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Can Blending Face-To-Face Teaching With E-Learning Support the Development of Phase 4 Apprentices in Mathematics? A Formative Evaluation Research Study.

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M.A. (Third Level Learning & Teaching) **2006**

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A thesis submitted to the Dublin Institute of Technology in part fulfilment of the requirements for award of Masters (M.A.) in Third Level Learning and Teaching

by

Peter Hinch

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DIT Learning and Teaching Centre, Directorate of Academic Affairs

Declaration

I hereby certify that the material which is submitted in this thesis towards the award of the **Masters (M.A.) in Third Level Learning and Teaching** is entirely my own work and has not been submitted for any academic assessment other than part-fulfilment of the award named above.

The material contained in this thesis may be used by future students provided that the source is acknowledged in full.

Signed……

Date……

Abstract

This thesis is a formative evaluation research study. Its purpose is to establish if blending face-to-face and e-learning delivery methods can support the development of Phase 4 apprentice plumbers in mathematics in the Department of Construction Skills in the Dublin Institute of Technology. The study also included the design, development and evaluation of a mathematics web site called Plumatics 4 U which is grounded in established theoretical criteria for effective blended delivery within third level education. This web site is currently in use by Phase 4 apprentice plumbers and is delivered through WebCT. The CD accompanying this thesis contains a short film giving an overview of the web site.

The research design used a mixed method approach combining both quantitative and qualitative data derived from questionnaires, interviews, non-participant observation and focus group sessions. The research, which lasted three months, involved forty Phase 4 apprentices, half of whom had the Leaving Certificate and the remainder the Junior Certificate as their highest second level educational qualification. Only one of the research group was female and their ages ranged from twenty to twenty-three years. A literature review was conducted covering areas such as formative evaluation of third level programmes, blended learning models, social constructivist approaches to learning and teaching and principles of effective web course design. Primary studies were used to inform the research process and identify a suitable methodology and methods of data collection.

The principal findings of the research indicate that Phase 4 student apprentices who took part in the blended learning module, and whose highest second level educational qualification is the Junior Certificate, showed a 10% improvement in examination results in questions with a mathematical content. The research also indicates that if Phase 4 students are to be offered the opportunity to participate in e-learning, additional resources will be required and staff will need to be trained in the use of the WebCT platform. The staff who deliver mathematics to this group believe that an e-learning site as a learning and teaching resource should be encouraged and fostered in the department.

Feedback from students who took part in the study shows that their experience of e-learning was extremely positive and that 84% would like to participate in this type of delivery method in the future. The feedback also indicated that the Plumatics 4 U web site would benefit from certain revisions such as the addition of more self-tests and the integration of a grading scheme for these self-tests.

The conclusions of this research show that teaching mathematics using a blended learning strategy can lead to improved student performance in examinations. Finally, it is recommended that the Plumatics 4 U web site be made available to other Institutes of Technology that deliver the Phase 4 plumbing programme.

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To the students who took part in the research and without whom this study could never have taken place I am extremely grateful. I would also like to thank Mr. Phil Murray, Head of the School of Construction; Mr. Seamus Murran, Head of Department of Construction Skills; and Mr. John Smartt, Assistant Head of Department (Plumbing, Heating and Refrigeration). A special word of thanks to the lecturing staff in the plumbing and heating section, especially Mr. Kevin Furlong, Mr. Tom McCormick, Mr. Tony Hayes, Mr. Michael Gleeson, Mr. Colm Shanahan, Mr. Paul Sherlock, Mr. Michael Nicholson, Mr. Michael McKeogh, Mr. Derek Cummins, Mr. Fergus McGuinness, Mr. Eamonn McDonnell, Mr. Stephen Nealon, Mr. Joe O'Toole and Mr. Jonathan Cussens.

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List of Abbreviations	
ADD	Attention Deficit Disorder
AHEAD	Association for Higher Education Access and Disability
APA	American Psychological Association
BERA	British Educational Research Association
CRA	Criterion-referenced assessment
DIT	Dublin Institute of Technology
ESF	European Social Fund
ETF	European Training Foundation
EU	European Union
FÁS	Foras Aiseanna Saothair (Training & Employment Authority)
f2f	Face-to-face
HEA	Higher Education Authority
HTML	Hypertext Markup Language
ICT	Information Communication Technologies
ID	Instructional Design
ISD	Instructional Systems Design
ISDD	Instructional Systems Design & Development
ITAC	Institute of Technology Apprenticeship Committee
LMS	Learning Management Systems
NRA	Norm-referenced Assessment
PDF	Portable Document Format
SAT	Systems Approach to Training
SCORM	Sharable Content Object Reference Model
SPSS	Statistical Package for the Social Sciences
UCC	University College Cork
UKOU	United Kingdom Open University
VLE	Virtual Learning Environments

WebCT	Web Course Tool
WWW	World Wide Web
W3C	World Wide Web Consortium
ZPD	Zone of Proximal Development

Chapter One

1.1 Introduction

The Irish apprenticeship system consists of seven phases alternating between on-the-job and off-the-job stages (Department of Education and Science, 2006). The on-the-job phases are numbers 1, 3, 5 and 7 while the off-the-job phases are numbers 2, 4, and 6. In the majority of crafts the duration of Phase 2 is 20 weeks while phases 4 and 6 are 10 weeks each. During Phase 2 the student apprentice attends a FÁS training centre, while phases 4 and 6 are delivered by the Dublin Institute of Technology (DIT) or another Institute of Technology. The current duration of an apprenticeship is four years, providing that all the phases are successfully completed within the required period. Any repeat examinations result in a longer time scale for the apprenticeship.

To be registered as an apprentice in Ireland, candidates '*must be at least 16 years old and have at least a grade D in any 5 subjects in the Junior Certificate'* (FÁS, 2006). Second level students in the Republic of Ireland have the option of taking two state examinations – the Junior Certificate and the Leaving Certificate. Second level students sit the Junior Certificate examination after three years and the Leaving Certificate after a further two years. Given the stated requirements, it can be seen that to be registered as an apprentice in Ireland there is no particular requirement regarding a minimum standard in any core subject such as mathematics or science.

There are twenty-six designated trades in the Republic of Ireland with 28,252 registered apprentices as of April 2005 (FÁS, 2005). A full breakdown of apprentices in each trade is contained in Appendix A. The trade of plumbing has four thousand registered apprentices which makes it the third largest of all crafts. As can be seen from Figure 1.1 below, the five trades of electrician, carpenter, plumber, bricklayer and mechanic represent 76% of all registered apprentices in the Republic of Ireland.

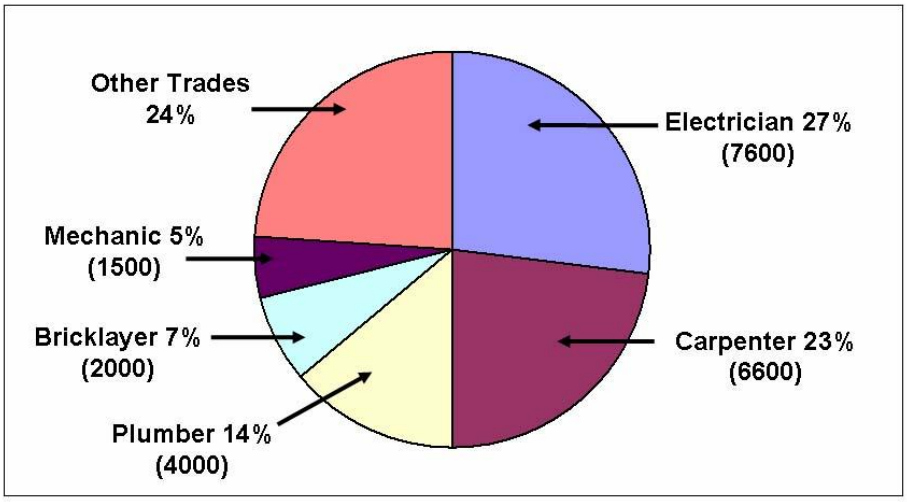

Figure 1.1 Registered apprentices in the larger trade disciplines in the Republic of Ireland.

Although 53% of all apprentices have a Leaving Certificate qualification the remainder would hold a Junior Certificate as their highest second level qualification (DIT, 2004). These percentages are representative of the total apprenticeship population and there is no breakdown of the number of apprentices in the different craft disciplines who hold either a Junior Certificate or Leaving Certificate. Interviews and questionnaires with 250 apprentice plumbing students who attend the School of Construction at the DIT have revealed that 60% hold a Leaving Certificate and 40% a Junior Certificate.

Despite these relatively large numbers of student apprentices in Ireland, it is interesting to note that there has been very little qualitative research carried out among apprentices, particularly in relation to their education (Goggin, 2004). To date, the majority of research studies have largely been quantitative in nature. This may be due to the large amount of data available from the major stakeholders such as Government Departments and the National Training and Employment Authority (FÁS), who have the responsibility of registering apprentices, monitoring their progress and implementing the *'statutory Rules of Apprenticeship in the designated occupations'* (Department of Education and Science, 2006). There has been important qualitative research carried out by the European Social Fund (ESF, 1999), O'Connor and Harvey (2001) and also by Field and O'Dubhchair (2001). However, in all cases the majority of qualitative

information was obtained from employers, professional associations, Government Departments and FÁS. To date, there has not been a qualitative research study carried out relating to the trade of plumbing and one of the primary reasons for this study is to remedy this situation. Creswell (1994) acknowledges that qualitative studies can be of use when little has been written about the actors and it is worthwhile listening to what they have to say.

1.2 Context of the Research

I have been involved in the education of apprentice plumbers as a lecturer since 1982. In that time I have had contact with hundreds of students. My involvement with Phase 4 apprentices has primarily been over the last five years and during that time I have become increasingly aware of the difficulties some apprentices have with mathematical calculations. One hundred and forty-four Phase 4 plumbing apprentices attend the Department of Construction Skills in the Dublin Institute of Technology each year. The majority of the students in the classes I teach are Phase 4 and Phase 6 apprentices. They often express a wish to continue their studies within higher education and in particular they would like to reach degree standard. I believe we as teachers should encourage and support them as much as possible in order that they achieve their goals.

It is important to outline how apprenticeship has developed in an international context and how it has been adapted and changed in the Republic of Ireland to reflect improved practice in the education system. It is also important to show how Institutes of Technology have a key role to play in effecting change. This section will outline the unique place that apprenticeship occupies within the third level educational framework in Ireland, and will argue that it is in the interests of these institutions to continue to foster, embrace and encourage this system.

Heraty *et al.* (2000) outline how apprenticeships have developed from the Guild systems of the eleventh century. Ní Cheallaigh (1999) believes that apprenticeship '*is the original model of internationalisation*' (p.1). This argument is based on the fact that qualified craftspersons can travel throughout the world and have their skills and qualifications recognised. It is often the case that language may not be a barrier when practical hands-on skills are required to successfully carry out an operation. For example, for many years, architects and designers have used symbols and characters to identify the various services within a building. These symbols are agreed internationally and understood by craftspersons without the need to interpret language.

Although apprenticeships are recognised and legislated for by governments throughout the world, their development has had the most impact within the European context. However, it is arguable whether this has always been conducive to the development of crafts and trades. For example, in Eastern European countries apprenticeship was strongly promoted while socialist regimes held power, but since the fall of Communism there has been a decline in this form of training and with the exception of Hungary, Lithuania and Slovenia, there is little evidence that this trend is changing (Ní Cheallaigh, 1999).

The European Training Foundation (ETF) is the European Union's centre of expertise supporting vocational education and reform in third countries. Its research has shown that Central and Eastern European countries are still in the process of identifying answers to the problems and challenges associated with vocational education and training. As a result of independence, between 40 and 60% of the total budget available for training is no longer available (European Training Foundation, 2004). The reasons for this are somewhat disturbing and are identified by ETF (2004, p.74) as lack of political consensus and, at civil service level, a lack of experience combined with an unwillingness to initiate reform and corruption. However, in the European countries not affected by relatively recent political upheavals, apprenticeship systems are changing, growing and expanding. The main catalyst driving these changes has been the development of the 'dual system' which originated in Germany. Within the dual system apprentices experience work-based training with employers and also attend training and/or educational modules in off-the-job locations. In recent years this method has been adopted by many countries including Austria, Denmark and Ireland (Ryan, 2000).

The earliest form of apprentice regulation in Ireland dates back to 1898 with the enactment of the Agricultural and Technical Instruction (Irl) Act. Following Apprenticeship Acts in 1931 and 1959 the next major reorganisation occurred with the introduction of the standards-based system in 1992 (Heraty *et al.* 2000). Following a slow start, recruitment into the new system grew rapidly as indicated in Figure 1.2.

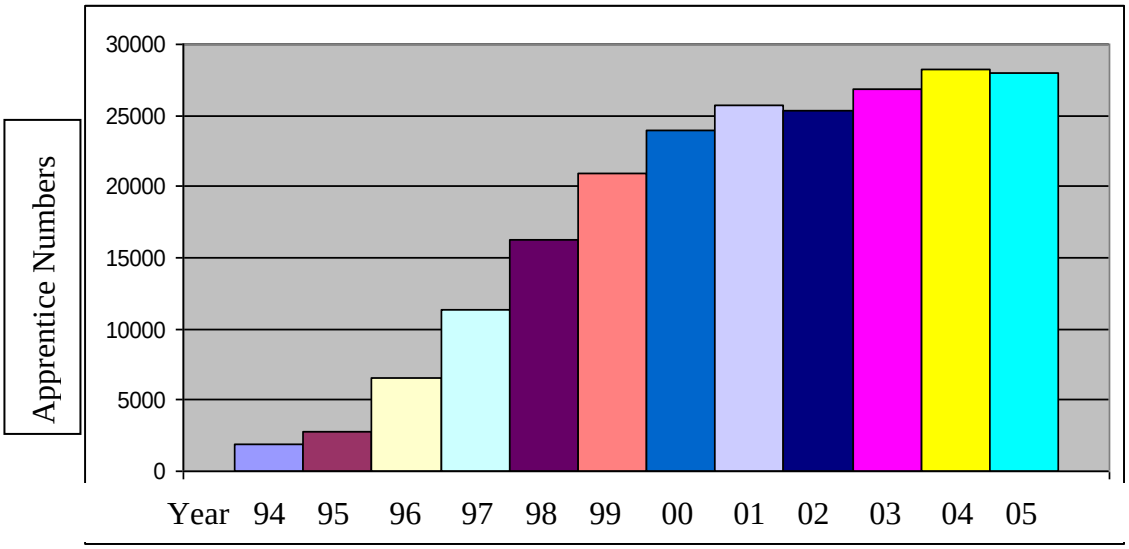

Figure 1.2 Registered apprentices from 1994 to 2005. (FÁS, 2004; FÁS, 2005)

By December 2004 the number of registered apprentices in the Republic of Ireland had risen to almost 28,000 (FÁS, 2004). The Skills Monitoring Report (2003) forecast that there will be a decline in many crafts by the year 2010. However, the report also suggests that the decline in the number of plumbing apprentices will be modest compared to that in other crafts. The success of the Irish system is self-evident from these figures, but what makes it unusual is that it arose from social dialogue between unions and employers rather than government initiatives (Field and O'Dubhchair, 2001). What is also interesting is the fact that 53% of those entering apprenticeships have a Leaving Certificate qualification (DIT, 2004).

Where exactly apprenticeship falls within the educational, vocational and training fields is a matter of considerable debate (Ryan, 2000). Apprentices in Ireland are governed by the statutory Rules of Apprenticeship and are guaranteed a minimum of forty weeks training and education in off-the-job locations (Department of Education and Science, 2006). This is divided into three blocks, the first of which is of twenty weeks' duration followed by two of ten weeks each. During the first off-the-job Phase most apprentices attend a FÁS training centre. The two subsequent off-the-job Phases are delivered by Institutes of Technology including the Dublin Institute of Technology. This means that the apprentices who attend the third level institutions are usually mature adults in their

early twenties who are in the later stages of their chosen profession. Apart from the traditional skills and knowledge required within each trade or craft, the educational system has a responsibility to help students develop key skills that are essential to knowledge-based economies, such as entrepreneurial and risk-taking attitudes as well as moral and civic qualities (OECD, 2005). In line with OECD recommendations, it has been announced that the day-to-day responsibility for institutes of technology in Ireland is to be transferred to the Higher Education Authority (Hanafin, 2005). This shift in emphasis towards a knowledge-based economy, where lifelong learning and knowledge transfer are now seen as paramount, places Institutes of Technology at the forefront of this challenge. When apprentices qualify as craftpersons, it will be essential to offer them opportunities in further education, which will naturally benefit the economy.

In the National Framework of Qualifications, qualified craftpersons attain a level 6 standard when they are awarded the National Craft Certificate (NFQ, 2006). This puts them one level below the Ordinary Bachelor Degree standard. The framework relates all education and training awards to each other and is described as learner-centred and is shown below.

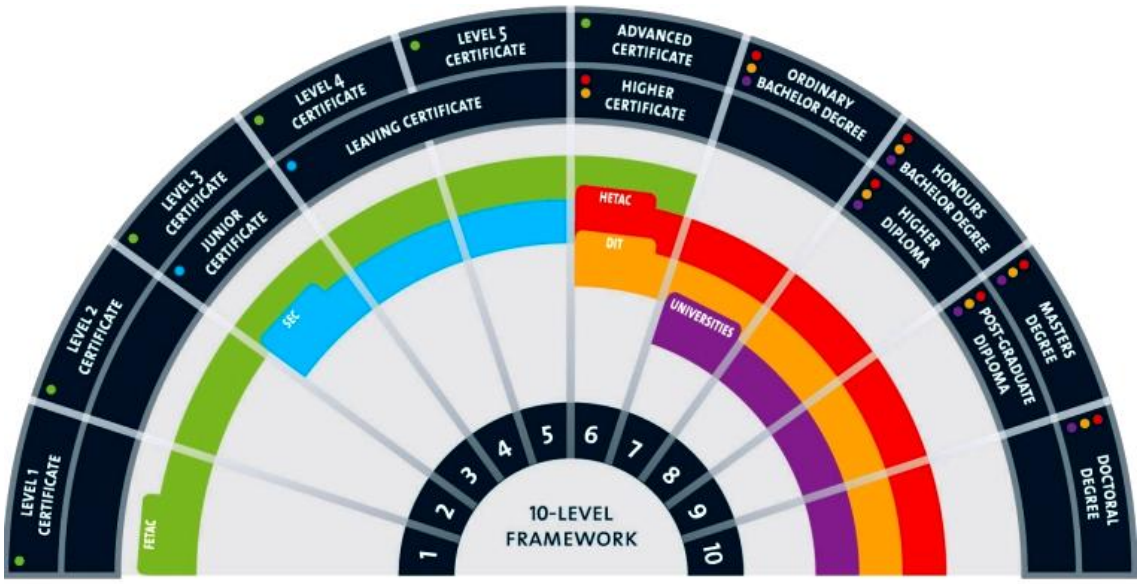

Figure 1.3 The National Framework of Qualifications.

Within the context of lifelong learning, it is argued that there is both a moral and social responsibility to offer qualified craftpersons a way to achieve such qualifications should they so wish. The evidence to support this argument is obvious when one considers the definition of apprenticeship as stated by Government, which is as follows:

> *Apprenticeship is a method by which a person works for an employer in a chosen occupation and learns the necessary skills, knowledge and attitudes to become a qualified craftsperson.*
> (Department of Education and Science, 2006).

The apprenticeship system in Ireland has been completely revamped within a relatively short timeframe, but unless it offers progression opportunities for graduate apprentices, the revised standards based system will not have achieved its true potential. This situation has already become apparent in the UK where, due to inaction on the part of traditional universities, *'graduate apprenticeships are to be designed jointly by national training organisations and universities or colleges in four pilot sectors'* (Ní Cheallaigh, 1999, p. 9).

I believe student apprentices need to be supported on two fronts. Firstly, there are those who fail their examinations. Within the apprenticeship system, any student who fails an examination cannot repeat it during the Phase. This means that the apprentice must repeat the examination at the end of the next Phase which occurs after they have returned to their employer. An analysis of the results of 768 Phase 6 apprentices shows that 39% have to repeat examinations (DIT, 2006a). To assist students who find themselves in this situation, myself and another lecturer run weekly revision classes on a voluntary basis. There is, however, a difficulty for students who are remote from the college and cannot travel to these classes. A possible remedy for this situation may be the development of an e-learning resource to support such students. The research which is the basis of this study may lead to interventions that will help students who need to repeat examinations.

The second area of support for apprentices is in helping them to further their education within their chosen craft. Unfortunately, there are very few programmes available within the craft sector which offer the opportunity for progression to students upon completion of their apprenticeship. However, one of the few successes in further education of this sort has been the introduction and development of an advanced plumbing programme In the Dublin Institute of Technology within the Department of Construction Skills. I have been involved in the design and development of this two-year programme which is the only course of its type available in Ireland and there is currently a waiting list of applicants keen to take up places (Department of Construction Skills, 2006). The success of this course shows the need to provide educational programmes for apprentices to enable them to achieve their full potential both as crafts persons and as individuals.

1.3 Rationale for the Study

The success of the Irish standards-based apprenticeship system is well evidenced by the increased number of registered participants as shown in Table 1.1 below.

Year	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Apprentice Numbers	1881	2762	6555	11371	16307	20893

Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Apprentice Numbers	23923	25675	25299	26845	27935	28252

Table 1.1 Registered apprentices from 1994 to 2005 (FÁS, 2004; FÁS, 2005).

Indeed, the European Social Fund has noted that there is a high satisfaction rate among all the stakeholders i.e. employers, apprentices and their families (ESF, 1999). However, there are weaknesses within the system that need to be highlighted and addressed. As previously mentioned 53% of apprentices have a Leaving Certificate qualification. Bearing in mind that this is the highest standard of second level education in the Republic of Ireland, it follows that the majority of this cohort could potentially be entitled to a place within any of the third level institutions. A problem remains regarding the 47% of apprentices who do not have this level of education, many of whom have difficulties with, for example, mathematics.

When the apprenticeship system was reorganised in 1992 the educational standard for registration was raised from three passes in the Junior Certificate to five. However, there is no stipulation regarding the necessity to achieve a minimum standard in any core subject. In reality this means that many apprentices would not have achieved a pass standard in subjects such as mathematics. Nevertheless, such people can, and do, gain entry to the apprenticeship system and as a result struggle to come to terms with the mathematical standards pertaining within a craft. Weaknesses such as this have been identified as *'quality assurance'* issues by Field and O'Dubhchair (2001, p.254).

Informal discussions with FÁS instructors from several training centres and college lecturers from various Institutes of Technology confirm the difficulty that a significant number of apprentices have with mathematics across a wide range of crafts. Many apprentices openly admit that they find it extremely difficult to come to terms with this element of their education and often ignore mathematical questions in examinations. This can mean that in order to pass a test they have to strive to achieve correct answers in all other questions should they fail or ignore just one with mathematical content. This leads to another problem unique to apprenticeship, which is progression.

