online activities successfully without being lost or distracted to other information on the web. Although the website kept a record of Message Board postings, it did not monitor students’ use of other sections and areas of the website. The website also could not show the pattern of student access to the learning environment from outside class hours. These observations confirmed our view that navigational scaffolding and direct links to interactive online activities assist in students’ successful experience in online learning environments.

The links to interactive online activities that provided immediate feedback to learners were well received by both teachers and students. Many online links allowed use of authentic learning experiences and real time data in classroom problem solving tasks (Bransford, 1990; Hoyles, Noss, & Kent, 2004). As anticipated in our design conjectures these interactive online learning activities were popular amongst students and appeared to enhance their confidence and understanding, but there was no measure used to determine a cause and effect association. There were some difficulties, as expected, in writing mathematics symbols and expressions for online tasks, but students were able to adapt to this new way of writing mathematics.
The MCA Online environment provided a means of asynchronous communication in the form of a Message Board and a synchronous communication facility as Live Chat, but both these systems were underused during the implementation. Technically, the communication platform was quite stable and did not require any special plug-ins or browser setting. But, students’ use of the Message Board remained confined to postings in response to teachers’ questions. The chat facility remained almost totally unused because both teachers and students did not show any enthusiasm for using it to talk about mathematics. The minimal use of Live Chat could be attributed to inherent difficulties in writing mathematics expressions on computers, the nature of learning and TAFE teachers’ reluctance to use chat systems. In terms of message board postings, the lack of postings may also be attributed to the teacher’s skills or lack thereof in soliciting and encouraging online dialogue. In our observations mathematics as a subject appeared less conducive to online community building through threaded discussions (Smith & Ferguson, 2005).

The conjecture about providing discipline specific content and links on the MCA Online website so teachers from these disciplines would be more willing to integrate the online learning environment in their classroom teaching did not materialise into practice as we found that many mathematics teachers did not have necessary computer skills to confidently integrate such an environment in their classroom teaching. However, there was an acknowledgement by teachers of the value of the MCA Online website in supporting mathematics learning. In addition, some departments also commented that the content on the MCA Online website was limited to basic mathematics learning and as such could only be useful as a refresher. However, as shown by the comments made by the Electro-technology department cited earlier in Section 4.3.2, it was possible to integrate resources provided by the MCA Online environment in a discipline specific learning website or platform. These observations led us to refine our conjecture regarding the effectiveness and use of an open access online learning environment to support mathematics learning in vocational education programs. As envisaged in design based research cycle (Figure 3.1) we proposed a redesigned and customised online learning environment that used the course content of particular vocational courses in developing the online learning environment. Our refined conjecture contended that this model of integrating and
blending MCA Online resources in vocational education courses could serve the mathematics support function while maintaining the context specific learning of a vocational or trade based teaching of mathematics.

4.5 Conclusion

This chapter has provided a comprehensive account of the context, conjectures and the process concerned with the design and implementation of an online learning environment in mathematics as the first cycle of this design based study. It has shown that the study emerged from the need of a TAFE department to improve its ability to support students from vocational education courses in their mathematics learning. A web-based learning environment, MCA Online, was developed in collaboration with two mathematics teachers to complement the learning support provided by a Maths Learning Centre in the department. In order to make mathematics teachers and students familiar with this new learning environment an induction module was written and workshops were held in five departments within the TAFE sector of the University. The MCA Online environment was also used in the Maths Learning Centre and in a blended learning format in a general mathematics class taught by the author.

The design, the development and the enactment process in the first cycle provided useful insights into building and using a web-based learning environment in mathematics classes. The design process brought to our attention a range of web-based interactive learning resources but also exposed the problems of writing mathematics content for the web-based environment. It also made it clear that mathematics teachers needed additional computer training in order to use the online learning environment effectively.

The implementation of the MCA Online website in various settings and our observations regarding its usability and effectiveness in attracting students to use it as a self directed learning environment led us to refine our conjectures and think about revising our approach to supporting students learning. The fact that students doing mainstream mathematics subjects did not respond to the services offered by the MCA Online independently, as tentatively anticipated in our conjectures, confirmed the
view that merely making technology based services available to students would not result in their appropriate and effective use. The implementation of the MCA Online website in the first phase of this study indicated the potential for its effective use in a blended environment where face to face teaching was supported and extended with the use of an online learning environment. These findings led to the second phase of this design experiment where a systematic study of blended online learning was conducted by supporting and extending face to face classroom based teaching of a business mathematics module with an online environment based on MCA online resources.


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