Within the standards-based system, if an apprentice fails to reach the necessary standard, he or she must retake the examination. This situation is compounded further by the fact that apprentices in phases 4 and 6 are only allowed one attempt per phase at each test. Some crafts have as many as ten examinations which cover both theoretical and practical aspects of a course. Apprentices who fail examinations in June will not have the opportunity to retake them until December, during which time they return to their employers and their apprenticeship is effectively frozen until they pass the tests. Unfortunately there are very few revision classes offered by the Institutes of Technology to help apprentices who fall into these situations.

The main thrust of the rationale behind this study is the perceived shortcomings in current mathematical education for apprentices. This area has been of interest to me for some time and I have, over a period of several years, undertaken a variety of initiatives in an effort to support apprentices in overcoming their difficulties in mathematics. For example, I developed a booklet with explanations, examples and exercises pertaining to the various calculations that Phase 4 apprentice plumbers are expected to understand and complete. This initiative had limited success because the apprentices had to work through the booklet independently and in their own time; when they required assistance it was not immediately available. Also, it proved less successful for those who were back with their employers and who needed learning support whilst awaiting the opportunity to sit repeat examinations. Another initiative was a study workshop twice weekly after classes. One evening session was dedicated to Phase 4 apprentices while

the other was for those attending Phase 6. Again this proved useful to those attending courses and while a small number of those awaiting repeat tests also came, I still believed that further improvements could be made.

A review of relevant literature and my own experience as an online student on the Postgraduate Programmes in Third Level Learning and Teaching has led me to believe that a blended delivery of face-to-face (f2f) learning combined with relevant online course material would make a genuine contribution to solving the difficulties that apprentices currently experience relating to craft mathematics calculations. There are many definitions of blended learning in the literature. Wilson and Smilanich (2005) state that *'blended learning generally means the application of two or more methods or solutions to a learning need'* (p. 12). Thorne (2003) offers a broader definition describing blended learning as *'an opportunity to integrate the innovative and technological advances offered by online learning with the interaction and participation offered in the best of traditional learning'* (p. 3). Within the context of this research study the definition of blended learning most applicable would be similar to that offered by Rossett *et al.* (2003) who believe that *'options for blended learning go beyond the classroom. They're formal and informal, technology and people-based, independent and convivial, and directive and discovery-oriented'* (p.1). I believe that apprenticeship education is best suited to social constructivism where collaboration and interaction are fundamental to the learning process. I therefore believe that a blended learning strategy should be broad enough to offer students as many opportunities to learn as possible.

By developing a web-based learning module to complement the existing classroom mathematics, I believe that apprentices who experience difficulties in this area can be better catered for. Such an e-learning mathematical programme specifically designed to meet the needs of, for example, plumbing apprentices, would not only complement classroom activities but also allow students to work at their own pace and, if necessary, remote from the face-to-face learning environment. Online activities can offer the opportunity for students to work on their own or collaboratively. Barkley *et al* (2005, p.25) believe that collaborative learning *'puts into practice the major conclusions from*

modern cognitive learning theory' such as acquiring, remembering and using knowledge. This means that students can take control of their own learning, but while this process is taking place they have a support structure available to them within a college environment.

A blended learning approach of traditional classroom lectures combined with online activities can offer a number of benefits such as allowing students to work at their own pace and at a time that suits them. In discussing blended learning Thorne (2003) states that *'the whole philosophy of self-managed learning provides individuals with choices about how and where they learn'* (p. 71). However, there may be some drawbacks associated with the online component, such as assuming that the students will access the content and apply the knowledge, or overestimating what online learning can accomplish. To help overcome problems such as these the designer / tutor must ensure that the content is relevant, well presented and that the student understands how to access the material. Wilson and Smilanich (2005) recommend that both a needs assessment and needs analysis be carried out to determine the validity of a programme or course. Finally, there must be a support structure in place to answer student queries and also offer help and feedback. Therefore considerable thought must be given to the design of online materials to ensure that the needs of students are catered for.

Such a resource would benefit those in attendance at the college and also those apprentices who have returned to their employer and are waiting to repeat examinations. By utilising an online resource, student support is available in two forms: firstly, in formative feedback built into the web site, and secondly through discussion boards between students themselves and a course tutor via email. Laurillard (1993) believes that if students are to achieve a high level of competence they should not be expected to supply additional supports for themselves, and furthermore states that the whole point of new technology is to improve the quality of teaching and learning.

To strengthen the basis for the rationale of this study, I have analysed the examination results of ninety-six Phase 4 apprentice plumbers. The results were as follows:

Apprentices with Leaving Certificate maths	60%
Apprentices with Junior Certificate maths	40%
Apprentices with Leaving Certificate who have difficulty with maths questions	10%
Apprentices with Junior Certificate who have difficulty with maths questions	39%
Number of maths questions analysed	288

Table 1.2 Analysis of examination results for Phase 4 plumbing apprentices

As part of the needs analysis for this study a survey was conducted amongst a group of eighty apprentices in the Dublin Institute of Technology (DIT), Bolton Street between April and June 2005. The results indicated that over 80% would be interested in participating in e-learning. With such a high number expressing interest, and bearing in mind that up to 39% of student apprentices need to repeat theory examinations (DIT, 2006a) I would argue that there is an onus on the teaching staff to respond to their needs. The survey also showed that 74% of students had access to the Internet at home. In interviews and questionnaires conducted between April 2005 and March 2006 with two hundred and fifty apprentice plumbers in the School of Construction, the majority (80%) indicated that some form of additional support would be appreciated and is indeed required, not only in relation to mathematics but in many other areas also.

1.4 Aim and Objectives

The aim of this study was to explore support mechanisms for student apprentices and evaluate their effectiveness. This involved the development of an e-learning resource using the WebCT platform to offer Phase 4 plumbing apprentices, who have not attained a Leaving Certificate qualification in mathematics, an additional means of mastering mathematical material. Through this, they experienced independent learning on problems associated with plumbing and mechanical engineering.

A formative evaluation research strategy was used where the process of delivering the teaching of mathematics in a blended learning environment was explored. The purpose was to seek improvement to a specific programme while being sensitive to those who participate in the study (Patton, 1990).

The objectives of this research study were:

- To determine whether a blended approach of teaching mathematics to Phase 4 apprentice plumbing students improves their performance and examination results;
- To ascertain if student apprentices view this blended approach as useful and helpful;
- To determine if apprentices within the study group find the online content relevant and challenging;
- To find out if staff who teach mathematics at this level believe a blended approach is successful;
- To clarify that the resources currently available are sufficient for this approach.

1.5 Delimitations

One of the major prerequisites when carrying out a research project is the need to be aware of the depth of treatment required and the work-load involved. Within any study there is a danger in trying to conduct too many interviews, analyse too many questionnaires or, possibly, work with too big a target group. Any of these pitfalls could lead to a very broad project where the researcher is in danger of sacrificing quality for quantity. Every piece of research has its limitations, and it is important not only to be aware of them but to acknowledge them (Robson, 2002). Within research generally, time and finance may also be constraints.

Having considered all relevant issues, the boundaries of the study needed to be established at an early stage. Initially, a quantitative analysis of examination results relating to mathematical questions was carried out. A decision as to how far back in time this analysis should go was required. Another area of concern related to the number of students and staff to be interviewed. Since the research method here is qualitative, a very large number of interviews would produce a vast amount of information, far too complex to analyse appropriately.

As this study incorporates comparative analysis, the size of the participating group was also crucial. For the findings to be valid, and any recommendations to be considered, it was essential that the research be carried out among a group reflecting the actual class number within the educational system. My original intention was to select a group of sixteen students because this is the recommended class size for apprentices and also the number of computers in the laboratory. However, within the three groups of Phase 4 apprentices there were twenty five suitable for inclusion in the research. Having discussed this matter with the assistant Head of Department, it was decided that all three groups would take part in the study and arrangements were made to cater for this situation. This meant that there would be a mix of students with both Junior Certificate and Leaving Certificate who would participate.

Increasing the number of students in the study added an extra dimension to it. One of the primary benefits was that it did not overtly target or identify students who might be considered weak in terms of their mathematical abilities because every member of the class had the opportunity to participate. Another benefit was that those students who had a Leaving Certificate qualification had the opportunity to give feedback regarding the e-learning resource.

Finally, one of the principal factors that must be kept in mind when carrying out research is the fact that it is a bounded system (Cohen *et al*., 2000; Merriam, 1998). Therefore, the very nature of a study enforces certain constraints on the researcher and the process. This matter will be covered in more detail in Chapter Three.

1.6 Research Ethics

Every piece of research that involves communication with students and staff and access to institutional records will incorporate an ethical dimension. Indeed, Cohen *et al.* (2000) believe that ethical concerns in educational research are extremely complex, and Hart (2005) makes the valid point that ethics and standards impact into many areas of research which may not involve human contact. For example, there may be ethical implications associated with literature reviews, interpretation of results and presentation of findings. Researchers must make themselves aware of the ethical principles and codes of practice that impact within areas of investigation because '*lack of awareness or misunderstanding of an Ethical Standard is not itself a defence to a charge of unethical conduct*' (American Psychological Association, 2002, p.2). Merriam (1998) takes this one step further by stating that

> *although researchers can turn to guidelines and regulations for help in dealing with some of the ethical concerns likely to emerge in qualitative research, the burden of producing a study that has been conducted and disseminated in an ethical manner lies with the individual investigator.*
>
> (Merriam, 1998, p. 219)

The Dublin Institute of Technology (DIT) has its own Research Ethics Committee which offers advice and guidance *'on all matters pertaining to the ethics of postgraduate research'* (DIT, 2006b, p. 2). The procedures state that all research proposals must be submitted to the Ethics Committee for approval with the exception of undergraduate and taught postgraduate research projects. As this study comes under the latter situation it was not necessary for me to submit an application for approval. However, I did write to the Head of School, Head of Department and Assistant Head of Department informing them of my research and sought their approval prior to the commencement of any fieldwork. A copy of this letter can be found in Appendix C.

In addition to its own guidelines, the DIT Ethics Committee also refers applicants to the Declaration of Helsinki (DIT, 2006c,) and provides a link with relevant extracts from the declaration on their web site to assist researchers. Another source of guidance for those involved in educational research is the 'Revised Ethical Guidelines for Educational Research (2004)' produced by the British Educational Research Association (BERA). These guidelines outline in great detail the responsibilities of those who undertake research in this field. They also make the interesting point that *'educational researchers must protect the integrity and reputation of educational research by ensuring they conduct their research to the highest standards'* (BERA, 2006, p. 12).

Prior to the commencement of the fieldwork for this study, it was necessary to obtain student consent even though the group consisted of volunteer candidates only. This initially involved speaking to the participants and subsequently obtaining their written agreement. Students were also informed about the need to participate in focus groups and also to complete questionnaires on completion of the study. To ensure that the students who took part in the research understood that they were free to withdraw at any time, I drew up an ethics statement which can be seen in Appendix D. This document was given to each student and the reasoning behind it was also explained. I was anxious to ensure that students were fully aware of their rights as participants in the research and that if for any reason whatsoever they wanted to withdraw from the study their wishes would be respected. The ethics statement was signed by each individual student and myself at that time.

Confidentiality was also an important issue. It was not sufficient to say that this was guaranteed as this statement needed to be qualified. For example, if findings are published and no names mentioned, it may still be possible to identify individuals or small groups (Bell, 1999; Robson 2002). Staff who deliver mathematics to Phase 4 apprentices would fall into this area (being few in number), so care was required regarding the construction of interview questions.

During this research I was conscious that those taking part were potentially vulnerable and as a lecturer within the college I held a position of authority over the students. To gain the trust of the students I made a decision not to correct or assess any test or examination that they completed whilst on the Phase 4 programme. This is in line with the BERA guidelines, section 22 page 8.

Having taken all of the above into consideration I believe that every effort has been made to ensure that this research is of the highest possible ethical standard and that at no time was any person compromised or any information misrepresented.

1.7 Outline of Chapters

In Chapter One an outline of apprenticeship in both an international and national context has been provided together with a detailed explanation of the rationale for this study. This section also set out the aims and objectives associated with the research and the delimitations imposed upon it by time constraints and group size.

The literature review in Chapter Two discusses the area of e-learning and learning technologies have impacted upon the field of third level education. As this research included the design of a web site specifically dedicated to mathematics for plumbing apprentices, this chapter also explores the area of web based curriculum design. This web site, titled Plumatics 4 U, contains fifty pages of interactive content with one hundred and twenty sample questions and it is currently live on the WebCT platform within the Dublin Institute of Technology. WebCT has been heralded by its vendor as one of the world's leading providers of e-learning serving thousands of colleges and universities in more than seventy countries worldwide (WebCT, 2006). The interactive content is designed to complement the classroom activities that form a major part of the Phase 4 apprentice plumbing programme. A selection of screen shots from the Plumatics 4 U web site are shown in Appendix B and a short film giving an overview of the site is also available on the accompanying CD-Rom.

Chapter Three outlines the research design, theoretical perspective, methodology and methods which were employed during the study. The research used qualitative and quantitative methods of data collection from current Phase 4 students and also from students who have completed this stage of their apprenticeship. The qualitative methods consisted of observation, interviews and focus group sessions; the latter was with both students and staff. Quantitative data was obtained from questionnaires and examination results. The use of a mixed method approach offered the opportunity for triangulation which is necessary for the findings to prove meaningful, generalisable and repeatable.

Forty Phase 4 student apprentices took part in the research and were timetabled one hour per week in the computer laboratory. They also had access to the password-protected web site from any computer connected to the Internet. On completion of the Phase 4 programme, plumbing apprentices sit three theory examinations which include mathematical calculations similar to the examples and questions on the Plumatics 4 U site. In the apprentice plumbing curriculum, mathematics is totally integrated within the three theory examinations and is not a separate paper. On completion of the final examinations a comparison was made of the results of students who took part in the formative evaluation research study with those of students from previous intakes who did not. These results are presented in Chapter Four and show that those who took part in the research had a 10% improvement in mathematical questions when compared to groups from previous intakes who were not part of the study. This chapter also analyses the results of two focus groups, one which consisted of participants from the study and another made up of lecturing staff in the plumbing section who deliver the mathematical content of the programme. A detailed discussion of the findings is presented in Chapter Five which uses the aims and objectives of the study as a frame of reference to interpret the results.

The final chapter presents the conclusions of the research study and makes a number of recommendations which could enable further e-learning resources to be developed in the department. Such resources could support student apprentices in their learning and in particular those who may have a weakness in areas such as mathematics. A blended approach using face-to-face and e-learning can lead to a student centred approach to learning because the onus is on the student to access the material on their own and at their own time. One of the advantages of e-learning is that the student works at his / her own pace and not at a pace dictated by the lecturer. Resources such as the Plumatics 4 U web site could also be made available to other Institutes of Technology and academic staff who might find it useful.

1.8 Summary

This chapter has outlined apprenticeship in both a national and international context and explained how the Irish standards based system has developed since the early 1990s. It has also shown where apprenticeship fits within the National Framework of Qualifications, which is a ten level system, allowing learners to compare and contrast qualifications and to plan their education, training and career progression. The rationale for this formative evaluation research study is to determine if blending face-to-face and e-learning delivery methods can support the development of Phase 4 apprentice plumbers in mathematics and lead to improved examination results.

The aims and objectives have been clearly set out to take account of the relevant stakeholders who are the student apprentices and the teaching staff. The study also sought to clarify if the resources currently available within the department are sufficient for blended learning, given that access to the Internet is an essential component. The delimitations of the study were presented and show how the number of students who participated in the research was determined. Finally, the issue of research ethics was discussed with particular reference to the guidelines produced by the British Educational Research Association (BERA). The areas of confidentiality, consent, and the right to withdraw from the research were highlighted and an ethics statement was also drawn up for student participants.

Chapter Two

Review of the Literature

2.1 Introduction

While there is a small but significant body of literature relating to apprenticeship in the Republic of Ireland (Field and O'Dubhchair, 2001; O'Connor and Harvey, 2001; Heraty *et al.* 2000; Ní Cheallaigh, 1999) there is almost no reference to the issue of educational support. This is acknowledged by Goggin (2004) who states that *'research into apprenticeship in Ireland has always been limited, particularly in relation to apprenticeship education'* (p. 6). Furthermore, regarding the area of mathematics, an exhaustive search of the literature fails to yield any information or studies relating to an Irish context. There are, however, several references to teaching mathematics via information communication technologies (ICT) that will be dealt with in this chapter.

This research study impacts on several key areas, the most important of which is the evaluation of an e-learning mathematics web site for apprentices as part of a blended delivery strategy. This chapter will explore strategies that can be used in designing and developing an e-learning resource with particular reference to mathematics. It will also critique several areas that impact on a blended approach to delivery such as face-to-face teaching, student support and programme design. The opening section looks at how information communication technology (ICT) has impacted into the field of third level education and how this technology has developed over time. This is followed by a review of situated cognition, a discussion of the various models applicable to e-learning and an analysis of how a social constructivist approach to learning is best suited to apprentice education.

The second part of this chapter explores what the literature tells us regarding strategies that can be adopted during the design of an e-learning module and how these practices have been integrated into the Plumatics 4 U WebCT mathematics module which forms the basis for this formative evaluation research study.

2.2 E-learning and New Technologies

The term 'new' technology is relative. At what stage does technology cease to be new and become established? Saljo (1999) points out that humans have been using technology since the dawn of civilisation and it is in our nature to constantly improve, change and learn as needs dictate. These technologies have primarily been tools but when associated with communication and learning they take on a new dimension. One of the earliest forms of communication technology was writing. This proved more reliable than speech which not only relied on face-to-face interaction but was also more likely to become distorted over time.

Education is principally about communication and for centuries the tradition of teacher and pupil interaction within the classroom was the predominant environment of learning. With the increasing availability of printed material and resources a new dimension to learning evolved. The opportunity for distance education arrived in the mid-nineteenth century with the development of a new technology – the postal service. It was no longer necessary for those seeking knowledge to physically attend a school or classes.

By the 1920s the new technologies of radio and film were being utilised to educate and train people. From the 1940s onward television has been used successfully as a medium for open and distance learning. The United Kingdom Open University (UKOU) is one of the success stories of distance learning by television broadcast. The UKOU broadcasts about twenty hours of programmes per week. Daniel (1996) points out that the highest annual enrolment on any single UKOU course module is 9,000 whereas there are about one million 'hard-core' viewers of the University's programmes. One of the major reasons for this is that many UKOU programmes are broadcast at reasonably popular viewing times. It is also part of the UKOU charter to promote the educational well-being of the community generally.

By the mid-1980s computer technology was developing at an impressive rate and a new innovation, the CD-Rom, entered the market place. Many felt that this was the opportunity for training and education to take a significant leap forward. However, within a decade it was beginning to be acknowledged that CD-based learning was not living up to expectations (Cross, 2004). Rosenberg (2001) cites the reasons for this failure as the differences in hardware, software and programming languages. Even those who produced materials on floppy disks were unprepared for the change from 5 ½" to 3½" format, and the incompatibility of Apple, UNIX and IBM machines further complicated the issue.

By the turn of the current century serious questions were being asked regarding what was now called e-learning, a term coined by Jay Cross in 1999. These related to the methods used in computer-based education and the need to link established pedagogical theories with this form of education (Jung, 2001). A particular problem was that computer language and programming were so complicated and specialised that only those who had these skills could write the material and often they did not possess the expertise or knowledge required to write appropriate educational content. Mason (1998) correctly sums up this era of e-learning by stating:

> *Painful as it is to remember, most of the first online courses were delivered in command-line systems which required skill and patience from even the dedicated user, let alone the intrepid novice.*
>
> (Mason,1998, p.3)

Thorne (2003) believes that a lack of understanding of the technology and pedagogy resulted in early attempts at e-learning as *'nothing more than taking text from a book and putting it on a screen'* (p. 32). Significantly, by this time the Internet and World Wide Web (WWW) were revolutionising the whole area of communication. The challenge now was to establish how these resources could be incorporated into worthwhile educational programmes that satisfied the needs of learners. However, by this time there was another obstacle to overcome i.e. the educational institutions themselves. Sax (2003) believes that many academics were uncomfortable with the concept of e-learning and felt that this new technology failed to embrace the humanistic

and spiritual values traditionally associated with third level learning. Within a period of thirty years the technological advances had been so rapid that the educational community could not keep up with the changes needed to integrate them into curricula. However, the technology was here to stay and some means had to be found to integrate it into the field of education.

2.3 Situated Cognition

Situated cognition, also referred to as situated learning, is a theory which *'shifts the focus from the individual to the socio-cultural setting and the activities of people within that setting'* (Driscoll, 1994, p. 156). Situated cognition suggests that when individual learners participate in communities of practice they master new skills by sharing their understanding. Brown *et al.* (1989) are often credited with developing situated cognition or situated learning theory. However, Greeno (1997) suggests that the concepts and ideas associated with situated cognition can be traced back over 100 years to the work of Dewey and Vygotsky.

Lave and Wenger (1991) write about apprenticeship in a global, holistic sense that goes beyond the traditional craft skill area and state that *'the historical significance of apprenticeship as a form for producing knowledgeably skilled persons has been overlooked'* (p. 62). Concepts such as this have led to the development of what is termed 'cognitive apprenticeships' where knowledge, skills and competences are developed within communities of practice. This methodology is applied within the Irish standards-based apprenticeship system whereby student apprentices work in teams or communities during both their on-the-job and off-the-job phases. While working on the job with their employers, apprentices are teamed with qualified craftspersons or senior apprentices who instruct and demonstrate relevant techniques that are essential if learners are to progress. This concept is also utilised in the off the job phases in the Institutes of Technology. For example, plumbing apprentices attending Phase 4 are examined in project work that is carried out in groups of two, three and four.

This research study found, in the observation carried out in the computer laboratory, that apprentices collaborated with one another in increasing numbers as the study progressed. Mentis *et al*. (2001) take this one step further and have established that *'situated cognition and Vygotskian thought contribute to our understanding of how to create vibrant and authentic on-line communities'* (p.1) and furthermore outline how these principles apply equally to traditional educational settings as well as e-learning communities. Oliver (1999) believes that situated cognition fall within the social constructivist paradigm and this concept will be further developed in section 2.6 of this chapter.

2.4 Models of E-learning

The literature informs us that e-learning falls into three broad areas. Firstly there is full distance learning where the student studies completely alone and receives communication only from a course tutor. This model developed at a time when distance learning was almost exclusively paper-based and relied on postal deliveries. Mason (1994) believes that this form of delivery is almost completely obsolete and is now only a matter of *'historical debate'* (p.22). The second model involves collaboration and communication between students themselves and also between students and tutors. This is now the most widely used method of e-learning (Rashty, 2005). While this model will often include face-to-face meetings and discussions among participants, much of the interaction occurs through discussion boards usually in asynchronous communications. The third model uses a blended approach of combining face-to-face delivery and e-learning material as a teaching method. Blended learning is not just a mixture of these different elements. Procter (2003) describes it as the effective combination of different modes of delivery, models of teaching and styles of learning. However, care and caution at the design stage are important because there is always the temptation to overwhelm the learner with content and offer too many choices (Bonk *et al*, 2002). Another difficulty relates to the lack of training, time and interest of academic staff in relation to developing e-learning materials (Sloep, 2003). Simply

uploading lecture notes onto the internet does not constitute developing a genuine e-learning curriculum.

2.5 Laurillard's Conversational Framework

Academic learning is a complex phenomenon that involves interaction between student and teacher. Laurillard's conversational framework is a twelve step process *'intended to be applicable to any academic learning situation'* (Laurillard, 1993, p. 102). This framework is described as being discursive, adaptive, interactive and reflective (Milton and Lyons, 2003; Shortridge, 2005) and hinges upon the concept of placing various forms of technological communication tools within tables that enable comparisons to be made. Many academics believe that this framework offers a sound pedagogical foundation upon which to design and build educational programmes and describe it as a teaching and learning model (Heinze and Procter, 2004).

However, there is a body of opinion developing which now suggests that Laurillard's conversational framework *'is better seen as a model of teaching strategy rather than a theory of teaching and learning'* (Milton and Lyons, 2003, p.304). This view is echoed by Gilbert *et al* (2005) who state that *'Laurillard's model, particularly of student reflection and adaptation, makes it less useful as an e-learning model'* (p.1) and outline several alternatives that can be utilised in designing e-learning material such as Merrill's Component Display Theory and the Sharable Content Object Reference Model (SCORM). While acknowledging that no one model has a particular advantage over any other, Gilbert *et al* (2005) nonetheless conclude that:

> *A difficulty faced in the application of any model of learning to the e-learning situation is the relative lack of research evidence for the application of such models, as distinct from their grounding in everyday teaching practice.*
>
> (Gilbert *et al,* 2005, p.4)

Blended learning can also explore the possibility of mixing various types of media with face-to-face teaching. When this happens the opportunity to satisfy the conversational framework phases can be offered. Laurillard (1993) describes the *'one-to-one tutorial as the ideal teaching situation'* (p.97). This view is shared by Prensky (2002) but both agree that it is rarely feasible for many reasons, not least those of university tradition, modern day economics and large student numbers. When a teaching opportunity arises whereby there is one-to-one interaction between student and teacher, '*this is described as the Zone of Proximal Development*' and happens '*quite naturally in post graduate classes*' (Leventhall, 2004, p.9). In apprenticeship education the average class size is sixteen students. This relatively small number offers the opportunity for one-to-one or small group interaction between students and lecturers.

2.6 Social Constructivism at a Higher Level

Lev Vygotsky (1896-1934) is responsible for the social development theory of learning which proposes that social interaction profoundly influences cognitive development (Riddle, 1999). Vygotsky's work began to attract the attention of western psychologists and educators in the 1970s. This theory is also known as social constructivism and emphasises the collaborative nature of learning. Traditional lecturing, as outlined above, is primarily focused on the teacher and in the case of large classes is almost entirely one way communication. In his theory of the Zone of Proximal Development (ZPD) Vygotsky observed that children learned in a more effective manner when under the direction of an adult and he describes it as

> *the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers.*
>
> (Vygotsky, 1978, p.86)

This is interpreted by Riddle (1999) to mean that a learner can perform a task in collaboration with a peer or under the guidance of an adult but not alone. The Zone of

Proximal Development can therefore be described as bridging a gap between the known and the unknown. Although Vygotsky's work was primarily associated with children, many researchers now believe that the fundamental principles are also applicable to adult learning.

Vygotsky's Zone of Proximal Development theory is a direct contrast to that of his contemporary, the Swiss psychologist Jean Piaget (Willis, 1996). Piaget believed that a child's ability to think developed in specific stages and that learning activities should match and not exceed the learner's level of development. Boudourides (2003) states that '*on the topic of stages of development, Piaget believed that development precedes learning, while Vygotsky believed the opposite*'. Bockarie (2002) concurs with this view and states: '*Piaget said that human development occurred in stages and that learners did not or could not see the world through the eyes of others*' and that Vygotsky '*saw development as a continuous learning process that linked one's current mental networks of association with new experiences gained through contact in, observations about, and reflections on the activities of everyday life*' (p.50).

Within the field of apprentice education the student is continuously observing and improving his/her skill level. The apprentice is constantly under the guidance of a qualified craftsperson while on the job and also under the tutelage of teaching staff while attending off-the-job phases. There are sound reasons underpinning this approach such as safety and the correct and economic use of materials. It is argued here that apprenticeship education is therefore ideally suited to Vygotsky's Zone of Proximal Development theory of learning development.

Murray and Arroyo (2002) believe that Vygotsky's ZPD can be adapted to e-learning environments provided that the design model is carefully chosen. The main tenet of their argument is that students will keep within the zone and they explain their point in the following illustration.

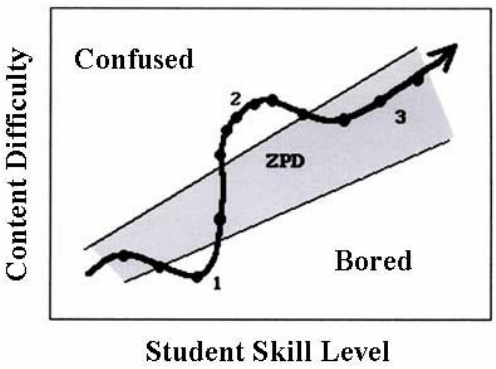

Figure 2.1 - Murray and Arroyo (2002) Zone of Proximal Development.

When the student is within the grey area, indicated by the number 3, he/she is said to be in the ZPD and learning is taking place. When students stray outside the boundary they are either bored or confused. Murray and Arroyo believe that teachers '*cannot directly control the cognitive properties of the student, so it is the tutor that must adapt to keep the student in the ZPD*' (p. 3). This is achieved by giving due care and attention to the lesson which should include sequencing content, opportunities for practice and quality feedback. For student apprentices to achieve what is termed 'experienced workers' standard' these principles are fundamental. Herschbach (1998) describes this approach as the active, contextualized character of learning, and stresses that student apprentices should be engaged in meaningful activities similar to those that will be engaged in when working on the job.

In designing the Plumatics 4 U mathematics web module, I was mindful of the principles outlined above and consciously designed the site to enable the students stay within the ZPD. For example, to prevent a student getting bored or confused, the first twelve pages of mathematical content have less than two hundred words per page. However, I included four self-tests within this first section, the purpose of which was to help the students to develop their skill levels while at the same time enabling them to proceed at a relatively fast pace. As they proceed through the module the mathematical problems increase in difficulty and as a consequence the worked examples and explanations are more comprehensive. This means that the word-count increases per page but at this stage the student should be motivated and interested enough in the

content and less conscious of the amount of text. The content is also relevant to what student apprentices are expected to know when they return to their employers. The design strategy used in the development of the Plumatics 4 U web site will be dealt with in more detail later in this chapter.

Vygotsky's ZPD theory of social constructivism requires that some form of support structure must be put in place to assist learners. This support is often referred to as scaffolding and may take several forms such as feedback (either face-to-face or online), hinting (where minimal assistance is provided) or problem decomposition whereby problems are broken down or divided into easily manageable parts that are simpler to solve (Murray and Arroyo, 2002). Scaffolding does not involve telling students the answer to a problem, but rather encourages them to discover the answer for themselves. This not only has the effect of improving student confidence but enables them to build upon what they already know. This type of support structure is referred to by Hsiao (2005) as cognitive apprenticeship where teachers provide scaffolds which encourage students to develop their knowledge and abilities.

Much learning for the apprentice occurs within a community of practice which not only includes the working environment but may also '*include unions or other collectives of workers who share a common interest*' (Bockarie, 2002, p. 51). Before commencing the design stages of a programme it is useful to specify both the objectives and the theory of learning and teaching that will be employed. This is described by Biggs (2003) as '*a marriage between a constructivist understanding of the nature of learning, and an aligned design for teaching*' (p. 27) which is constructive alignment. This issue will be discussed later in this chapter. From all this it can be seen that prior to the design of an educational programme, it is necessary to establish a foundation upon which to build a learning platform to enable students to fully benefit from the experience. As part of this formative evaluative research study a primary resource which formed this learning platform was the Plumatics 4 U web site and the planning and preparation that led to this development will be discussed next.

2.7 Selecting a Design Model

Before deciding on any educational development or programme design some form of strategy must first be established, and e-learning is no exception. There are several terms used to describe this process such as Instructional Systems Design (ISD), Instructional Systems Design & Development (ISDD), the Systems Approach to Training (SAT), or simply Instructional Design (ID). There are more than 100 different ISD models, but almost all are based on the generic "ADDIE" design, which stands for Analysis, Design, Development, Implementation, and Evaluation (Kruse, 2006). Dick and Carey (1990) have also designed an ISD model that consists of a nine stage process beginning with the identification of instructional goals and ending with summative evaluation. The United Kingdom Higher Education Academy recommends that when designing a course or module, the designer should seek to answer several pertinent questions, such as:

- What do students need to know?
- How do I encourage and enable them to do these things?
- How will I know what they have learnt?

(Higher Education Academy, 2006)

The Plumatics 4 U web site followed the ADDIE model and was based on the following criteria:

- Determining the need;
- Setting goals and objectives;
- Designing the programme;
- Developing the resource;
- Implementation;
- Assessment;
- Formative Evaluation.

Each of the above points will be discussed separately in the context of how they influenced the web site design.

2.7.1 Determining the Need

Determining the need makes it possible to provide a solid foundation for learning. This in turn will help ensure that the materials are both relevant and challenging to learners in order to enhance their intellectual development. An important feature at this stage is to establish that there is a demand for a resource and if possible to incorporate features such as flexibility, upgrading and cost savings where possible (Thorne, 2003). It is sometimes the case that a gap has been identified in a programme and as a consequence a need for change arises. This was exactly the situation that my initial research identified, and as a result I was motivated to seek an improvement in the mathematical performance of Phase 4 apprentices who were experiencing a difficulty with this element of their learning programme.

However, it is often the case that *'courses appear or change for all sorts of reasons'* (Toohey, 2000, p.25) and may not follow an instructional design as outlined above. The reasons for this are complex and diverse but may include the wish to follow a particular educational philosophy, a commitment to try new methods of teaching, departmental survival or a response to student or community demand.

2.7.2 Setting Goals and Objectives

Cannon and Newble (1989) believe that the establishment of clear objectives is fundamental to curriculum planning for two reasons. Firstly, clear objectives allow the rational choice of content for teaching and learning activities, and secondly, they are important in the planning of valid assessments. E-learning educational programmes have the facility to inform students of the goals and objectives at each stage of the

learning process. In e-learning materials these objectives are often stated on the opening screen. This is a valuable part of the learning process and is of great benefit to the student in offering direction, guidance and relevance to a programme or module. I used this strategy in the Plumatics 4 U web site to help keep students focused on the particular tasks and exercises. With fifty pages of content to access on the site, a student could easily get confused, lost and as a result give up. When goals and objectives are made available to students they should be worded in a manner that is easily understood. Many designers write goals in line with the acronym SMART (Platt, 2002) which stands for:

- Specific
- Measurable
- Attainable
- Realistic
- Timed

Creating achievable goals and objectives will give a direction to the design.

2.7.3 Designing the Programme

A primary objective in curriculum design is to encourage a deep approach to learning. The philosophy of deep versus surface learning was first developed by Marton and Saljo (1976). Gibbs (1992) believes that the factors that lead to a deep approach are the opposite to the factors that lead to a surface approach. Gibbs believes that for deep learning to succeed there should be relatively low class contact hours, student interest in the subject, freedom to learn and good teaching. Biggs (2003) identifies good teaching as having a motivational context, learner activity, interaction with others and a well structured knowledge base. While these attributes pertain mainly to face-to-face teaching there are opportunities to integrate them into e-learning educational programmes. To make these goals achievable many believe that the integration of face-

to-face and e-learning in a blended environment offers the best opportunity for students to achieve their full learning potential (Marsh *et al*, 2003).

Bersin (2003) believes that important factors to consider at the design stage are:

- The audience, their skill level, and how much time they have;
- The time available to develop, roll out and complete the programme;
- The size and scale of the audience;
- Resources available such as budgets, designers, computers and teaching space;
- The shelf life of the content;
- The ratio of the different media when using a blended approach.

An illustration of how important these were in relation to my web module design relates to the issue of computer resources. Initially I had intended offering students a short induction on how to access the password protected web site. However, the results of informal interviews indicated that almost 30% of those with a Junior Certificate qualification did not have access to the Internet at home. Furthermore, it became obvious that although many students considered themselves computer literate, their main interaction with this technology involved gaming and almost none of them used email. This highlighted for me the necessity for pre-design research aimed at the target group.

2.7.4 Developing the Resource

Meredith and Newton (2003) discuss the different approaches that higher education institutions take regarding the development of e-learning resources. The two extremes are described as 'bottom up' and 'top down'. The bottom up approach is where a group of enthusiasts, usually teaching staff, develop material often during their own time. If not encouraged by higher level management these people will often lose impetus and move away from this approach. On the other hand, it sometimes happens that following initial success higher level management take over, unfortunately with the same end

result. The top down approach is where the institution develops its own policy and puts support structures in place to train and help staff to develop their specific resources in a professional manner. This latter approach is the DIT strategy and those staff who are involved in the design and delivery of e-learning modules and courses have benefited from this initiative. The development and support of e-learning is outlined in the Dublin Institute of Technology Strategic Plan 2001-2015 which states that during this timeframe the Institute will *'develop flexible web-based course delivery mechanisms'* and also *'develop modularised e-learning programmes'* (DIT, 2001, p.17).

With the development of web-based platforms such as WebCT, Blackboard and Moodle, it is now possible for lecturers and course designers to develop educational materials using computer programmes that most people are familiar with, such as Microsoft Word, PowerPoint, Excel and Frontpage. This is a major step forward because it is no longer necessary to have a working knowledge of computer programming or hypertext markup language (HTML) to develop e-learning content.

It is acknowledged by Sloep (2003) that the best people to develop online educational content are the academic staff who normally deliver it, albeit in a traditional lecture environment, and that *'leaving it to support staff and publishers would be a recipe for disaster'* (p.1). However, it is also necessary that academics with an interest in developing e-learning material are provided with the necessary staff development opportunities to ensure that established learning and teaching pedagogies are satisfied. By following these recommendations the material can be aligned with the curricula as recommended by Biggs (2003).

Thorne (2003) also believes that blended learning should be set in the broader context of learning and recommends that a model such as Kolb's (1984) learning cycle be followed. This involves guiding the learner through a cycle of four key steps. Firstly, the student has a learning experience; then he/she reviews or reflects on what happened and may seek feedback; thirdly, the learner theorises about what happened and explores options or alternatives; finally, he/she plans what to do differently next time.

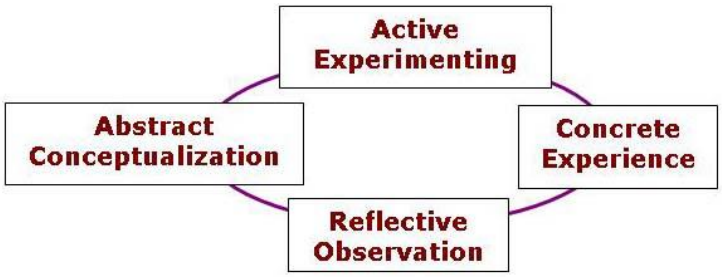

Figure 2.2 – Kolb's Learning Cycle (Kolb, 1984)

This cycle is also referred to by Race (2001) who describes the four stages as doing, feedback, digesting and needing.

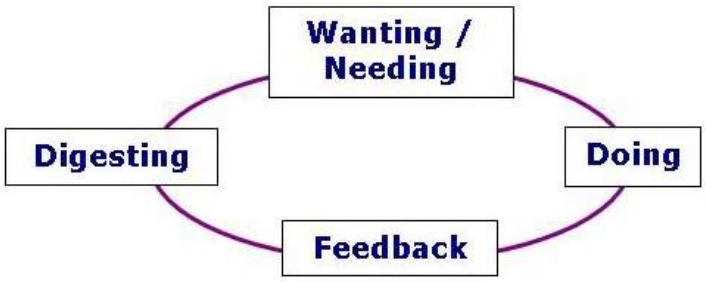

Figure 2.3 – Kolb's Learning Cycle adapted by Race (2001)

In designing the Plumatics 4 U web site I decided on a specific strategy with three distinct strands. The first is an explanation of the topic, the second includes worked examples, and in the final stage the students have the opportunity to take a self-test to check their knowledge. This strategy is followed throughout the fifty pages of content on the site and is shown below in graphic form.

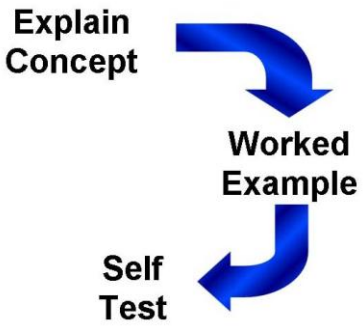

Figure 2.4 – The design strategy of the Plumatics 4 U web site

Strategies such as these are well documented in the literature. For example, Jolliffe *et al.* (2001) believe that *'any body of knowledge to be used in a Web environment must be designed so that the number of variables is kept to a minimum'* (p. 16). Boettcher (2003) discusses a three level approach where each level represents an increasing difficulty. Within Boettcher's framework the Plumatics 4 U web site would be represented at level two and should 'engage the learner in the solutions, gradually increasing in complexity of the applied rules and principles' (Boettcher, 2003, p.3)

By using models such as these, the curriculum designer can introduce different methods into a blended programme. For example, in a face-to-face environment there are opportunities for students to collaborate in activities or answer questions, but a major disadvantage of classroom teaching is that the pace of learning is usually determined by the lecturer. By offering an e-learning resource to students that complements classroom activities, students have the opportunity to revise face-to-face sessions while working at their own pace. Recognising these different situations acknowledges that learning does not take place in a neat and ordered way (Thorne, 2003). This was fundamental in the development of the mathematical e-learning resource for apprentices because I wanted students to have the opportunity to learn at their own pace in an environment of their choosing. Also, by offering feedback that was built in to the site and through the discussion board, combined with worked examples and self-tests, the design and development followed Kolb's cycle.

2.7.5 Implementation

Having put resources and effort into the design and development of e-learning materials, the next important feature is how to successfully utilise them and consideration should be given as to how they will be used and who will use them (Rossett *et al*, 2003). In the case of a blended learning programme consideration will also have to be given to the mix of the various delivery methods. The available physical resources such as classrooms and computer laboratories, along with scheduling will also

need to be considered. This particular issue proved to be extremely important within my own research and will be discussed in Chapter Five.

Students who are new to an e-learning environment may need to be introduced to the concept in a supportive manner (Mason, 1998). This is particularly important where the student is remote from the delivery institution and is expected to collaborate with other course participants. In such situations Salmon's five-stage model could prove useful (Salmon, 2002). These stages are: access and motivation, socialisation, exchange of information, knowledge construction and development. Odin (2002) believes that labelling them sequentially gives the impression that each stage has the same degree of relevance in the overall learning process, but that in practice the first three could be described as preparatory while the last two constitute the heart of collaborative learning. Horst (2005) believes it is unclear if Salmon's model can be applied to a blended learning situation. Many institutions have developed innovative approaches to introducing students to e-learning and to supporting them during courses. The University of South Australia, for example, runs student support workshops, offers learning guides which can be downloaded from the Internet and provides learners with a CD-Rom to introduce them to programmes (Tait and Mills, 2003).

Within the educational curriculum for Irish plumbing apprentices, there is no provision for the inclusion of ICT. Some lecturing staff, such as those who deliver the electrical controls module to Phase 6 students, have found it useful to use computers as an educational aid but this does not form a mandatory portion of the curriculum. I was therefore not surprised to discover that the level of computer literacy among apprentice plumbing students was quite low. This factor had to be taken into account when implementing blended learning. To give students every possible assistance in accessing the Plumatics 4 U web site I designed and developed an instruction handout specifically for the apprentices who needed to log on to this resource. A copy of this handout can be found in Appendix N.

2.7.6 Assessment

While quite a lot of innovation and creativity is evident in many e-learning programmes the issue of assessment can be problematic. These difficulties are outlined by Maier and Warren (2000) as: accessing enough computers so that all students can take an examination at the same time; invigilators and supervisors may need to be computer literate to answer queries and address problems such as logging on; ensuring that those taking a test do not access information illicitly or communicate among themselves; and the type of questions associated with e-learning examinations which are often quite limited such as multiple choice, fill-in-the blanks or complete the answer.

Regarding this final point, Toohey (2000) believes that well-structured assessments should allow students to demonstrate their understanding of the subject matter while at the same time offering the opportunity to show increased intellectual abilities. This in turn reinforces the concept of deep learning as outlined by Biggs (2003) who emphasises the need for students to create knowledge. Indeed, Scouller (cited in Biggs, 2003, p.172) found that students saw multiple choice tests as requiring low cognitive level processes and that using a deep approach was negatively related to this type of question.

Finally, it is clear that new and innovative methods are required if e-learning assessment is to achieve the quality of traditional examinations (Maier and Warren, 2000). In the meantime many educators in the e-learning community are combining several methods within assessments, such as questionnaire and interview, or multiple choice and short essay (Biggs, 2003). While the Plumatics 4 U site did not form any part of the official examination procedure pertaining to apprentices, the worth of it was evaluated by a comparison of the examination results of those who took part in the study with the results of students from previous intakes who did not.

2.7.7 Formative Evaluation

There are many reasons why educational programmes need to be evaluated. Marsh *et al,* (2003) discuss evaluation from the perspective of cost reduction and improved quality of delivery, while Milton and Lyons (2003) are concerned with the validity and reliability of programmes. Somewhere within this complex mixture lies the question of assessment. In this context the term 'evaluation' refers to the process of gathering information about a programme while 'assessment' is a measurement of the level of student achievement or ability. Ramsden (1992) is in no doubt as to what evaluation is, and states:

> *Evaluation is not at heart about collecting evidence to justify oneself, nor about measuring the relative worth of courses or teachers. It is about coming to understanding teaching in order to improve student learning.*
>
> (Ramsden, 1992, p 240)

In evaluating the blended learning mathematics module, I used a form of triangulation. This involved comparing the results of student questionnaires with the findings from focus group sessions. Two focus group sessions were held, one with a representative group of apprentices who took part in the study, and a separate one involving the teaching staff within the plumbing section who deliver the mathematics module. While this matter will be discussed in greater detail later, it is mentioned here to confirm that the primary objective was to help improve student performance as outlined by Ramsden.

To help in evaluating the worth of educational programmes, there are several manuals and guides available, such as Conole *et al,* (2000) and Harvey (1998). When designing and planning any educational programme it is considered good practice to build in a mechanism to help in the evaluation process which may not only relate to the course content, but also to the area of teaching practice (Cannon and Newble, 1989). Within the higher education sector, evaluation may be undertaken either internally or externally to reflect the ethos or investment of relevant stakeholders such as internal quality

control personnel, academic management or government departments. Harvey (2002) outlines the many areas where evaluation occurs both from an internal and external perspective and believes that when carried out by external agencies, it fails to take issues of learning and teaching into account and thereby *'legitimises the status quo'* (p.245). In the case of course design and curriculum development, evaluation may be formative or summative. Formative evaluation will often take place during the delivery or development stages of a course. This can not only impact on the curriculum content but may also offer opportunities to reflect upon teaching practice. Summative evaluation takes place upon completion of a programme and is used to assess the total impact of the outcome (Robson, 2002).

2.8 E-learning Mathematical Programmes

Of all the courses, modules and programmes offered within the e-learning paradigm, one of the most difficult to deliver and challenging to design are those involving mathematics (Smith and Ferguson, 2005). There are several reasons for this but one of the most obvious is the requirement for computer screens to easily display mathematical formulae and diagrams. While the basic mathematical symbols such as addition (+), subtraction (-), multiplication (*) and division (/) are easily accessed by even the most basic computer user, difficulties can arise when more complicated symbols are required. With a small amount of assistance students can be taught how to insert square root symbols and how to indicate squared numbers with superscript. Most computers with Microsoft Word may also include Equation Editor, a mini-programme that allows for the insertion and manipulation of mathematical formulae, but as the content gets more complicated and the problems more difficult the software is either not available to students or too difficult to use.

Wilkinson (2001) outlines how engineering students used a programme called MathCad as part of their mathematical education, but makes it clear that the learners had to be taught how to use the computer programme to make the best use of it. Leventhall

(2004) believes that for most students studying mathematics in an e-learning environment the pressure to learn these new skills is overwhelming. An example of the difficulties students face when learning mathematics is related by Wilkinson (2001) who outlines how when students were asked to read particular sections of a text book prior to a lecture '*only 3 per cent did so regularly, 67 per cent sometimes and 30 per cent never did*' (p. 157).

A major study by Smith and Ferguson (2005) found that in courses delivered entirely online the drop out rate for mathematics was higher than that in any other field of study. The explanations they offer for this are:

- Students who participate in e-learning courses are from a different population than face-to-face students;
- E-learning students tend to be older, work full time and may be returning to higher education after a long break;
- Mathematics is less tolerant than other subjects in that when a gap in knowledge occurs the student is often held up and progress ceases.

Teaching mathematics is different to teaching most other subjects. Mathematics teachers often refer to the language of mathematics, and for this reason alone information communication technologies (ICT) need to be more user-friendly for students. Teaching mathematics in a classroom setting involves speech, gesturing, demonstration and possible peer-to-peer interaction. Mathematics impinges into many areas of study such as science and engineering and these fields struggle to attract students. It is therefore crucial that efforts are made to make online mathematics more accessible to students who wish to study via a Virtual Learning Environment (VLE). For this to happen, Leventhall (2004) believes that the following requirements are necessary within Learning Management Systems (LMS) and VLE's such as WebCT and Blackboard:

1. A simple equation editing tool is required that can show how formulae are built up using both the Whiteboard and Chat area;
2. The facility to show at least two screens simultaneously thereby creating a virtual classroom setting;
3. A facility that allows some form of gesture possibly using a mouse;
4. Technology to enable verbal interchange while online.

Although none of the above is available in WebCT or Blackboard, the technology for items 1, 2 and 3 already exists. The challenge for software designers and programmers is to develop the fourth item. There is an onus therefore on VLE designers to incorporate them all into e-learning environments.

All students attending the Dublin Institute of Technology have access to a mathematics module available through WebCT. The material available is targeted primarily at engineering students and while the content is excellent it is not appropriate for plumbing apprentices. The content is offered as a revision resource with pages displayed in PDF format. There are a limited number of examples offered and no feedback is available. Student apprentices who are weak in mathematics have indicated that this site is of little use to them. I have come to this conclusion having listened to the opinion of plumbing apprentices who have accessed this resource.

2.9 E-Learning and Disability Education

Although there are many who criticise e-learning education, one area where it impacts in a very positive manner relates to supporting people with disabilities. Disabilities can be divided into two distinct areas, visible disability and invisible disability, and ICT can offer groups of affected people an alternative means to access educational content that previously proved extremely difficult or even impossible. For example, in the first situation, a student with a mobility disability who has access to a computer can take the same e-learning course as any other able-bodied individual. For students with a visual

impairment software is available which utilises speech synthesizers to read text while other programmes are available which offer blind users the opportunity to access information with ease (Porter, 2004). There are also students who may suffer from an invisible or hidden disability which is defined as '*dyslexia, epilepsy, ME etc.*' (DIT Guide to Policy and Procedures for Students with Disabilities, p.3).

With the increase in student numbers within third level colleges and equality of access, there are many students with disabilities now attending tertiary education programmes. Research undertaken by AHEAD, the Association for Higher Education Access and Disability, indicates the increased percentage of students attending third level education over the past decade as shown in Table 2.1 below.

1993 – 1994	**1998 – 1999**	**2004**
0.65%	1%	2.38%

Table 2.1 Percentage of students with disabilities attending third level education in the Republic of Ireland (Assist Ireland, 2005).

What these statistics clearly show is that the participation rate of students with disabilities in the university sector has doubled between the years 1998 and 2004. What they fail to show is that the same progress did not occur within the Institute of Technology sector where the participation rate of students with disabilities has remained almost unchanged within the same period. One of the principal reasons for this situation is

> *the fact that the Institutes of Technology cannot access funding through the Higher Education Authority (HEA) strategic initiatives like their counterparts in the university sector. Therefore they can have difficulty in funding support services for students with disabilities*.
>
> (Assist Ireland, 2005).

The situation regarding services for students with disabilities attending the Dublin Institute of Technology is much brighter than that outlined above, and there has been a marked increase in those seeking assistance from the Disability Service in recent years. For example, in the academic year 1998/1999 sixty-eight students were registered as having a disability. By 2006/2007 this figure had risen to six hundred and twenty. The increase is outlined in Figure 2.5 below and the actual student numbers shown in Appendix E with an approximate breakdown of the disabilities (DIT, 2006d). The number of apprentices registered with the Disability Service in the DIT for 2005 was eighty-five.

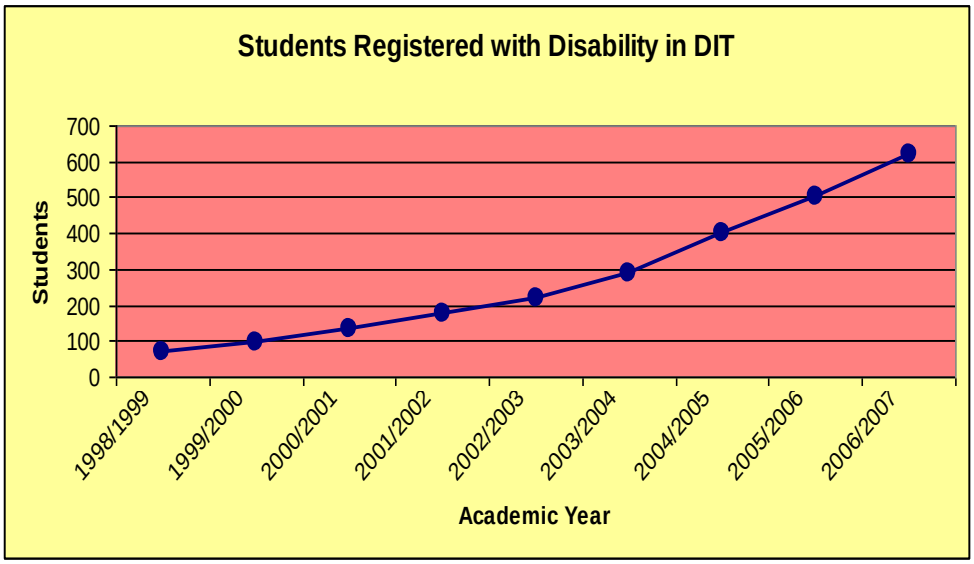

Figure 2.5 Students with disabilities attending DIT

There has been considerable progress made within the area of web design and presentation particularly with regard to students with learning disabilities such as dyslexia and attention deficit disorder (ADD). AHEAD is an independent non-profit making organisation working to promote full access to and participation in third level education for students with disabilities in Ireland. A recent initiative funded by the European Union (EU) involved the development of a web site specifically designed for people with disabilities. This site, entitled 'Quest for Learning', was designed and promoted in collaboration with The Dublin Institute of Technology (DIT), FÁS and

University College Cork (UCC). This web site not only has useful information for students, but also for teachers and web designers (Quest for Learning, 2005).

When designing web based material there are a number of guidelines that must be observed, such as:

- The use of colour which should not cause eye strain;
- The use of san serif fonts such as arial or verdana;
- Ensuring that there is no left to right scrolling on web pages;
- Being careful that the content is pitched at the level of student knowledge.

These are only a small selection of useful strategies that web designers should be aware of when undertaking the task of uploading content (Learning Technology Team, 2005). These guidelines are also supported by organisations such as the World Wide Web Consortium (W3C) who promote best practices in the development of e-learning materials. Web sites such as Watchfire WebXACT (2005) are a useful aid for designers to ensure that their material is compliant with current best practices. This site provides a free online service that lets designers test single pages of web content for quality**,** accessibility, and privacy issues. The Plumatics 4 U web site follows the guidelines outlined above and is designed to be user-friendly for students with learning disabilities.

Making e-learning material accessible is not just about ensuring that it is compatible with the various browsers and the latest technologies. It is also about equality. By ensuring that web content is user-friendly to everyone, including those with disabilities, we are offering an opportunity for all to participate on an equal basis.

2.10 Summary

In this chapter I have outlined how e-learning in education has developed during the past quarter of a century. I have also described how I believe blended learning involving ICT and face-to-face teaching can occur within a social constructivist framework. The ADDIE design strategy was used in developing the web site which forms a fundamental part of this study.

I have also shown that delivering mathematics in a solely online environment is extremely difficult. However, when delivered in a blended manner many of the problems outlined above can be addressed provided that the programme has been designed using proven sound educational practices.

The primary focus of any teaching strategy or programme design must be the welfare of the student, and it could be the case that some students may have a disability. In the case of a hidden disability the teacher may be the last to know, and in the case of an e-learning student we may never be aware of such a situation. By ensuring that e-learning material is compatible with automated tests such as Watchfire WebXACT (2005) we are offering students an equal opportunity to participate in educational programmes.

Chapter 3

Research Design, Theoretical Perspective, Methodology and Methods

3.1 Introduction

It is argued in this thesis that there exists educational inequality in the apprenticeship system and that this is exacerbated by modular competence-based curricula which form the foundation of the Irish apprenticeship system. Writing about the nature of enquiry, Cohen *et al*. (2000) state that *'raising awareness of inequalities is an important step to overcoming them'* (p.34). This is one of the primary reasons why I believe this study is important to the field of mathematical education for apprentices. Half of all registered apprentices have a Leaving Certificate qualification but the remainder do not. Following the analysis of examination scripts of Phase 4 apprentice plumbing students, it has been established that a significant number have difficulty with the mathematical element of their education.

3.2 Research Design

This is a formative evaluation research study using mixed methods of both qualitative and quantitative data collection. Cohen *et al*. (2000) describe evaluation as a means of examining *'the effectiveness of a project'* (p. 38). The purpose of evaluation is to make recommendations for change that will in turn lead to improved student performance. However, evaluation needs to be carefully thought out and a plan put in place to ensure that the research achieves its desired goals and that the results are valid and meaningful. Ramsden (1992) offers sound advice by stating:

> *Evaluation is not at heart about collecting evidence to justify oneself, nor about measuring the relative worth of courses or teachers. It is about coming to understand teaching in order to improve student learning.*
>
> (Ramsden, 1992, p. 241)

The use of formative evaluation can be traced to the 1920s when it was used to evaluate educational film but it did not become a systematic design method until the 1960s (Tessmer, 1993). The term 'formative evaluation' is attributed to Scriven (1967) but it is sometimes referred to as 'developmental testing', 'alpha/beta testing' and 'learner verification and revision'. Although evaluation can usefully be used to test the quality of course curriculum materials, Scriven (1967) believes that another important aim of evaluation is teacher improvement. This point is echoed by George and Cowan (1999) who believe that formative evaluation can lead to *'self-evaluation by an individual teacher or an academic department'* (p. 2). It is hoped that this study will lead to important insights and innovations in both of these areas.

Tessmer (1993) describes formative evaluation as *'a judgement of the strengths and weaknesses of instruction in its developing stages'* (p. 11). Within this study the worth of using a blended teaching strategy of e-learning and classroom activities pertaining to Phase 4 mathematics was evaluated while the activities were forming or happening. Hart (2005) concurs with this view and believes that formative evaluation can '*provide evidence on design decisions during the development of a policy or programme'* (p.330). A range of data collection methods were used to ensure that the findings were valid and reliable and this also offered the opportunity for triangulation. Laurillard (1993) believes it is more important that data collection be intensive rather than extensive and states that *'any teaching innovation must be formatively evaluated if it is to be optimised'* (p.247). In line with this suggestion, I have limited the quantitative data collection to a number of key areas which is outlined below.

During the research I used a mixed method approach involving both quantitative and qualitative methods and analysis (Creswell, 2003). The quantitative data was gathered from an analysis of the examination results of Phase 4 apprentices from previous intakes who did not participate in the study, and also from two questionnaires completed by both Phase 4 and Phase 6 students. The rationale for this is that the organisations with responsibility for apprenticeship education, such as FÁS and the

Department of Education and Science, primarily use quantitative research methods. Organisations such as trade unions and employer groups are more likely to accept findings based on quantitative research which can be applied and compared to large numbers of individuals. Therefore, any recommendations are likely to be more influential if expressed in a quantitative fashion. This opens up the question of generalisation. Merriam (1998) states *'the question of generalisation has plagued qualitative investigators for some time'* (p. 207) and goes on to point out that for a study to have externally validity it must first be internally valid. Silverman (2005) however, expresses the view that generalisation is possible where qualitative and quantitative methods are used with adequate population sizes and purposive sampling. This explains the rationale for using both qualitative and quantitative methods of data collection within this study.

The qualitative data for the study included interviews and focus group sessions with both student apprentices and academic staff on this programme. Observation was also used as a qualitative research method with the students who participated in the research and this area will be expanded upon later in this chapter. Creswell (1994) believes that qualitative studies are useful when little has been written about the actors and it is worthwhile listening to what they have to say. This is certainly the situation regarding qualitative research in the area of apprenticeship within Ireland. Up to this juncture, the majority of the studies in the area of apprenticeship in the Republic of Ireland have been quantitative in nature. It is difficult to establish why this is the case but it may be due to the substantial resources dedicated to this type of education, which are considerable, especially when one considers that there are over 28,000 registered apprentices in Ireland (FÁS, 2005).

The most significant piece of qualitative research published to date relating to apprenticeship was an evaluation study by the European Social Fund (1999), which noted a high satisfaction rating for the Irish standards based system. O'Connor and Harvey (2001) also carried out qualitative research in which *'the main form of data collection was by semi-structured interviews'* (p. 335). Within their research they

interviewed fifteen employers, six FÁS instructors and six lecturing staff from the institutes of technology. No apprentices were used in this research study. Field and O'Dubhchair (2001) carried out *'a small-scale survey of employers and apprentices in the North-Eastern Region of the Republic'* (p. 247). Their research was based on a survey questionnaire and involved twelve employers and twenty-six apprentices. To date there has not been a qualitative study dedicated to plumbing apprentices. When one considers that plumbing is the third largest trade in Ireland with over 4,000 registered apprentices the need for this study becomes apparent. It can also be seen from the above that there is a need to canvas the views and opinions of student apprentices relating to their experiences of the off the job phases of their education. For this research, data was collected from 250 students and an additional forty apprentices participated in the formative evaluation study. From the limited amount of literature pertaining to the Irish apprenticeship system, this may well be one of the largest pieces of research carried out to date using a mixed method approach of qualitative and quantitative data collection.

The epistemology that best describes apprenticeship education is constructivism because it acknowledges the importance of the individual. During their apprenticeship, an individual student builds on the knowledge received at previous stages and thereby improve knowledge and skills (Wenger, 1994; Seitz, 1999). The theoretical perspective that forms the basis of this formative evaluation research study is that of interpretivism. Interpretivism is characterised by a concern for the individual. This is in line with Crotty (1998) who believes that the interpretative paradigm strives to interpret and understand the world in terms of its 'actors' who in this study are apprentices who may have difficulty with mathematics in the Phase 4 curriculum.

The theoretical perspective, epistemology, methodologies and methods which were used in this study are broadly based on the model outlined by Crotty (1998, p.5) and are shown below.

Theoretical perspective:	Interpretivism
Epistemology:	Constructivism
Methodology:	Formative evaluation research
Mixed Methods:	Interviews
	Focus groups
	Questionnaires
	Quantitative analysis of examination results
	Observation

Before any study is undertaken, it is essential that the researcher is clear as to what direction he/she wishes to take. Silverman (1993) states that *'it establishes how one will go about studying any phenomenon'* (p. 2). As this thesis is a formative evaluation research study cognisance was taken of the need for caution in undertaking such research. Robson (2002) believes that *'evaluations are things to avoid unless you have a good chance of doing them properly'* (p. 209), and believes that for an evaluation to be carried out successfully it must meet the following criteria:

- Utility – It must prove useful to the audience;
- Feasibility – It should be carried out within a specific time-frame, be within budget and take account of political and practical implications;
- Propriety – Evidence must be provided to show that the evaluation was carried out both fairly and ethically;
- Technical adequacy – The researcher must have the technical skill to develop material and collect data but also be sensitive to the actors in the study.

This evaluation research study is primarily student centred and the principles and guidelines outlined above will be explained further in the following sections.

3.3 Theoretical Perspective

The theoretical perspective used in this formative evaluation research study is that of interpretivism. The logic for choosing this approach is that by understanding student difficulties and ascertaining the reasons for them, it is possible to interpret the results and thereby make recommendations for change (Hart, 2005). This research involved three groups of Phase 4 student apprentices. Although forty students participated in the study, their progress within the Phase 4 programme is measured and assessed as individuals. Cohen *et al*. (2000) believe that the interpretive paradigm *'is characterized by a concern for the individual'* (p. 22) and describe this as anti-positivist in nature.

It is important to outline that this research study is not objectivist in nature and therefore does not follow a positivist paradigm. Positivism was developed by the French philosopher Auguste Comte. It claims that knowledge can only be advanced by observation and experiment and it chiefly uses quantitative methods of data collection (Guba and Lincoln, 2005). Indeed, Foley and Valenzuela (2005) state that *'qualitative research has become the site of philosophical and methodological revolt against positivism'* (p. 218). Positivism strives to be objective, predictive and measurable but it is often described as not being interested in interpreting the world in terms of its actors. Bartlett *et al.* (2001) believe that positivism is usually unsuitable for educational research because the statistical nature of the data *'may show trends but they do not explain why people have done or said certain things'* (p. 44).

Interpretivism can be traced back to the late 19th and early 20th centuries and was in direct contrast to the then dominant philosophy of positivism (Schwandt, 2000). In very general terms, positivism follows strict scientific guidelines and is largely based on quantitative data. As a consequence of this, *'invisible or theoretical entities are rejected'* (Robson, 2002, p. 20). In the social sciences, positivism has been replaced by what is now described as post-positivism and this term is used to describe a myriad of research styles such as ethnographic studies, phenomenology, grounded theory, action research, critical theory, feminist methodology, evaluation and many more. What

unifies this list and distinguishes it from positivism is the hermeneutic approach it takes and the concern for the individual. Carr and Kemmis (1986) argue that interpretive social science should be based on the principal of *'practical judgement, which is informed by knowledge grounded in the actor's own understanding and circumstances'* (p.144). They furthermore believe that when dealing with the individual, positivist research is unsuitable because it fails to understand the human, social, historical and practical constraints within which real practice occurs.

While there was quantitative analysis of questionnaires and examination results included within this study, considerable emphasis was also given to the qualitative data collected from interviews, observations and focus group sessions. The concept of using quantitative and qualitative research methods together is relatively common and is acknowledged by both Wisker (2001) and Cresswell (2003).

3.4 Epistemology

In the previous section, emphasis was placed on the individual and the epistemology best suited to such studies is, I believe, constructivism. Crotty (1998) states that *'constructivism describes the individual human subject engaging with objects in the world and making sense of them'* (p.79). Constructivism encourages students to build upon past experiences and knowledge resulting in the development of new ideas and skills. This strategy fits into the Irish standards based apprenticeship model perfectly, because as students move through the various phases developing their skills and understanding, their progress is monitored and assessed as their abilities improve. Denzin and Lincoln (2003) argue that within the constructivist paradigm there are multiple realities and often no single truth. Again, this leads us back to the individual student and to ask the question: how best might we serve them?

The roots of constructivism can be traced back to the 18th century Italian philosopher Giambattista Vico (Gustafson, 2000). As a theory, constructivism impacts upon areas

such as philosophy, psychology, sociology, and education. Within the field of education, some of the major contributors have been Piaget, Dewey, Vygotsky and Bruner (Huitt, 2003). In the educational sphere constructivism has, over time, separated into two particular areas which are defined as "social constructivism" as promoted by Vygotsky, and "cognitive constructivism" which is advocated by Piaget. While both streams agree that learning is based on prior knowledge, Vygotsky's social constructivism '*places additional emphasis on the social context of learning*' (Miller, 2005, p.2). This philosophy links into apprenticeship education which is a combination of both on-the-job and off-the-job phases.

Seitz (1999) describes how traditional education of apprentices has developed in recent decades. The long established method of apprenticeship teaching incorporated three primary components – modelling, coaching and fading. In the more modern system of apprentice education, as currently practised in the Irish standards based model, Bruner's spiral approach is utilised. In this model (which is shown below) each core principle is revisited more formally at each rung up the educational ladder, increasing in complexity, thereby enabling the student to progress towards the experienced workers' standard that is required on the job (Wenger, 1994).

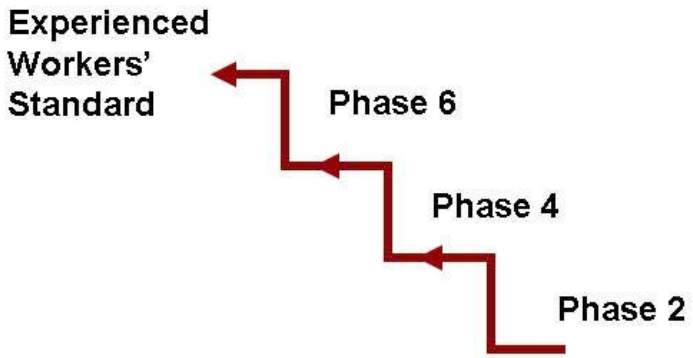

Figure 3.1 Bruner's spiral approach model as it applies to the Irish standards based apprenticeship system

Bockarie (2002) believes that there is a definite link between constructivist theories and apprenticeship – both being cognitive and craft based. For student apprentices who do

not experience any difficulty during their apprenticeship the third level educational system serves them well, and there are many students who are in this category. However, my research has shown a significant number experience difficulty in the area of mathematics, and as a consequence are at a disadvantage which can result in a delay in the completion of their apprenticeship. The development of the Plumatics 4 U web site is based on a constructivist philosophy. It offers students the opportunity to build upon material they are exposed to in a classroom environment. This support is, I believe, a form of scaffolding, which utilises the Vygotskian theory described as the Zone of Proximal Development (ZPD). This area is given a greater depth of treatment in the literature review chapter.

It is useful at this stage to reflect on the criteria outlined by Robson (2002) in relation to evaluation, alluded to earlier in this chapter, with particular reference to the concept of utility. From these criteria it can be seen that the research is student focused and designed to be of practical use to apprentices. Constructivism puts the student at the centre of the research process. It should recognise the valuable contribution participants can offer to the process while also acknowledging their freedom to cease participation at any time. From the teachers' perspective, constructivism encourages self-reflection which can in turn lead to improved performance and satisfaction (Carr and Kemmis, 1986).

3.5 Methodology

The purpose of the methodology is to help understand the process of the research as distinct from the product (Cohen *et al,* 2000; Scriven, 1967). The methodology should keep us focused on the task and guide the researcher through the process. The question being addressed within this study is, I believe, ideally suited to evaluative research because it deals with human phenomena (Gillham, 2000) who, in this case, are Phase 4 plumbing apprentices, and how they could achieve better results by means of a blended learning delivery strategy. This blended approach offers the opportunity to investigate a

different teaching strategy while also incorporating important issues such as equality. Equality in this sense refers to those apprentices who have a difficulty with mathematics but are currently offered little viable support to rectify this situation. Those apprentices who are academically weaker at mathematics within the apprenticeship curriculum are at a distinct disadvantage which manifests itself in successive off-the-job phases. In the epistemology section, reference was made to Bruner's spiral approach and how tasks get progressively more complicated and difficult as the student progresses. The Irish standards based apprenticeship curriculum follows this model in a quite rigid fashion, whereby both practical skills and theoretical knowledge increase in difficulty and complexity as the student progresses through his/her learning programme.

The objective of this study is to evaluate if a blended teaching strategy can help improve the mathematical ability of Phase 4 apprentices. This research is concerned with the process and as such is formative evaluation (Robson, 2002). This links back to the aims and objectives of the research which can be briefly summarised as seeking improvements for the individual. This is in line with the humanistic perspective outlined by Carr and Kemmis (1986) who state *'that education is a human encounter whose aim is the development of the unique potential of each individual'* (p.24). This humanist approach is also concerned with the worth of the individual, his/her self-esteem and motivation to learn (Carr and Kemmis, 1986). This approach, which focuses so much on the person, has been one of the primary forces driving this study. Evaluation will determine the activity but is not itself the activity. As a methodology it is the bridge between the theoretical perspective and the research methods to be used to gather data. These methods are often described as instruments and will be dealt with in the next section. In an oft-cited quote, Scriven tells us:

> *Evaluation is itself a methodological activity which is essentially similar whether we are trying to evaluate coffee machines or teaching machines, plans for a house or plans for a curriculum.*
>
> (Scriven, 1967, p. 40)

Finally, Robson (2002) summarises the complete concept of evaluation by stating that *'the purpose of evaluation is not to prove but to improve'* (p. 209).

3.6 Research Methods

The final part of the research design relates to the methods that are employed in the collection of data and information that help determine the final outcome. It is often the case that the methods chosen will produce facts and figures in addition to information and data from questionnaires, interview notes and focus group sessions. However, the methods chosen will be determined by the theoretical perspective, epistemology and methodology already described. A comparison could be made to that of a building, where the methods are what is seen, but the foundation, which is never seen, must be solid and dependable. In the research arena the theoretical perspective, epistemology and methodology provide the foundation upon which the final conclusions stand.

3.6.1 Quantitative Methods

Quantitative analysis has its roots in the positivist arena where facts are of primary importance. It is often portrayed as objectivist in its approach to investigation (Cohen *et al*. 2000; Travers, 2001). When used as the sole method of data collection, quantitative research methods are considered unsuitable where the human phenomena are important. Indeed, there are some critics who are trenchant in their views on this subject, such as Ions (cited in Cohen *et al*. 2000, p. 18) who states that quantitative methods are '*a branch of mathematics rather than a humane study seeking to explore …the human condition*'. In pure scientific research, the 'hard data' associated with quantitative methods carry more weight than the 'soft data' resulting from qualitative analysis (Patton, 1990). Numerical data has a special significance to people because of its precision and accuracy. However, there are those who have a more enlightened view and believe that research should not be divided or pigeon-holed into selective arenas such as Denzin and Lincoln (2000) who suggest *'that these methods may be no better or worse than any other, they just tell different kinds of stories'* (p. 10).

As 250 apprentices completed questionnaires in this study it was necessary to include quantitative methods of data collection. Quantitative methods were also required for the analysis of mathematical questions in Phase 4 examinations.

3.6.2 Questionnaire Design

Two questionnaires were completed by students during the course of this study. The first was completed by Phase 6 apprentices who were not involved in the blended learning teaching strategy. The second questionnaire was completed by the Phase 4 apprentices who took part in the research after their final examinations. Before discussing the two questionnaires in detail, I would like to outline the planning and rationale that led to the final design. Both questionnaires broadly followed the recommendations of Oppenheim (1992) and were group-administered which ensures a guaranteed response rate. The design followed a 'funnel approach' whereby early questions are broader in nature than the latter ones. All the questions were of the closed type with the exception of one in the Phase 4 questionnaire.

The appearance of a questionnaire is vitally important (Cohen *et al*, 2000) and to ensure that the layout was satisfactory I sought clarification from my supervisor who recommended certain changes. The final layout was factual and short with wording that the apprentices would be familiar with. Each question was kept short, with less than twenty words, and the answering options followed a distinctive and similar pattern (Oppenheim, 1992). The Phase 6 questionnaire contained ten questions while the Phase 4 questionnaire had fourteen.

3.6.3 Qualitative Methods

Qualitative research has its roots in the 'Chicago school' and can be traced back to the 1920s (Denzin & Lincoln, 2003). Early studies focused on the field of anthropology but it was not long before it began to be used in other areas such as education, social work and medicine. Qualitative research crosses over many research areas and is sometimes difficult to define. For example, Shank (1995) states *'it is difficult to find an unambiguous and definitive statement as to what qualitative research in education actually is'* (p. 3). However, in its simplest form, qualitative research may include observation, open-ended interviews and focus group sessions. Creswell (2003) offers his opinion by stating that *'a qualitative approach is one in which the inquirer often makes knowledge claims based primarily on constructivist perspectives'* (p. 18). Again, this is in keeping with the epistemology previously outlined. Qualitative data collection was an important factor in this study and took the form of interviews, observation and focus group sessions with both students and staff. As I was anxious to understand the feelings and attitudes of both of the above groups, it was necessary to incorporate qualitative methods of data collection into the research.

3.6.4 The Mixed Method Approach

Much modern research includes both quantitative and qualitative methods (Creswell, 2003; Wisker, 2001) and this study incorporated both types. There are sound reasons for incorporating both quantitative and qualitative methods in a research design such as the opportunity to use triangulation which can be used to compare the results of both methods (Patton, 1990). The diagram below shows how the quantitative and qualitative methods were used in this study and how triangulation was employed to add validity and credibility to any findings.

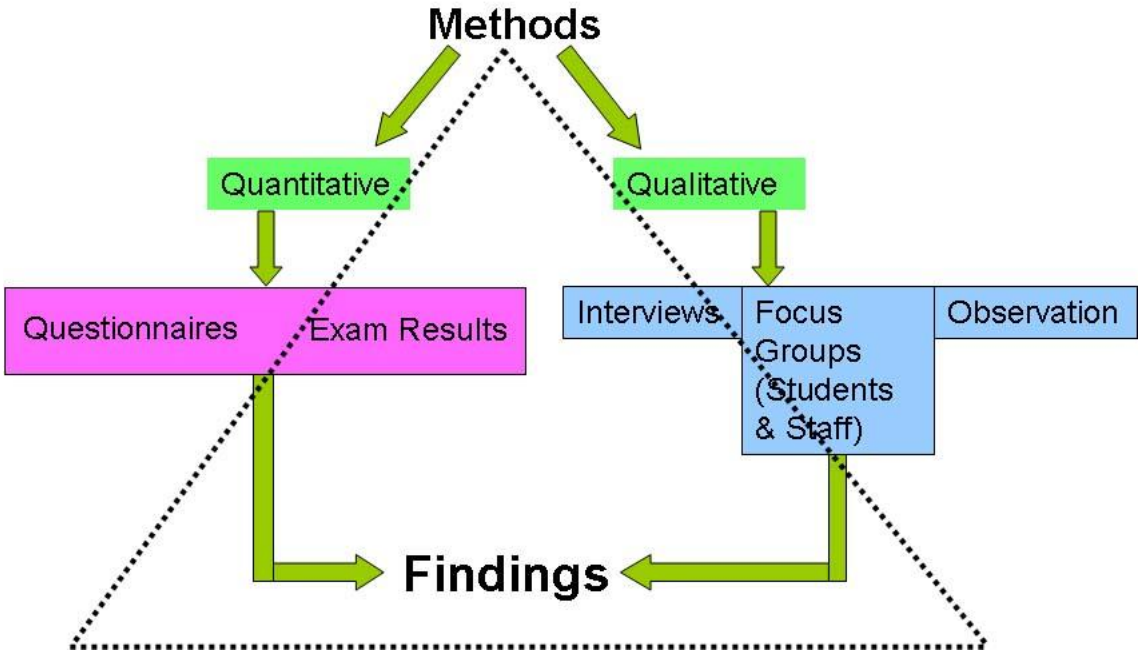

Figure 3.2 Diagrammatic representation of the mixed method approach utilised in this research study.

A mixed method approach will also offer a more complete picture of events particularly where people are involved. If only one method is employed (which is sometimes referred to as a fixed design) it may only focus on the researcher's perspective whereas flexible designs such as the mixed method approach tend to focus more on the participants (Robson, 2002). It is also the case that although quantitative methods can identify weaknesses in a study it may be difficult to explain why they occur and offer solutions. Qualitative methods on the other hand will often help to explain particular phenomenon and may offer solutions to problems. Finally, qualitative methods usually focus on the micro-level while quantitative analysis is ideally suited to large scale research (Patton, 1990).

Within this study the quantitative methods of data collection involved two substantial pieces of work. The first involved the analysis of examination scripts of Phase 4 apprentice plumbing students, with particular reference to mathematical questions. In total 160 scripts were analysed which contained 288 mathematical questions. By

comparing the examination results of those who took part in the study with those of apprentices of a similar educational level who did not, it was possible to explore the effects of the blended approach to facilitating learning in mathematics. The second piece of quantitative analysis related to two different questionnaires. The first questionnaire was completed by 106 Phase 6 apprentices. This group fulfilled an important function in the research because they had all completed the Phase 4 programme in five different third level institutions. This enabled the gathering of information on a national level, which arguably added a degree of validity to the findings. This questionnaire was completed early in the research study. The second questionnaire was completed by the forty Phase 4 apprentices who participated in the research and was carried out at the end of the study. It can be seen from these figures that a quantitative data collection method was best suited for the collection of this information. George and Cowan (1999) recommend caution when using questionnaires as a method of data collection particularly where the respondents are remote from the research site as this can lead to a low return rate. Where low returns are the case the results can often be distorted. With this in mind, I decided that all questionnaires would be filled out within the college environment.

The qualitative data collected was from interviews, observation and focus group sessions. I used semi-structured interviews as recommended by Wisker (2001) whereby a small number of set questions were asked while still offering the opportunity for some divergence. These interviews took place before the students had participated in the blended learning strategy. The apprentices who took part in the study were allocated one hour per week in the computer laboratory. In total, there were five 1 hour sessions. This offered me the opportunity to observe the students while they were in the computer laboratory. Silverman (1993) believes *'observational studies have been fundamental to much qualitative research'* (p. 9). Denzin (2001) also advocates the use of observation and believes that researchers should learn to listen and look particularly where interpretivism forms part of the research process.

At a DIT e-learning seminar held in December 2005, a group of third level students spoke about their experience using WebCT and expressed their concern at the lack of support in using this resource. As a result of this feedback, a decision was taken to offer students, who participated in this study, one hour per week in the computer laboratory, with a lecturer in attendance for support if needed. This support was in line with the epistemology of the research which has previously been outlined and was a form of scaffolding designed to assist student learning. Although the laboratory sessions were held weekly, the students could access the password protected Plumatics 4 U web site from any computer outside the campus linked to the Internet. On completion of the research, a focus group of students was formed which offered the participants the opportunity to provide feedback in relation to issues such as the support structure and course content.

It can be argued that the quantitative and qualitative methods used in this study are distinct entities, yet also manage to complement each other. While the quantitative data is cold and distant it is necessary if recommendations are to prove worthwhile, hence the need for such large numbers of questionnaires and the analysis of a significant number of examination scripts. This is acknowledged by Patton (1990) who believes that in the case of quantitative research generalisation is possible when the reactions of many are found from a limited set of questions. Silverman (2005) concurs with this view where a mixed method approach is utilised in the research study.

The qualitative aspect of this research dealt with the learning abilities of apprentices both in a classroom setting and as participants in an e-learning programme. The qualitative approach enables the researcher to get close to the participants and view the situation from their perspective. This study also allowed the investigation of circumstances where at present little is known and where further research may come later (Gillham, 2000).

3.6.5 Interviews

Almost all forms of qualitative research involve the use of interviews to collect data (Merriam, 1998) and within this study the use of this technique proved to have an important function. The number of different types of interviews outlined in the literature is dependent upon which source one reads (Cohen *et al*, 2000) but in general terms they fall into three broad areas. These are described by Merriam (1998) as 'Highly Structured, Semi-structured and Unstructured' (p. 73). Highly structured interviews are a form of written survey and tend to be quite rigid in their approach which uses predetermined questions often ignoring the individual's right to expand upon an opinion. At the other end of the spectrum is the unstructured interview which is described by Robson (2002) as *'a lengthy, intimate conversation; as a general tool, it is not an easy option for the novice'* (p. 278). The most widely used form of interview in qualitative and flexible design research is that which uses a semi-structured approach and allows the interviewee time to elaborate and expand upon areas of concern. This latter form of semi-structured interview was used as a qualitative data collection method in this study.

Patton (1990) states that *'the purpose of interviewing is to find out what is in and on someone else's mind'* (p. 278). This is an important point to be aware of because it could be the case whereby an inexperienced researcher (which I consider myself to be), could inadvertently seek to influence the respondents' opinion by either incorrect interpretation of results or incorrectly asked questions. To minimise problems such as those outlined above, George and Cowan (1999) recommend that interviews should be used in conjunction with other methods because *'on their own they risk being unrepresentative and not rigorous'* (p. 77).

As part of this research I carried out semi-structured interviews with 144 Phase 4 apprentices over a period of twelve months. These interviews took place with groups of two or three students in the practical workshops where there is scope for interaction and communication between student and lecturer. The participants were from three

different intake groups and each group spent eleven weeks in the Institute with thirty-five hours contact time with lecturers per week. When the opportunity is presented to spread interviews over such a lengthy time span it is possible to determine if any trends or patterns are developing. A degree of caution is required when using and collecting data from longitudinal studies. Robson (2002) outlines some of the difficulties associated with this method of data collection as the time involved, sample attrition rates, and the need for special methods of data collection. However, these issues did not impact on the data collection in this study and the information gathered was used primarily as a means of triangulation to confirm the quantitative findings that emerged from questionnaires. The decision to use interviews and not questionnaires was deliberately taken because I wanted to have a dialogue with the students, and although the specific data that I was recording could have been collected in a questionnaire, the exchange of ideas and opinions is extremely valuable. Travers (2001) acknowledges this fact by stating that the researcher is *'likely to obtain some rich, original data'* (p. 3) and will also understand far more about what takes place in the interviewee's environment. In discussing longitudinal and trend studies Cohen *et al.* (2000) state that these *'are sometimes termed developmental research because they are concerned both to describe what the present relationships are among variables in a given situation and to account for changes occurring in those relationships'* (p. 169). When these interviews took place the research was in a development stage, including the Plumatics 4 U web site. A crucial piece of information that I needed to determine was the opinion of apprentices relating to blended learning. I believed that by interviewing the students and speaking about blended-learning the responses would be varied and complex, which turned out to be the case. If this data was collected by questionnaire the limited response would not have offered the students the opportunity to express their views.

The issues discussed above regarding student opinion of blended learning was not presented as data in the study. The data collected related to three specific areas which were: the second level educational qualifications of those interviewed; their opinion as to the level of mathematics in the trade of plumbing; and whether or not they had assess to the Internet from home.

3.6.6 Observation

Observation as a research method has its roots in ethnography (Angrosino and Mays de Péres, 2000). It offers the researcher the opportunity to participate in the research or to remain outside as a detached observer. Observational data can *'permit the evaluation researcher to understand a program or treatment to an extent not entirely possible using only the insights of others obtained through interviews'* (Patton, 1990, p. 25). Therefore, observation can be advantageous to a study and may offer the opportunity for triangulation. As such, observation is a qualitative method of enquiry. In the research outlined in this study, non-participant observation was used for two specific purposes. Firstly, to examine the degree to which students interacted and communicated with each other and secondly, to determine whether students could access the Plumatics 4 U web site on their own with the information provided. Occasionally, I was asked by students for assistance and on such occasions I willingly answered the query but detached myself from the situation immediately afterwards. The rationale for this approach was that I did not want to appear to be directing the students to particular areas of the web site but wanted to give them the freedom to surf, browse it and carry out exercises and tests as they so desired. However, occasionally some needed help in accessing and navigating the site and in such situations the lecturer becomes *'the guide who directs learners to resources'* (Porter, 2004, p. 20).

Observation is particularly useful in small projects which are conducted over a relatively short time. However, a degree of caution is required to ensure that the researcher does not affect the situation under observation (Robson, 2002). It is also the case that observers have their own prejudices and may not enter the field with a completely blank slate or open mind (Patton, 1990). There is also an ethical dimension to be aware of when using observation because although participants may have agreed to take part in a study, they may feel uncomfortable when under observation and may not have the strength of will to withdraw or express their concerns. As can be seen, I used observation in a very limited way and only for the two specific purposes outlined above. A simple matrix was used to collect field notes and this is shown in Appendix F.

During each computer laboratory session I recorded those who needed assistance accessing the site and also those who collaborated during the activities.

3.6.7 Focus Group Sessions

Focus groups are a type of interview conducted between a researcher and the participants in a study. Cohen *et al.* (2000) suggest they are *'useful to triangulate with more traditional forms of interviewing, questionnaire, observation etc.'* (p. 288). Focus groups date from the 1950s when they were used as a tool by market researchers for consumer opinion on products or services (Fontana and Frey, 2003). Before using focus groups, the interviewer has to decide whether to direct and control the proceedings (Patton, 1990) or let the interviewees decide upon the direction themselves (Cohen *et al*, 2000).

Focus groups have the advantage of being a relatively inexpensive form of data collection which can yield a significant amount of information within a short time frame. They also empower the participants and allow them to express their views freely (Robson, 2002). In this study two focus groups were used. The first consisted of the students who participated in the research and the second involved the teaching staff in the plumbing section. Both focus group sessions were taped and the transcripts are contained in Appendix G and Appendix H. The focus groups fulfilled two distinct roles. The student focus group gave those who took part in the research the opportunity to give feedback relating to their experience of e-learning and to comment on the content of the material on the web site. The staff focus group was more concerned with the overall concept of blended learning as a strategy and with the area of student support and how e-learning could impact in this field. Both focus group sessions will be given a greater depth of treatment in Chapter Five.

3.7 Triangulation

Triangulation may be used to ensure the validity and the credibility of the research findings and has the advantage of not relying on any singular data source or method (Patton, 1990). Its purpose is to add rigour to the research (Robson, 2002). Cohen *et al.* (2000) define triangulation as *'the use of two or more methods of data collection in the study of some aspect of human behaviour'* (p. 112). In this study several methods were employed which offered the opportunity for triangulation. These included qualitative methods such as interviews, focus groups and observation. One of the principal reasons for using triangulation is to ensure validity and reliability (Merriam, 1998). If a research study is not valid then it is essentially worthless. Likewise, if it is unreliable then it cannot be replicated. These matters are extremely important in this research study because with such large numbers of apprentices affected by the subject matter, generalizability of the findings may be an issue.

While there are many scholars who advocate and promote the use of triangulation (Fontana and Frey 2003; Stake 1995; Patton 1990), there are also those who are somewhat critical of its use. Silverman (1993) for example, believes that triangulation is *'usually inappropriate to qualitative research'* (p. 156) and urges a degree of caution when making comparisons of different methods. Care is required when interpreting the results not to use one method to over-ride another in search of a convenient argument. Silverman (1993) believes the best solution is to distinguish the 'how' from the 'why' questions *'and to triangulate methods and data only at the 'why' stage'* (p. 158). Within this research study, I used triangulation to establish why so many Phase 4 apprentices had difficulty with mathematics by firstly analysing examination scripts, and then establishing that these were the students with a Junior Certificate qualification. Then, by interviewing students who held only a Junior Certificate, I was able to establish a need for this study. As further confirmation of the necessity for a supportive mathematical resource for students, I held informal interviews with staff in the department who all agreed that this study was worthwhile.

3.8 Summary

This chapter has shown how a strategy of enquiry best suited to the research question was developed. The theoretical perspective is that of interpretivism with the epistemology of constructivism which is most appropriate to apprenticeship education. It is argued that within this formative evaluation research study a mixed method approach of data collection, incorporating quantitative and qualitative methods, was particularly useful. The rationale for using interviews, focus group sessions, observation and questionnaires was detailed and these different methods enabled the use of triangulation which added rigour and validity to the study.

It has been shown that the majority of studies carried out to date within the Irish apprenticeship system are quantitative in nature and that no study of plumbing apprentices has been conducted. There is also a lack of qualitative research within the Irish apprenticeship education system.

Chapter Four

Presentation of Findings

4.1 Introduction

This chapter will present the findings from both the quantitative and qualitative data. The quantitative data was collected from two questionnaires and also from an analysis of the examination results of Phase 4 student apprentices. The first questionnaire involved Phase 6 apprentices who have all successfully completed the Phase 4 off-the-job programme. The second questionnaire was completed by the Phase 4 apprentices who took part in the research and was undertaken towards completion of the study.

The qualitative data was obtained from interviews, observation and focus group sessions. Part of the reason for using these methods was to confirm the findings from quantitative data and offered a degree of triangulation. Although the results from these qualitative methods are incorporated into the various tables, the methods themselves will be discussed in detail.

The presentation of the quantitative data is broadly in line with the layout recommended by Hart (2005) who suggests that research findings be presented in tables rather than pie charts, graphs or figures. He furthermore believes that whole numbers should be used in favour of percentages. The rationale for this argument is that percentages alone can often distort the power of the data. I have therefore decided that where numbers are not consistent the findings are presented in tables that include both numerical information and percentages. In the quantitative data where the numbers are constant the findings are shown in the form of pie charts.

4.2 Data Analysis

A major consideration within any research study is the analysis of data. The researcher needs to be aware of the type of data required, the population from which it will be gathered, the methods of analysis, and verification (Cohen *et al*, 2000). When quantitative data is collected, for example in questionnaires, the analysis cannot commence until all the information has been gathered. However, in the case of qualitative research it is often possible to commence analysis during the data collection process. Once the data has been collected the next step is to reduce it to manageable proportions. This process is referred to as 'Data Reduction'. Miles and Huberman (1994) make the interesting point that *'data reduction is not something separate from analysis. It is part of analysis'* (p. 11). It occurs throughout the research process and continues until the final report is completed. In the case of large surveys and questionnaires it can be carried out with the aid of computer packages such as SPSS (Statistical Package for the Social Sciences).

When large amounts of data are analysed using computer software packages the information is often required to be 'cleaned' (Robson, 1993). This process ensures that the information entered into the computer is correct. In this study quantitative data was collected from a total of 146 questionnaires. The relatively small amount of data was easily catered for using the Microsoft Excel programme. The study also included data from interviews, focus group sessions and non-participant observation sessions. These qualitative data sources are treated differently and are often rich in content because they include the thoughts, views and opinions of the actors involved.

4.3 Quantitative Data Presentation

The quantitative data presented in this section will cover the following areas:

- Apprentices with Leaving and Junior Certificates Nationally;
- Plumbing Apprentices with Leaving and Junior Certificates;
- Pre-research Phase 4 examination results;
- Phase 6 questionnaire results;
- Post-Research Phase 4 questionnaire results;
- Post-research Phase 4 examination results;
- Access to the Internet.

4.3.1 Apprentices with Leaving and Junior Certificates Nationally

There are currently 28,252 student apprentices registered in the Republic of Ireland. Statistics show that 53% of all apprentices hold the Leaving Certificate qualification (DIT, 2004). This data is shown in Table 4.1 below.

Apprentices Nationally	Apprentices with Leaving Certificate	Apprentices with Junior Certificate
28,252	14,840 (53%)	13,160 (47%)

Table 4.1 Second level qualifications for apprentices nationally throughout the Republic of Ireland.

There are no figures available which indicate the standard of second level qualifications of participants in individual trade areas for the twenty-six different apprenticeships. Although there is anecdotal evidence that apprentices who only hold a Junior Certificate have a difficulty with mathematics, there is no reliable evidence to back this assertion. As part of this research study it was therefore necessary to determine the number of plumbing apprentices who held the Junior Certificate and the Leaving Certificate.

4.3.2 Plumbing Apprentices with Leaving and Junior Certificates

Table 4.3 below shows that 60% of apprentice plumbing students hold a Leaving Certificate qualification while the remainder (40%) hold a Junior Certificate only. These figures were determined following interviews and questionnaires with 250 apprentice plumbing students attending the Dublin Institute of Technology School of Construction at Bolton Street. This data was collected from three different intakes of apprentices between March 2005 and March 2006. The Phase 4 apprentices were interviewed while the Phase 6 apprentices completed a questionnaire.

The use of cross-sectional analysis allowed for a comparison to be made around a specified theme which in this case was the second level educational attainment of apprentices. As shown in Tables 4.2 and 4.3 below, 250 apprentices were asked to indicate their second level qualifications. The data from the Phase 4 apprentices was obtained from semi-structured interviews while that from the Phase 6 apprentices was from questionnaires. Using such large numbers, and also combining different methods of data collection, can contribute to the generalizability of findings while also adding rigour to the analysis (Mason, 1996).

Group	Number of Apprentices	Course Date	Leaving Certificate	Junior Certificate Only
Phase 4	48	March to June 2005	62%	38%
Phase 4	48	September to December 2005	66%	34%
Phase 4	48	January to March 2006	48%	52%
Phase 6	50	September to December 2005	56%	44%
Phase 6	56	January to March 2006	70%	30%

Table 4.2 The variation in second level qualifications among different course groups.

The second level educational qualifications of apprentice plumbers vary considerably and this is evident when the different intakes of students are analysed. It can be seen from Table 4.2 above that the percentage of apprentices having only a Junior Certificate in an average Phase 4 class of sixteen students varies from 38% to 52%, and in one Phase 6 class this figure was as low as 30%. It is therefore difficult to present an accurate figure representative of the educational attainments of apprentice plumbers as a whole, but when 250 students were surveyed the results showed that 60% held a Leaving Certificate and the remainder the Junior Certificate. Determining a representative sample size is never clear-cut (Cohen *et al,* 2000) but I believe the above figures are broadly representative of the second level qualifications of apprentice plumbing students. For example, in the year 2005 there were 205 apprentice plumbers attending Phase 4 courses in the various Institutes of Technology throughout Ireland (FÁS, 2005). Table 4.2 shows that ninety-six of the total group attended the Dublin Institute of Technology, so the representative sample was 47%.

Mason (1996) believes *'that qualitative researchers should ensure that there is a very direct link between their sampling strategy, their data analysis and the type of social explanation they intend to construct'* (p. 93). In line with this, and to add reliability to these results, this exercise was repeated with different intake groups in 2006 with the results calculated to provide an average percentage. Determining the above percentages was an important factor in the research because while there was anecdotal evidence which suggested that apprentices who held only a Junior Certificate qualification had a difficulty with mathematics, there was no data available to back this up.

When averaged out for the trade of plumbing the final figures are as follows:

Total number of apprentices:	250
Apprentices with Leaving Certificate:	60%
Apprentices with Junior Certificate only:	40%

Table 4.3 Plumbing apprentices with Leaving Certificate or Junior Certificate.

4.3.3 Pre-Research Phase 4 Examination Results

Having established the second level educational qualifications of plumbing apprentices, the next procedure was to establish if those with only the Junior Certificate had a difficulty with mathematics in theoretical examinations. To determine if this was the case it was necessary to analyse the examination scripts of Phase 4 students. The number of scripts analysed was in the same ratio as that indicated in Table 4.3 above where 60% of the apprentices had a Leaving Certificate and 40% had a Junior Certificate only. It should be noted that in the Phase 4 apprentice plumbing curriculum students sit three theory examinations into which the mathematics questions are totally integrated. Each examination paper includes up to three questions with a mathematical content. The findings shown in Table 4.4 below are from an analysis of examination scripts of students who attended the Phase 4 apprentice plumbing programme at DIT Bolton Street between January 2004 and June 2005. The results show that 39% of apprentices with a Junior Certificate fail one or more mathematical questions and that these students are four times more likely to fail mathematical questions when compared to those who hold a Leaving Certificate.

Number of scripts analysed:	160
Number of mathematical questions analysed:	288
Apprentices with Leaving Certificate who failed one or more mathematics question:	10%
Apprentices with Junior Certificate who failed one or more mathematics question:	39%

Table 4.4 Analysis of examination results for Phase 4 plumbing apprentices with Leaving Certificate or Junior Certificate.

The results for theoretical examinations vary from group to group, and to test if the above findings were reliable, a comparison was made of the examination results of forty-eight students who attended the Phase 4 programme at DIT Bolton Street between September and December 2005. These results are shown in Table 4.5. This comparison did not form part of the findings shown in Table 4.4 but was used to verify the previous research figures to confirm their reliability. While the findings are not identical to those in the previous table, they are broadly similar, except that a greater number of students held a Leaving Certificate.

Total number of Phase 4 apprentices:	48	
Number of apprentices with Junior Certificate:	16	34%
Number of apprentices with Leaving Certificate:	32	66%
Apprentices with Junior Certificate who failed one or more mathematics question:	12	25%
Apprentices with Leaving Certificate who failed one or more mathematics question:	6	12%

Table 4.5 Analysis of examination results for Phase 4 apprentices who attended the School of Construction between September and December 2005.

What the above figures also indicate is that of the sixteen apprentices who hold only a Junior Certificate qualification, twelve (i.e. three-quarters) had some difficulty with at least one mathematics question.

4.3.4 Phase 6 Questionnaire Results

Two questionnaires were used in this research study. The first was completed by Phase 6 apprentices who did not participate in the blended learning mathematics module, while the second was completed by the Phase 4 apprentices who had access to the Plumatics 4 U web site. This second questionnaire was completed towards the end of the study. Both questionnaires followed the outline recommended by Oppenheim (1992).

One hundred and six Phase 6 apprentices completed the questionnaire which is shown in Appendix I. There were two important reasons for collecting this data. Firstly, half of this group had attended the Phase 4 programme in the DIT, while the remainder attended other Institutes of Technology throughout the country. The responses to the various questions were therefore representative of a wide range of Institutes of Technology which deliver the Phase 4 programme. The second reason for involving this group is that they had all successfully completed the Phase 4 programme, notwithstanding the fact that almost one-fifth had failed at least one of the three theory examination at an earlier stage, as indicated in Table 4.9.

As shown in Table 4.6 below, 49% of the Phase 6 apprentices attended an Institute of Technology other than the DIT during their Phase 4 programme. This mix of students from a variety if Institutes gave a broad sampling of opinion to the questionnaire findings. A complete breakdown of the data from the Phase 6 questionnaire can be found in Appendix J.

Question one asked apprentices to indicate where they completed their Phase 4 off-the-job programme.

Institute of Technology Attended	Number of apprentices	Percentage
Dublin Institute of Technology	54	51%
Blanchardstown I.T.	40	38%
Dundalk I.T.	3	2%
Athlone I.T.	4	4%
Cork I.T.	5	5%

Table 4.6 Breakdown of where plumbing apprentices attended Phase 4 programme.

Question two asked the apprentices to indicate if they had failed any Phase 4 theory examinations.

Apprentices who failed theory examinations in Phase 4:	19	18%
Apprentices who did not fail theory examinations in Phase 4:	87	82%

Table 4.7 Phase 6 apprentices who failed theory examinations in Phase 4.

Question three asked the Phase 6 students to indicate if they held a Junior Certificate or Leaving Certificate as their highest second level qualification.

Apprentices with Junior Certificate only:	40	38%
Apprentices with Leaving Certificate:	66	62%

Table 4.8 Second level educational qualifications of Phase 6 apprentices.

By further analysis of questions two and three it was possible to ascertain the failure rate of those who held a Junior Certificate when compared to those with a leaving Certificate. This type of analysis where several questions are combined to provide further data can be useful and is referred to by Oppenheim (1992) as *'data transformation'* (p. 286). The results show that among this group 30% of those with a Junior Certificate failed a theory examination compared to a figure of 11% of those with a Leaving Certificate.

Phase 6 apprentices with a Junior Certificate who failed a theory examination	12	30%
Phase 6 apprentices with a Leaving Certificate who failed a theory examination	7	11%

Table 4.9 Comparison of failure rate between Junior and Leaving Certificate apprentices.

The issue of student support is central to this research project. When asked if extra support was available during the Phase 4 programme outside of the regular timetabled classes only 25% answered 'Yes'. The type of support available varied between after-class sessions and night classes that students had to pay for as shown in Table 4.11. A significant number (58%) indicated that they would have availed of additional support if it was offered to them.

Question four asked apprentices if there were any support structures in place, outside the regular timetabled classes, available to them during the Phase 4 programme.

Yes – Support available	27	25%
No – Support unavailable	79	75%

Table 4.10 Support structures available to apprentices.

Question five asked those who were aware of additional support to indicate how it was provided. This question also asked students to indicate if any online support was available. No apprentice was aware of any such support.

Type of support Available	Number of apprentices	Percentage	Student comments
Night classes	3	3%	Very expensive
After class sessions	3	3%	

Table 4.11 Types of additional support available for student apprentices.

In question six apprentices were asked if they would have availed of additional support had it been available to them.

	Number of apprentices	Percentage
Those who would have availed of support	61	58%
Those who would not have availed of support	16	15%
Those who did not know if they would have availed of support	29	27%

Table 4.12 Students who would have availed of support.

Following on from the previous questions, students were asked in question seven to indicate their preferred method of support. Not surprisingly, one-to-one and group tuition accounted for 87% of students' preferred methods of support. This type of support is often described as the ideal teaching environment but is rarely feasible for a variety of reasons such as large student numbers (Laurillard, 1993; Prensky, 2002).

It is interesting to note that the concept of Internet-based learning only appealed to 9% of the respondents. This may be due to the fact that e-learning does not form part of the education curriculum for apprentice plumbers. These results are shown in Table 4.13 below.

	Number of apprentices	Percentage
Those whose preference would be face-to-face tuition on a one-to-one basis	29	27%
Those whose preference would be face-to-face tuition in a group setting	64	60%
Those whose preference would be learning via the Internet	9	9%
Those whose preference would be distance learning using paper based material	4	4%

Table 4.13 Students' preferred method of support.

Two questions particularly relevant to the mathematical content of the Phase 4 programme were asked in the final part of the Phase 6 questionnaire. Question eight asked the students to describe the level of difficulty of the mathematical content of the Phase 4 programme. Over one-third described the level as 'Difficult' and this group was almost exclusively those with a Junior Certificate qualification only.

	Number of apprentices	Percentage
Those who felt the level of mathematics in Phase 4 was difficult	37	35%
Those who felt the level of mathematics in Phase 4 was easy	14	13%
Those who felt the level of mathematics in Phase 4 was about right	55	52%

Table 4.14 Student perception as to the level of mathematics in the Phase 4 programme.

Question nine asked the students if they believed that additional support in craft mathematics should be available in the Phase 4 programme. It can be seen that two-thirds of students believe that additional support should be available. It could be argued therefore that there is an onus on the Institutes of Technology to respond to this because at present so little is available for students who need to repeat theory examinations.

	Number of apprentices	Percentage
Yes – Additional support should be available	71	67%
No – Additional support should not be available	17	16%
Don't know	18	17%

Table 4.15 Student response when asked if additional support should be available.

The final question asked the Phase 6 students to indicate if they had access to the Internet from home. This particular question has significant implications with regard to e-learning where access to learning platforms such as WebCT or Moodle are required and will be dealt with in more detail in section 4.8 of this chapter.

	Number of apprentices	Percentage
Phase 6 apprentices with access to the Internet from home	68	64%
Phase 6 apprentices who do not have access to the Internet from home	38	36%

Table 4.16 Phase 6 student apprentice access to the Internet from home.

4.3.5 Post-Research Phase 4 Questionnaire Results

Forty apprentices took part in the research study and the day after their final theory examination they completed a questionnaire, a copy of which is in Appendix K. Among this group 50% had a Junior Certificate which is a higher average than what I believe the national figure to be. The findings show that 98% of the students found the experience to be worthwhile or very worthwhile with 93% stating that the content on the Plumatics 4 U site was relevant to the Phase 4 programme. There was a high level of satisfaction with the worked examples and self-tests also.

With the exception of questions nine and eleven (which were answered by thirty-eight students) every other question was completed by the forty students who participated in the research. Therefore, as the numbers are consistent, these results are presented in pie charts. A complete breakdown of the figures that are presented in this section can be found in Appendix L.

The first question asked the apprentices to describe their experience of e-learning.

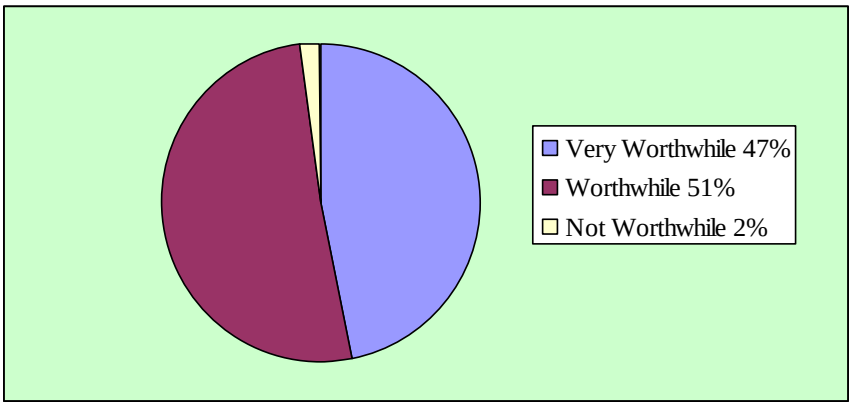

Figure 4.1 Student apprentice experience of e-learning.

In question two the apprentices were asked to describe the level of the mathematical material contained in the Plumatics 4 U web site.

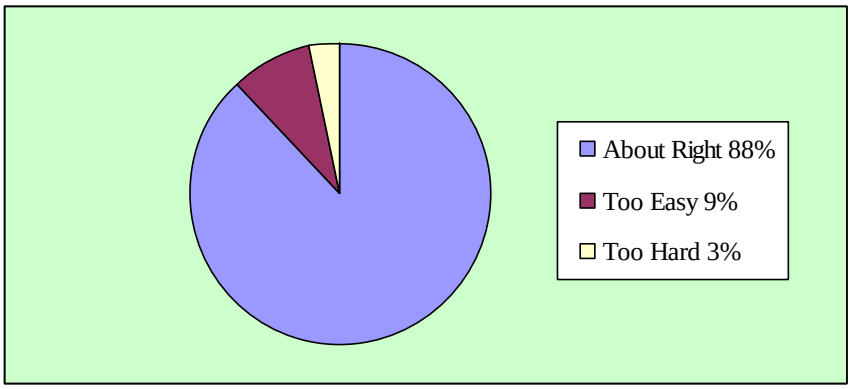

Figure 4.2 Student opinion of the level of material on the Plumatics 4 U web site.

Question three asked the students if they felt the content of the Plumatics 4 U web site was relevant to the Phase 4 apprentice plumbing programme.

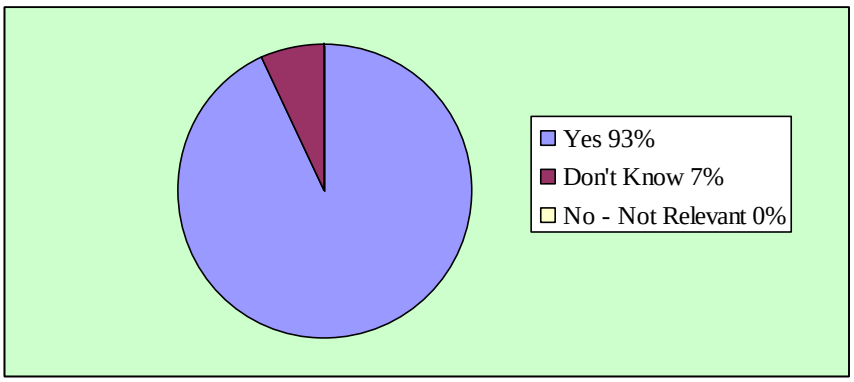

Figure 4.3 Results regarding the relevance of the web site.

Question four referred to the self-tests and asked the students to indicate which statement they agreed with. The three options were:

- There were too many self-tests
- I would have liked more self-tests
- The self-tests were not necessary

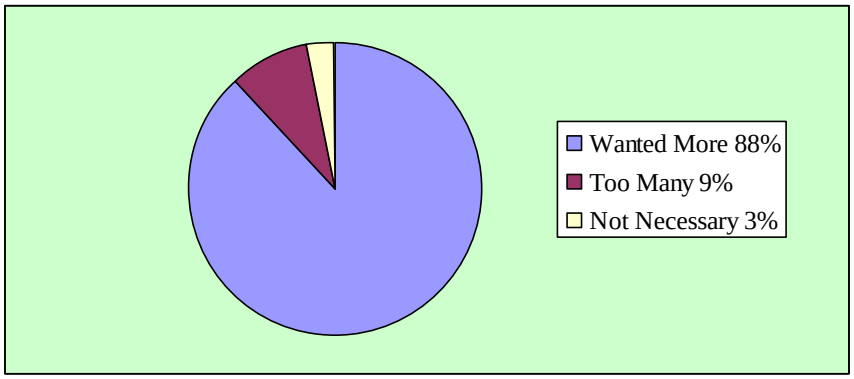

Figure 4.4 Findings relating to the self-tests contained on the web site.

Question five related to the worked examples on the site and again offered three options which were:

- The worked examples were helpful
- There could have been more worked examples
- The worked examples were not necessary

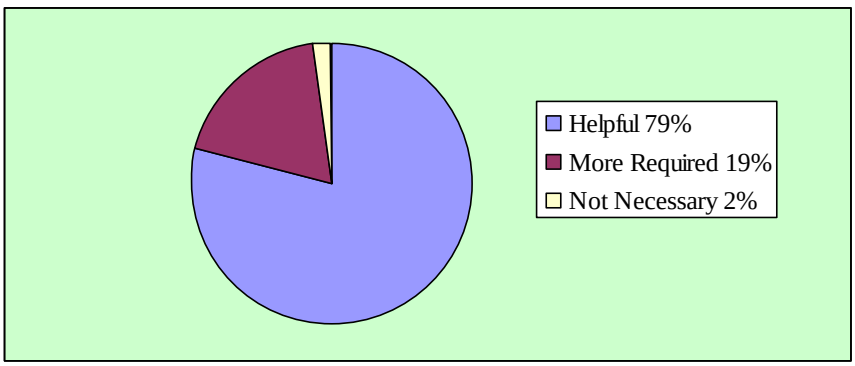

Figure 4.5 Student opinions of the worked examples contained on the web site.

Question six asked the students how useful they thought this e-learning resource would be for Phase 4 apprentices.

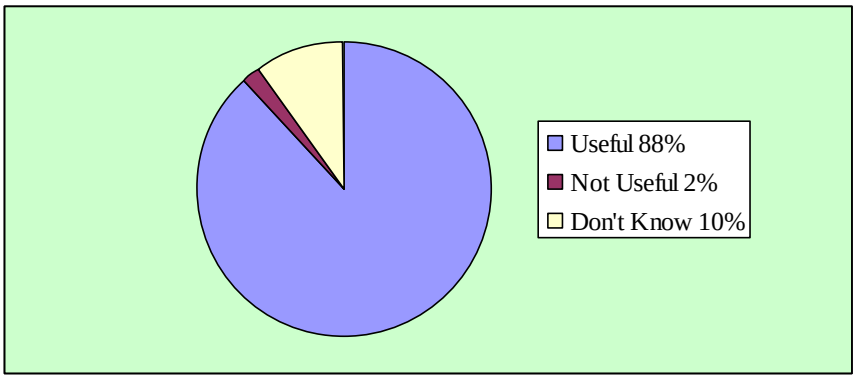

Figure 4.6 Results regarding the usefulness of this e-learning resource.

In question seven the students were asked if they would recommend this e-learning module to fellow apprentices. Ninety-five per cent answered 'Yes'. This is a very important finding and may justify making the online content available to Phase 4 apprentices who attend Institutes of Technology in other parts of the country.

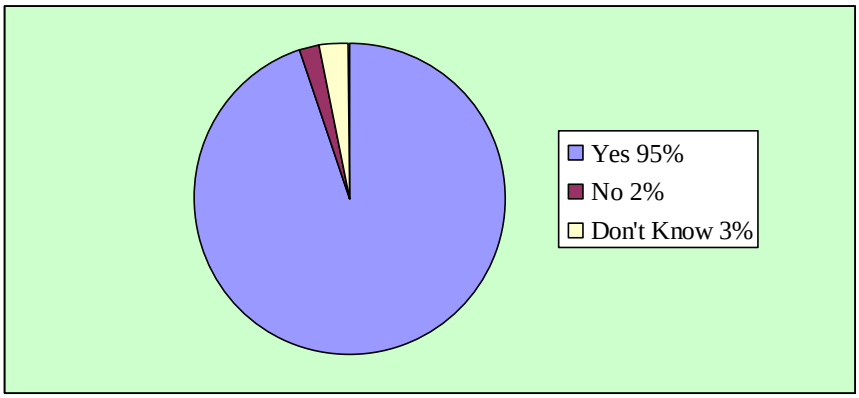

Figure 4.7 Student views as to whether they would recommend e-learning to fellow apprentices.

Question eight enquired as to whether the students would like to participate in e-learning in this subject in the future.

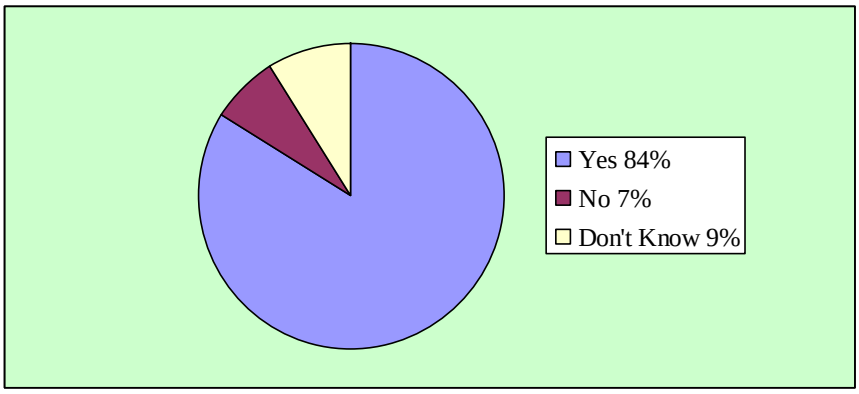

Figure 4.8 Student interest in future participation in e-learning.

In question nine the apprentices were asked to give a reason for recommending this module to fellow students. Thirty-eight students responded to this question. In addition to giving a reason for recommending the e-learning module, many also made a comment regarding their own feelings relating to the blended learning experience. This proved to be very useful feedback and all except two comments were positive.

While all the statements are contained in Appendix M, a selection of the responses to this question are shown below.

- *'I would recommend it because it was helpful. You could take your time over it at home.'* (Student 4/1 B)

- *'I would definitely recommend this module as I found it to be a great study aid and a good interactive way of learning which I think everyone would agree with'.* (Student 4/1 H)

- *'Found it very good for when I was studying.'* (Student 4/2 A)

- *'Because it's a good web site. Gives you good information and pictures are good'*. (Student 4/2 B)

- *'It's good that the site can be accessed from outside the college. You can try the questions and check the answer'*. (Student 4/2 F)

- *'Because some people struggle with maths and would be too embarrassed to say anything publicly'*. (Student 4/2 G)

Question ten asked the apprentices if they felt support was available to them during the e-learning module. Feedback from questions such as this is a valuable resource and needs careful consideration. Patton (1990) believes that the value of feedback cannot be over-emphasised and states that in relation to evaluation research, *'giving feedback can be a major part in the verification process'* (p. 267). The availability of student support was of major concern throughout both the design and implementation of this e-learning resource, and it was interesting to find that 93% of the apprentices believed that support was available in the blended approach of classroom activities combined with the Plumatics 4 U web site when required. This is, I believe, in line with Laurillard (1993) who states that programmes *'are most successful when students are properly prepared, and know what to expect when they encounter a programme, what they are expected to get from it, and what to do with it'* (p. 216).

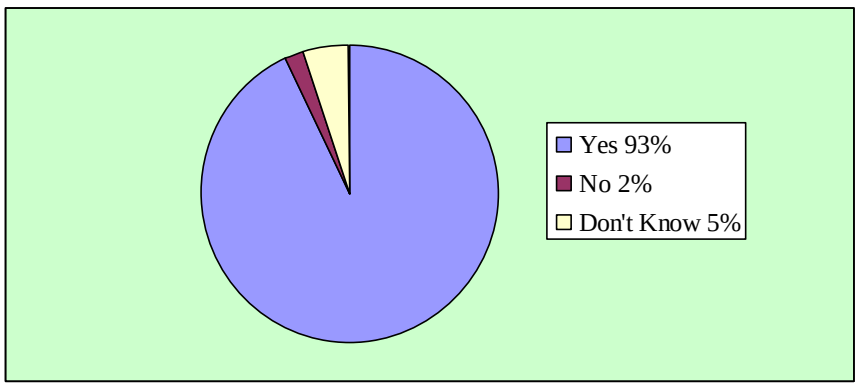

Figure 4.9 Findings regarding the level of support available to students.

In question eleven the apprentices were asked if they accessed the Plumatics 4 U web site outside the planned weekly session in the computer laboratory. Thirty-eight of the forty students answered this question.

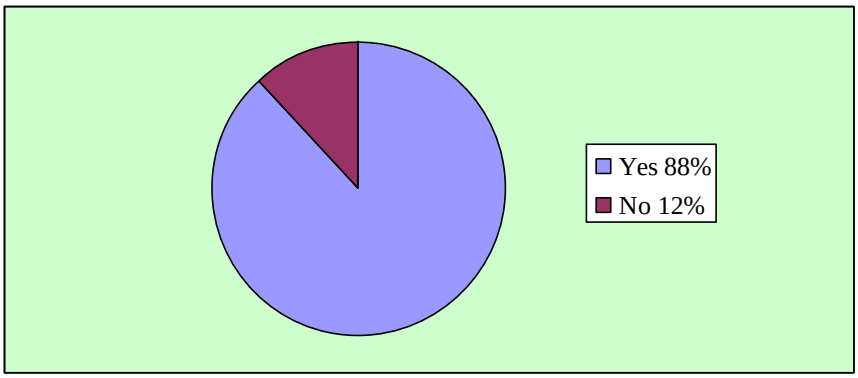

Figure 4.10 Use of the web site outside weekly sessions.

Question twelve asked those who answered 'Yes' to the previous question to indicate where they accessed the Plumatics 4 U site from. The results shown relate to the thirty-eight students who answered 'Yes' to question eleven.

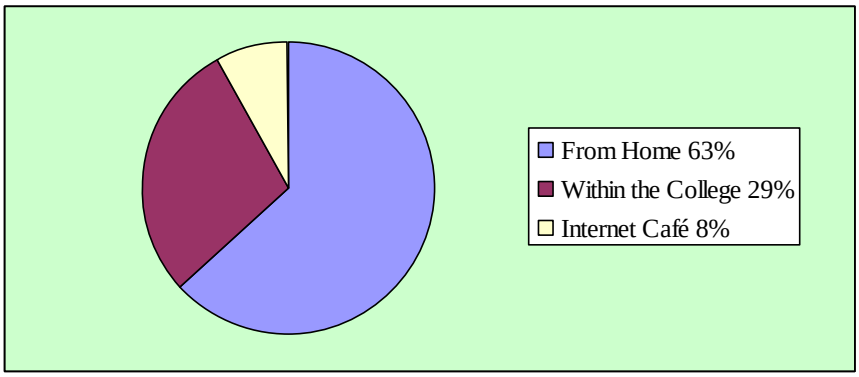

Figure 4.11 Where students accessed the web site outside the weekly planned session in the computer laboratory.

Question thirteen asked the students to indicate if they had access to the Internet from home. Access to the Internet is a vital component with regard to e-learning using WebCT and will be dealt with in section 4.8 of this chapter.

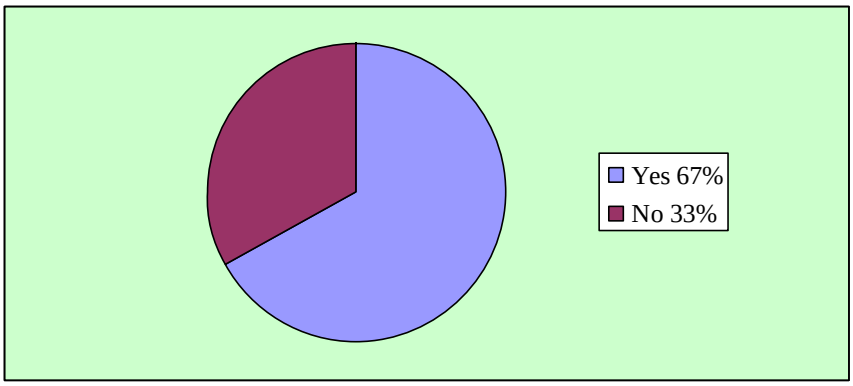

Figure 4.12 Student access to the Internet from home.

The final question asked the apprentices to indicate their highest second level qualification.

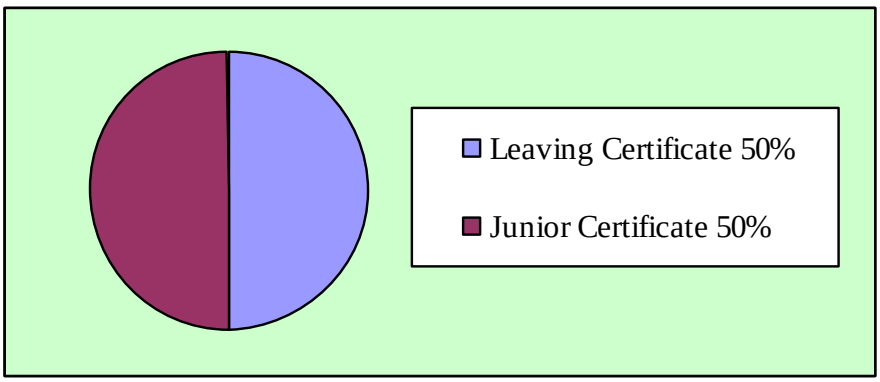

Figure 4.13 Second level qualifications of those who took part in the research.

By transforming the data from questions thirteen and fourteen (Oppenheim, 1992) it was possible to identify the number of apprentices with the Junior Certificate or Leaving Certificate involved in the study who had access to the Internet from home. This information is presented in both a table and a pie chart.

	Junior Certificate	**Leaving Certificate**
Access to the Internet from home	15 (75%)	14 (70%)
No access to the Internet from home	5 (25%)	6 (30%)

Table 4.17 Phase 4 student apprentice access to the Internet from home.

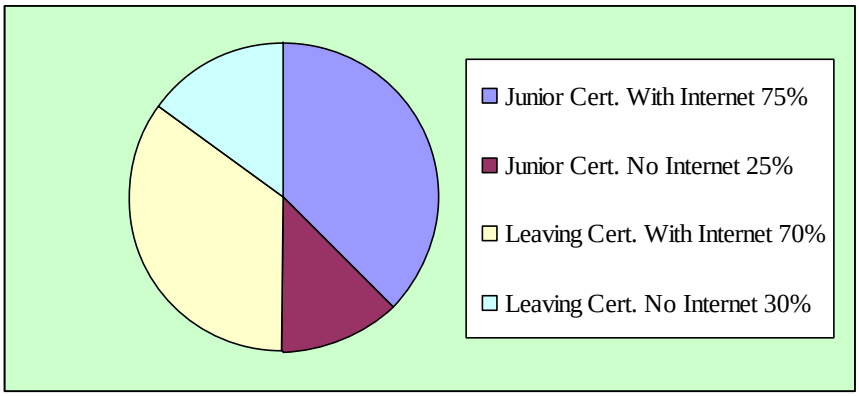

Figure 4.14 Phase 4 student apprentice access to the Internet from home.

4.3.6 Post-Research Phase 4 Examination Results

It has been shown in Table 4.4 that 39% of plumbing apprentices who only hold a Junior Certificate second level qualification fail at least one mathematics question in the Phase 4 theory examinations. On completion of the research an analysis of the examination scripts of those who took part in the study was undertaken. Although Table 4.3 indicated that on average 60% of plumbing apprentices hold a Leaving Certificate and 40% a Junior Certificate, these figures fluctuate in different intake groups as shown in Table 4.2. It is therefore not surprising that the second level qualifications of students who participated in the research differed slightly from that shown above.

Total number of apprentices who took part in the research study:	40
Apprentices with Leaving Certificate:	50%
Apprentices with Junior Certificate:	50%

Table 4.18 Second level qualification of those who took part in the research.

Table 4.19 below shows that upon completion of the blended learning mathematics module, those students with a Junior Certificate who failed at least one mathematics question fell from 39% to 29%.

Number of scripts analysed:	120
Number of mathematics questions analysed:	240
Apprentices with Leaving Certificate who failed one or more mathematics question:	8%
Apprentices with Junior Certificate who failed one or more mathematics question:	29%

Table 4.19 Analysis of examination results for Phase 4 plumbing apprentices with Leaving Certificate and Junior Certificate.

4.3.7 Access to the Internet

The following data was collected from both semi-structured interviews and questionnaires. When students were asked if they had access to the Internet from home pc's the following results were obtained.

Number of apprentices surveyed:	250	
Those with Internet access from home:	158	(63%)
Those without Internet access from home:	92	(37%)

Table 4.20 Number of apprentices with Internet access from home.

For students to participate in an e-learning module or programme using WebCT, Moodle or similar web based portals, they need access to the Internet either from home or within the college environment (Armitage and O'Leary, 2003). Table 4.20 above shows that 63% of apprentices had access to the Internet from home. This figure included both Phase 4 and Phase 6 apprentices. In question ten of the Phase 6 questionnaire, 64% of respondents indicated that they had access to Internet from home. However, further analysis of Phase 4 interviews shows that students with a Junior Certificate qualification only are less likely to have an Internet connection from home as shown below.

	Number of Apprentices	**Percentage**
Apprentices with the Leaving Certificate who have access to the Internet from home	46	70%
Apprentices with the Leaving Certificate who do not have access to the Internet from home	20	30%
Apprentices with the Junior Certificate who have access to the Internet from home	22	55%
Apprentices with the Junior Certificate who do not have access to the Internet from home	18	45%

Table 4.21 Further analysis relating to access to the Internet.

4.4 Qualitative Data Presentation

The qualitative data presented in this section will cover the following areas:

- Focus group sessions;
- Observation;
- Phase 4 student apprentice interviews.

4.4.1 Focus Group Sessions

Focus groups are often described as group interviews (Robson, 2002; Oppenheim, 1992). Two focus group sessions were included in this study, one with a group of students who participated in the research and a second with members of the teaching staff in the plumbing section who deliver the mathematics modules. The number of participants in a focus group session is important with between eight and twelve considered to be the ideal number (George and Cowan, 1999; Oppenheim, 1992).

The two focus group sessions were used for different purposes. The session with the students was used as a means of cross-referencing the findings of the Phase 4 questionnaire which were presented earlier in this chapter. This is in line with the recommendations of Mason (1996) who states *'cross-sectional analysis implies that you are making comparisons across the whole of your data set, around certain specified themes'* (p. 158). These themes relate to the students' attitude to e-learning and their views as to the blended learning process and its future as it applies to apprentice education. For example, in question eight of the Phase 4 questionnaire, 84% of the students indicated that they would like to participate in e-learning in the future. This opinion was confirmed by those who took part in the focus group session. When asked if they would like more subject matter made available through WebCT they stated: *'It would be great for revision'* Student G; and *'If there were lots of subjects it would be great'* Student B.

The students who took part in the focus group session indicated that overall their experience of blended learning was positive. Student C stated that *'It's good because it helps you go through the stuff'* while Student D commented that *'It helps you remember formulas'.* An interesting finding that emanated from this group was their opinion that a student's mathematical ability was not related to his/her second level educational qualification. Commenting on this issue Student E stated *'I don't think it makes any difference what exam you have. If you want to learn you just do it.'* It would be fair to say that the findings from the student focus group session were confirmed by those which emerged from the Phase 4 questionnaire. A full transcript of the student focus group session is contained in Appendix G. Making comparisons is not the same as generalising and a degree of caution is required when using focus groups as the relatively small numbers may not be representative of the wider population (Robson, 2002).

The staff focus group session had a different purpose to that of the student focus group session. In this case I was seeking the opinions of fellow teaching professionals which was a form of peer review. This type of reflection can lead to improved performance and satisfaction (Carr and Kemmis, 1986). Much of the focus group discussion centred on students' attitude to learning and the future of e-learning as a revision resource. On the subject of attitude, Lecturer G commented *'I think a lot of apprentices have low self esteem and their attitude to things like maths has to change. If you can address their attitude to maths I believe that's the secret.'* While there was general agreement with this view some staff members felt that students have a responsibility to take control of their own learning needs. Lecturer K expressed this view quite strongly by stating *'Where we have apprentices with attitude problems we often don't have the time to help them on a one-to-one basis. But we can say 'its there, so use it' and they have to take responsibility for their own learning.'*

Many lecturers felt that the WebCT facility could offer students extra options when it comes to course revision. Lecturer T commented *'I think this sort of initiative has a great future.'* While Lecturer K observed *'It's a big extra option. It's a huge addition*

to what they have at the moment and a tremendous facility for the students.' Opinions and views from people with a high degree of knowledge is extremely important (Mason, 1996) and can offer excellent feedback and suggestions for improvement. A full transcript of the staff focus group session is contained in Appendix H.

4.4.2 Observation

Before considering the use of observation as a means of data collection it is important to be sure of the reasons for its use (Mason, 1996). Within this study observation was used in the computer laboratory to find out two specific pieces of information. The first was to record the number of students who needed help in accessing the Plumatics 4 U web site. This information was important because I needed to ascertain if the student instructions that I developed for this purpose were clear. The second purpose of using observation was to determine if any of the students collaborated in the computer laboratory during the online sessions. Online collaboration in e-learning communities is well documented (O'Donnell and Garavan, 2003) but in this instance students were observed helping each other while working at independent computer stations within the same location.

The observation notes show that in week one 70% of the students needed assistance logging on to the web site. Over a period of five weekly sessions this figure fell to 15% which represented six of the forty students. The observation notes also show how students collaborated with each other in the computer laboratory. In week one six pairs of apprentices were observed working together during the session. By week five this figure had increased to fourteen pairs.

I used a matrix as recommended by Patton (1990) to record the field data. Although the matrix is a simple tool it is also a very useful method of data collection. The rationale for using a matrix as a data collection instrument was that it allowed information to be recorded quickly and accurately and did not prove to be a distraction to the students.

Cohen *et al.* (2000) outline many examples and uses for matrices and conclude that *'they are useful summary devices'* (p. 90). The data collected during the observation sessions is presented in Appendix F.

4. 4.3 Phase 4 Student Apprentice Interviews

The use of semi-structured interviews as a form of qualitative data collection is well documented in the literature (Merriam, 1998; Robson, 1993; Cohen *et al,* 2000). Within this study 144 Phase 4 students from three different intakes were interviewed over a period of twelve months using a semi-structured method of enquiry. These interviews took place in the practical workshops which offer the opportunity for interaction and communication between students and lecturers in an informal setting. The purpose of these interviews was to establish three crucial pieces of information which were central to this study. Firstly, I needed to find out how many apprentices had a Junior Certificate qualification only; secondly, it was necessary to get the views of apprentices regarding the level of mathematics as it applies to the trade of plumbing; finally, I wanted to establish the number of students who had access to the Internet from home. This information was documented and cross referenced with data from questionnaires and focus group sessions which offered the opportunity for triangulation, validity and rigour (George and Cowan, 1999).

Another important function of these semi-structured interviews was to establish if this research study was worthwhile, and therefore this method of enquiry was a form of pre-test which established consistent results over a twelve month period and offered a degree of reliability and stability (Cohen *et al,* 2000). The data collected contained information that was confidential and sensitive and I was aware that the apprentices who spoke to me did not want to be quoted or identified. The data was therefore presented in a quantitative was and is contained in Tables 4.2, 4.3, and 4.20 and when compared to both the Phase 4 and Phase 6 questionnaire findings have been found to be consistent and reliable.

4. 5 Summary

This chapter has outlined the quantitative and qualitative data collected before, during and after students had the opportunity to participate in the blended learning mathematics module. A breakdown of the second level education qualifications of plumbing apprentices was presented and these figures were used to determine the percentage of students who have difficulty with mathematics during the Phase 4 programme. The importance of collecting data from Phase 6 apprentices was outlined. The number of students who had access to the Internet was also discussed. The findings show that the Phase 4 students who participated in the study showed an improvement in their examination results.

The strategy of using a mixed method approach has meant that much of the data integrates well into the final results. However, by using these different methods it was possible to confirm the findings by triangulation while also adding rigour and validity. In Chapter Five these findings will be analysed and discussed in relation to the aims and objectives of the research.

Chapter Five

Discussion of Findings

5.1 Introduction

Morse (1994) believes that one of the first principles of any research is that it present a fair and balanced argument. To help achieve this, the findings should be placed within a framework. However, within the tertiary sector it is acknowledged that there is '*a scarcity of systematic evaluative studies of web-based learning environments*' (Sheard and Markham, 2005, p. 353) with the result that frameworks and methodologies used to carry out evaluations are still being developed. To measure the success or otherwise of a web-based learning programme Sheard and Markham (2005) suggest analysing the outcomes against two critical criteria. The first is the usability of the resource by the target audience, and the second is the effectiveness of the resource in meeting educational objectives. Both of these criteria form part of the research objectives within this study, and will be discussed in this chapter.

In Chapter Three an argument was put forward outlining the rationale for a mixed method approach to data collection whereby both qualitative and quantitative methods were used in this study. It can also be seen that the teaching and learning philosophy underpinning the Plumatics 4 U web site design is constructivist in nature. Greene (1994) believes that constructivism should move *'beyond the telling of stories'* (p. 540) and that evaluation should catalyze social action. The findings presented in Chapter Four indicate that offering a blended learning approach of face-to-face and e-learning material has improved the performance of this group of Phase 4 apprentice plumbing students in mathematics. While the results of the study could not be described as dramatic, I believe they are nevertheless significant and this argument will be discussed in this chapter. It may be beneficial at this point to restate the aims and objectives of the research as outlined in Chapter One.

The aim of the research was to evaluate if a blended approach to teaching mathematics could offer student apprentices with a Junior Certificate an additional means of support. The objectives divided into five main areas. Firstly, to determine if a blended approach to teaching mathematics could result in an improvement in the examination results of apprentices; secondly, to seek the views of student apprentices who took part in the research and to ascertain if they found this blended approach useful and helpful; thirdly, to determine if the apprentices found the e-learning material to be relevant and challenging; fourthly, to find out if staff who deliver mathematics to Phase 4 apprentices believe that a blended approach can be successful; and finally to ascertain whether the resources currently available in the Department of Construction Skills are sufficient to support this blended approach. These objectives will be revisited in the summary section of this chapter where they will be put into the context of the overall findings.

5.2 Student Access to the Internet

Access to the Internet is essential for e-learning activities using web based platforms such as WebCT or Moodle (Armitage and O'Leary, 2003). Some of the positive features of e-learning via the Internet are *'the flexibility of access from anywhere online; ease of access to experts, and access to materials from a range of other sources'* (O'Donnell and Garavan, 2003, p. 23).

Analysis of interviews and questionnaires with 250 student apprentices in the DIT showed that only 63% had access to the Internet from home. This data was gathered before the blended learning module was delivered and those questioned did not include students who took part in the study. Of the forty apprentices who did participate in the research, 67% had Internet access from home. Again this comparison of data from different cohorts added a degree of reliability to the findings.

It cannot be assumed that because students are familiar and confident with new technology such as mobile phones, iPods and MP3 players that they will know how to access information in an online programme. Indeed the Horizon Report (2006) states that *'information literacy should not be considered a given, even among "net-gen" students'* (p. 5). My initial intention was to allow students make their own arrangements for Internet access following a structured induction to the e-learning module. However, I was concerned that if this strategy was followed, a significant number of apprentices ran the risk of not benefiting from the exercise. Bearing in mind that one-third of the students who participated in the study did not have access to the Internet from home, a decision was made to hold one-hour weekly sessions in the computer laboratory in the School of Construction. It was interesting to note that 88% of the students indicated that they accessed the Plumatics 4 U site outside the weekly class session. I tried to ascertain if those students who held a Leaving Certificate qualification were more likely to have Internet access than those who had the Junior Certificate but the data from the various sources failed to yield any conclusive results on this point.

Comeaux and McKenna-Byington (2003) state that the concept of *'blending online and traditional courses is a valued option for students on campus'* (p. 351) and the findings of this study are in line with this opinion. The figures shown above indicate that students respond to these extra facilities when they are offered to them. It is therefore essential that educators continue to provide such opportunities for students to enable them achieve their full learning potential.

5.3 Comparative Analysis of Examination Results

It should be noted that the examinations for apprentices are set nationally by the Department of Education and Science in conjunction with FÁS, the Irish National Training and Employment Authority. Unlike many third level programmes, lecturers

involved in apprenticeship education have no control over the examination content and only mark the tests.

One of the major influences on student learning is the need to perform well in assessments and examinations (Ramsden, 1992; Gibbs and Simpson, 2002, Rust *et al*, 2005). For this reason one of the ultimate tests in this evaluation study involved comparing the examination results of those who took part in the research with those of apprentices from previous intakes who had not had this opportunity. The sampling strategy is as important as the methodology or instruments used to collect data and may ultimately determine whether the findings stand or fall (Cohen *et al,* 2000).

In the analysis of examination results of previous groups of apprentices, it was found that 39% of those who held only a Junior Certificate qualification failed at least one mathematical question per theory test. This finding was based on an analysis of 288 mathematical questions from 160 scripts, where 60% had a Leaving Certificate and 40% had a Junior Certificate only. These findings are presented in Table 4.4. The post-research analysis of those who took part in the study examined 120 scripts containing 240 mathematical questions. The group involved in the current study was made up of students, 50% of whom had a Leaving Certificate and 50% of whom had a Junior Certificate only. The number of Junior Certificate students who failed at least one mathematical question fell to 29%. These findings are presented in Tables 4.18 and 4.19. It can be seen that the number of student apprentices who held a Junior Certificate was 50% which is 10% higher than the pre-research figure. It could be argued therefore, that the percentage improvement is statistically higher given that the number of students with a Junior Certificate who took part in the research represented 50% of the total group while in the pre-research analysis a figure of 40% was used as a benchmark for comparison. In actual fact, the percentage who got at least one mathematical question wrong was lower than might have been expected. These figures are represented in Figure 5.1 below.

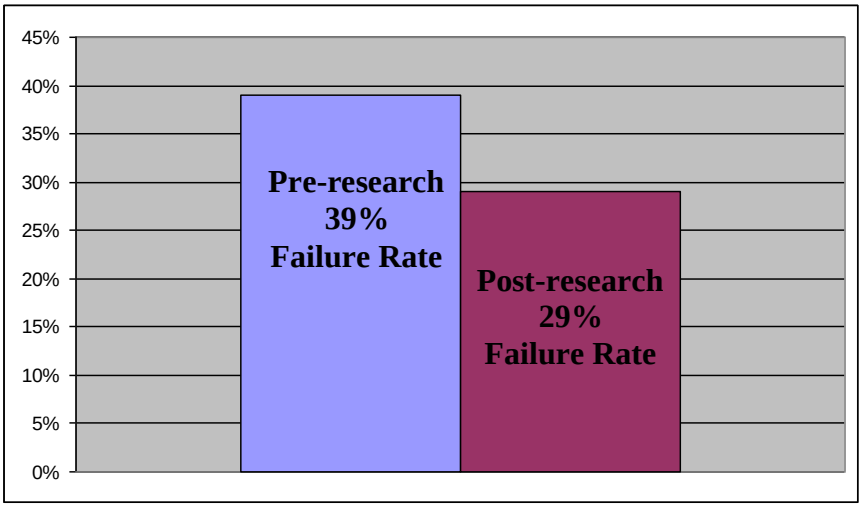

Figure 5.1 Percentage of apprentices with a Junior Certificate who failed at least one mathematics question.

An improvement of 10% in the examination results for Phase 4 apprentices in mathematics could best be described as significant rather than dramatic. However, the results of the Phase 4 questionnaire and the Phase 4 student focus group session indicate that the students benefited from the e-learning experience and would recommend it to future apprentices.

5.4 Student Focus Group Session

After the students had completed their final examinations I invited eight of them to participate in a focus group session. George and Cowan (1999) recommend focus groups with six to twelve participants. The group consisted of four students who had a Junior Certificate qualification and four who had a Leaving Certificate. This focus group was a direct reflection of the educational level of the forty participants who took part in the research. This follows the recommendations of Tessmer (1993), who believes that for formative evaluation research projects all groups within a study should reflect a mixture of the learners' abilities. A full transcript of the student focus group session can be found in Appendix G and shows that the e-learning module

complemented the mathematical content of the classroom sessions. The students identified areas of the module that they found most helpful, such as the self-tests, and this type of feedback is useful when modifications and revisions are undertaken.

One major disadvantage of focus group sessions is the limited number of questions that can be asked (Patton, 1990). Therefore, I confined the discussion to certain key areas such as access to the site and the e-learning content. I was also conscious that each participant was given the opportunity to express his/her opinion and that the group would not be dominated by any individual.

I used the focus group session to confirm some of the key issues relating to the blended learning approach to which the students were exposed. Areas that emerged from this discussion included ease of access to the site, the relevance of the e-learning material and the future prospects for this teaching strategy. Accessing the site did not prove to be a problem which meant that the induction, student instructions and weekly computer laboratory sessions worked as a strategy to give students every opportunity to participate in an e-learning environment. Some of the students in the focus group said they would like to see more subjects available through the WebCT platform. This concept may prove helpful for revision purposes particularly for apprentices waiting to repeat examinations.

5.5 Staff Focus Group Session

The major stakeholders in this evaluation research study are the students, the teaching staff and school management. Much attention within this thesis has been devoted to the students. In this section the attention will be focused on the opinions of staff and management on the concept of blended learning and its potential as a resource. Greene (1994) stresses that the choice of methods *'must match the information needs of the identified evaluation audience'* (p. 538). Mindful of this, on December 7th 2005, one month before the commencement of the research study involving the student

apprentices, I held an information session for the management and lecturing staff of the Plumbing Section. The purpose of this session was to inform those present of my research and in particular to let the teaching staff see the Plumatics 4 U web site in a live setting. This enabled them to understand the strategy of blending e-learning and face-to-face teaching and also offered the opportunity for them to see first-hand and comment on the web site content. Sixteen staff members attended the session as did a member of the DIT Learning Technology Team to further explain the WebCT web learning platform. A copy of the letter sent to all those who attended this information session is contained in Appendix O.

Towards the end of the research the lecturing staff who deliver mathematics to Phase 4 apprentices were invited to take part in a focus group session. This group consisted of seven lecturers whose teaching experience ranged from one year to over twenty years. The focus group meeting was taped and a transcript can be found in Appendix H. George and Cowan (1999) believe that *'it is sensible to involve colleagues to help you make sense of findings and decide implications and priorities for action'* (p. 14). With this in mind, at the start of the session I distributed a two-page handout with some preliminary findings from the research in order to stimulate the discussion. The format was informal and I followed a semi-structured approach which occasionally meant that the discussion strayed from the point. I was happy to let this happen because I wanted those involved to feel free to express opinions and I felt it contributed to a relaxed yet informative debate.

There was general agreement that initiatives such as the Plumatics 4 U site are beneficial to students, even when I suggested that the improvement in examination results was modest. Some of the group believed that many apprentices have difficulty with mathematics because of their attitude to this subject. Tessmer (1993) addresses the question of attitude and believes that *'most formative evaluation studies have measured student performance gains and ignored measures of student attitude or acceptance'* (p. 13). Some lecturers suggested that because many apprentices perceive plumbing to be a physical operation, they are unwilling to acknowledge the depth of theoretical

learning associated with the trade. It was agreed that the type of mathematical problems associated with the plumbing trade is different to much of the second level syllabus that apprentices would be familiar with. The mathematics in the off-the-job phases could better be described as applied mathematics. The group felt that while the standard of Phase 4 mathematics is not higher than that of the Junior Certificate many apprentices still experience difficulty.

Some lecturers stated that one of the major benefits of e-learning was the fact that students could work at their own pace and could also revise when they felt the need. This point is also acknowledged by Muirhead (2002) who states that e-learning enables '*more student control over what, where, when and how they study*' (p. 2). Those staff members who had spoken to the students about the Plumatics 4 U web site said the feedback was very positive. It was acknowledged that part of the reason for this response from the students was the fact that they were given the opportunity to participate in weekly sessions in the computer laboratory. A structured student induction to WebCT was considered essential for them to fully benefit from the experience. The lecturing staff were generally supportive of this e-learning initiative and believed that it could be explored further in the future.

Up to this point there has been little mention of the management of the School of Construction during this evaluation research project. This could give the impression that the management did not play a proactive role during the study. Such an assumption would be incorrect. There were many occasions when I was asked to give impromptu progress reports in an informal manner, which I was more than happy to do. On completion of the study I queried a member of the management staff as to why they appeared to have a 'hands-off' approach to this research study. The answer I was given was that a decision was taken not to interfere with the research for fear of influencing any results. This I believe showed confidence both in the research and the researcher. I was also requested to speak at the Institute of Technology Apprenticeship Committee conference (ITAC) on the recommendation of the school management. The dissemination of information from this research will be dealt with in Chapter Six. The

support within the DIT for e-learning could be described as a 'top down' approach (Meredith and Newton, 2003) where the Institute has developed its own policy and structures to promote this form of education. In a recent report commissioned to evaluate how e-learning is impacting within the Dublin Institute of Technology it was acknowledged that

> *The Learning Technology Team has directly worked with more than 50% of DIT academic staff, and the quantity of undergraduate degree programmes making course materials available on the Internet using WebCT now exceeds 70%.*
>
> (LTT, 2005, p. 3).

Rahman (cited in Porter, 2004, p.249) emphasises that faculty management must support e-learning programmes if they are going to survive, and that the general faculty staff should support and participate in online education.

5.6 Observation

George and Cowan (1999) state that *'it will usually be best to use several methods of formative evaluation to provide a composite impression of the learning, teaching and assessment'* (p. 35). With this in mind, observation was used to determine whether the students could access the web site with ease or if they required assistance. I developed a simple matrix in line with the type recommended by Patton (1990) to record the field notes. A copy of this matrix, including the observation results, can be found in Appendix F.

During the first session in the computer laboratory I explained how the site could be accessed and demonstrated how to input student identification and passwords. In the second session less than half of the apprentices required assistance and in the third week only five students needed help. To give the apprentices every possible assistance regarding logging on to the site, I designed an instruction handout that was given to each student during the first computer laboratory session. This follows the

recommendations of Porter (2004). A copy of this handout can be seen in Appendix N. Beetham (2004) details a variety of supports that can be used to assist students ranging from guidelines and toolkits to individual supervision and learning contracts. I believe that the strategy of providing weekly computer laboratory sessions combined with handout guideline instructions was successful. This was confirmed by both the observation findings and the Phase 4 questionnaire which found that 88% of the participants accessed the Plumatics 4 U site at times outside the timetabled computer laboratory sessions. This finding was also supported by reference to the WebCT tracking facility which allows the designer to see at what times students log on to the site and on completion of the study there had been 3,700 hits on the Plumatics 4 U site. The field notes from the observation sessions, which are in Appendix F, show that from week one to week five the number of students who needed support logging on to the site fell from 70% to 15%. The various methods outlined above show how triangulation can be used to establish a valid argument and give reliability and validity to findings (Tessmer, 1993).

The use of observation also allowed me to study how students co-operated with each other during the planned computer laboratory sessions. Commenting on the interaction between students in an online environment Muirhead (2002) states that *'ultimately, the primary challenges facing today's instructors are not technological but involve the issue of social interaction'* (p. 2). This is a strong statement and one that I would not necessarily agree with. For example, it is well documented that teaching mathematics in an online environment is handicapped by a deficiency in the technology (Smith and Ferguson, 2005; Leventhall, 2004; Wilkinson, 2001). This area is discussed in detail in section 2.15 of Chapter Two.

During the timetabled computer laboratory sessions approximately one third of the group interacted in various ways. Some questioned each other about mathematical problems while others sought clarification about formulae. I would not describe the interaction as constant or deeply significant because generally most students worked at their own pace irrespective of their peers. This point was confirmed by answers given to

question nine in the Phase 4 questionnaire which are in Appendix M. This type of self-paced approach can offer students who are shy or those who have a difficulty keeping pace with others a level playing field (Porter, 2004).

5.7 Summary

The findings show that Phase 4 apprentices with only a Junior Certificate qualification have a difficulty with mathematics when compared to their fellow apprentices who hold a Leaving Certificate. The objectives of this research study, outlined in Chapter One, can be divided into five broad areas.

- The first relates to those students whose highest second level educational qualification is the Junior Certificate and the objective was to ascertain if a blended approach of face-to-face teaching and e-learning material could lead to an improvement in their examination results in mathematics. The findings indicate that an improvement did occur for this group of student apprentices.

- Secondly, to ascertain if student apprentices view this blended approach as useful and helpful. The study found that 84% of the participants would like to take part in a blended teaching and learning approach in the future.

- Thirdly, to determine if apprentices within the study group found the online content relevant and challenging. The findings indicate that 88% of the participants described the mathematical content of the Plumatics 4 U web site as 'About Right' while 93% agreed that the material was 'Relevant'.

- The fourth objective was to determine if staff who teach mathematics at this level believe a blended approach to be successful. The lecturing staff believed that this resource is a worthwhile contribution to student learning and should be integrated into the programme. They also felt that e-learning in general was a

resource that could be explored further for the education of apprentices and in particular it could be useful for revision sessions.

- The final objective was to determine if the resources available in the Department of Construction Skills were sufficient for a blended teaching strategy using e-learning material. The existing resources were found to be satisfactory in relation to current levels of use. However, if more modules are to be made available using e-learning then more computer resources will be required.

Chapter Six

Conclusions and Recommendations

6.1 Introduction

The aim of this study was to determine if blending face-to-face teaching with e-learning could improve the examination results of Phase 4 student apprentices in mathematics. This chapter draws together the evidence from the literature review and the findings of the primary research with Phase 4 and 6 apprentices to formulate the main conclusions and recommendations of the study. McDonald and O'Neill (2006) outline how e-learning has undergone rapid development during the last decade due to advances in technology and changing educational needs, and how it is currently being successfully utilised in the educational sector in the Republic of Ireland. Within the Dublin Institute of Technology over 1,000 modules are now available to students on the WebCT platform (LTT, 2006). It is disappointing to note that only ten of these modules relate to the teaching of apprentices. When one considers that there are approximately 28,000 registered student apprentices in the Republic of Ireland, the need for further research in this area becomes apparent. The research presented in this thesis is an attempt to redress the balance and aims to contribute to the limited knowledge base that currently exists.

The conclusions of this study will be presented under the following headings:

- The need for additional student support;
- Student induction and course design;
- Blended learning strategy;

6.2 Conclusions

The literature shows that a social constructivist framework is ideally suited to apprentice education (Bockarie, 2002). It also informs us that blended learning is an effective combination of different modes of delivery, models of teaching and styles of learning (Procter, 2003). This study has found that where e-learning and face-to-face teaching are incorporated into a craft mathematics apprenticeship programme, the examination grades of students improve.

I am interested and concerned with the welfare and progress of individuals who in this instance are Phase 4 student apprentices. The qualitative findings have proven to be very positive from both a student and a staff perspective. The students in the study found the experience enjoyable and worthwhile which is clearly evident from focus group sessions and also from the questionnaire results. I believe this is vitally important because if students 'buy into' a learning strategy they are more likely to benefit from the experience. It may also encourage them to continue and expand their knowledge, not only within their chosen profession, but in the wider context of lifelong learning. This can lead to an improvement in attitude which was identified in the staff focus group session as an important ingredient within the learning process.

The staff in the plumbing section believe that blended learning, and in particular e-learning, could have a significant impact which would benefit apprentices in their education. They specifically identified its potential use as a revision resource for students and acknowledged that many apprentices have a difficulty with mathematics. Within this context they believed that initiatives such as the Plumatics 4 U WebCT site are of great advantage to students, enabling them to work through mathematical formulae and worked examples, and take online tests at their own pace.

The main conclusions emanating from this study are as follows:

The Need for Additional Student Support

The findings from this study show that additional support should be provided for student apprentices by third level institutions, particularly in the area of craft mathematics. Apprentices whose highest second level qualification is the Junior Certificate are three times more likely to experience difficulty with mathematics than apprentices with the Leaving Certificate.

Student Induction and Course Design

With careful student induction and course design, a blended teaching strategy of face-to-face and e-learning can lead to an improvement in the examination results of apprentices with regard to mathematics.

Blended Learning Strategy

When offered the opportunity to participate in a blended learning environment, student apprentices whose highest second level qualification is the Junior Certificate showed a 10% improvement in mathematical questions when compared to students of a similar educational standard from previous intakes who did not take part in the study. O'Donnell and Garavan (2003) believe that *'there is positive recognition for the benefits of blended learning'* and outline how it is compatible with learning orientations such as constructivism (p. 11). This thesis has shown how a blended learning and teaching strategy has benefited Phase 4 student apprentices who have previously experienced difficulty with mathematics. To apply this blended approach to apprenticeship education it will be necessary to develop further e-learning modules which will benefit these students.

6.3 Recommendations

To put the recommendations into context it may be useful at this stage to briefly reflect on the objectives of the research. The first objective was to determine whether a blended approach to teaching mathematics to Phase 4 apprentice plumbing students would improve their ability and examination results. The results show that a 10% improvement was achieved in this area. The second objective was to ascertain if student apprentices found the blended approach evaluated in this study useful and helpful. The results indicate that they did. The third objective was to determine if apprentices within the study group found the online content relevant and challenging. Again the results were very positive. However, feedback from students indicated that the Plumatics 4 U web site would benefit from certain modifications. The principal change would be the inclusion of additional self-tests for students. A second change would involve a grading system integrated into the self-tests, which would generate a mark for those taking an online test. This could be achieved by using a programme such as Respondus which is compatible with WebCT. The fourth objective was to determine if staff who teach mathematics at this level believe a blended approach is successful. The teaching staff feel that the use of WebCT as a teaching and learning resource should be further developed. The final objective sought to clarify that the resources currently available are sufficient for this approach. The existing resources of two computer laboratories each with sixteen machines is adequate for a limited amount of computer and web based learning such as that involved in this study. However, if and when more students use this resource more facilities will be required.

The recommendations that emerge from this formative evaluation research study are as follows:

- This blended learning method of teaching mathematics to Phase 4 plumbing apprentices should continue to be used within the Department of Construction Skills and the examination results of students monitored to establish if the

improvements evident in this study can be replicated over an agreed timeframe of at least three semesters;

- That teaching staff involved in the education of apprentices should be encouraged to seek development in the area of WebCT course design. This could enable further modules to be developed using blended learning and teaching strategies. In particular, revision packages for students should be developed using WebCT as a teaching and learning platform. To encourage and assist academic staff in the use of WebCT as an aid in apprentice education, a group of those interested in developing online resources could be established with a view to sharing resources and ideas;

- The Plumatics 4 U site should be demonstrated to other Institutes of Technology that deliver the Phase 4 plumbing programme and if necessary made available to them. To help achieve this an introductory film, similar to the one accompanying this thesis, could be distributed to those interested in viewing the site content. This web site should also be made available to Phase 4 plumbing apprentices who are remote from third level campuses and are awaiting the opportunity to sit repeat examinations;

- Additional self-tests should be included on the Plumatics 4 U web site. This could enable students to reinforce their learning and identify weaknesses that they need to address. This in turn would help students take responsibility for their learning;

- An online grading system, integrated with the self-tests, could offer student apprentices a mark allowing them to monitor their progress. This strategy may help to motivate students, an issue which was identified as a problem area by the staff in the focus group session.

6.4 Dissemination of Information

Although there are almost 28,000 registered apprentices in the Republic of Ireland the educational community is a relatively small one. This research study took fifteen months to complete and during that time many colleagues and teaching acquaintances became aware of the work. As a result, I was asked to make a presentation outlining the research at the Institute of Technology Apprenticeship Committee (ITAC) Conference on 5th May 2006 at the Limerick Institute of Technology. This proved to be an extremely worthwhile exercise because those in attendance were all involved in the education of student apprentices in the various Institutes of Technology throughout the country.

I was also requested to present the findings at the DIT E-learning Summer School which was held at the Aungier Street campus on 19th June 2006. On this occasion the audience did not constitute those who teach apprentices but consisted of academic lecturers. It is important that researchers take advantage of opportunities to present their work and thus get valuable feedback from their peers. It is also my intention to submit a paper from this work to an apprenticeship educational journal for publication as I believe it is a valuable contribution to educational research in apprenticeship.

6.5 Summary

This formative evaluation research study was carried out to establish if a blended learning teaching strategy could help improve the examination results of Phase 4 apprentice plumbers in mathematics. In particular it sought to establish if plumbing apprentices, whose highest second level educational qualification is the Junior Certificate, were more likely to have difficulty with mathematics than their counterparts who hold the Leaving Certificate. The research has revealed that plumbing apprentices with only a Junior Certificate are three times more likely to have difficulty with mathematics when compared to those with the Leaving Certificate. The results also

indicate that when this group of students was taught mathematics using a blended strategy combining face-to-face and e-learning resources, the examination results showed a 10% improvement. It is clear from the findings that when students are introduced to an e-learning environment that is well prepared, supportive and relevant, they respond in an extremely positive manner to it.

The academic staff in the plumbing section believe that blending face-to-face teaching and e-learning should be further developed with particular reference to revision modules that could be made available to students awaiting the opportunity to sit repeat examinations. The management in the Department of Construction Skills and in the School of Construction have shown significant interest in this research, particularly since the preliminary findings have been made available. As already outlined, on the recommendation of the school management, I presented the findings from this research at the ITAC conference in May 2006 and I have been requested by management to make a further presentation to teaching colleagues at a school meeting later this year.

Since March 2006, when the fieldwork for this study concluded, I have made a further module available on WebCT for Phase 4 plumbing apprentices. The feedback from students regarding this new module has also been extremely positive. I believe that using a blended approach to teaching apprentices should be further developed and that more modules should use this strategy.

6.6 Finally

Although the Internet has been in existence since the early 1960s, its use as a means of communication was limited until the development of the World Wide Web in 1991 (Howe, 2005). As an educational tool, it is still developing and will continue to do so until it finds its proper niche. The future for blended learning is bright but it must be developed in a coherent manner that offers support, while at the same time being challenging and student centred. Thorne (2003) believes that

> *The potential of blended learning is almost limitless and represents a naturally evolving process from traditional forms of learning to a personalized and focused development path.*
>
> (Thorne. 2003, p. 5)

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Appendix A

Table of Registered Apprentices in Ireland as of 2005

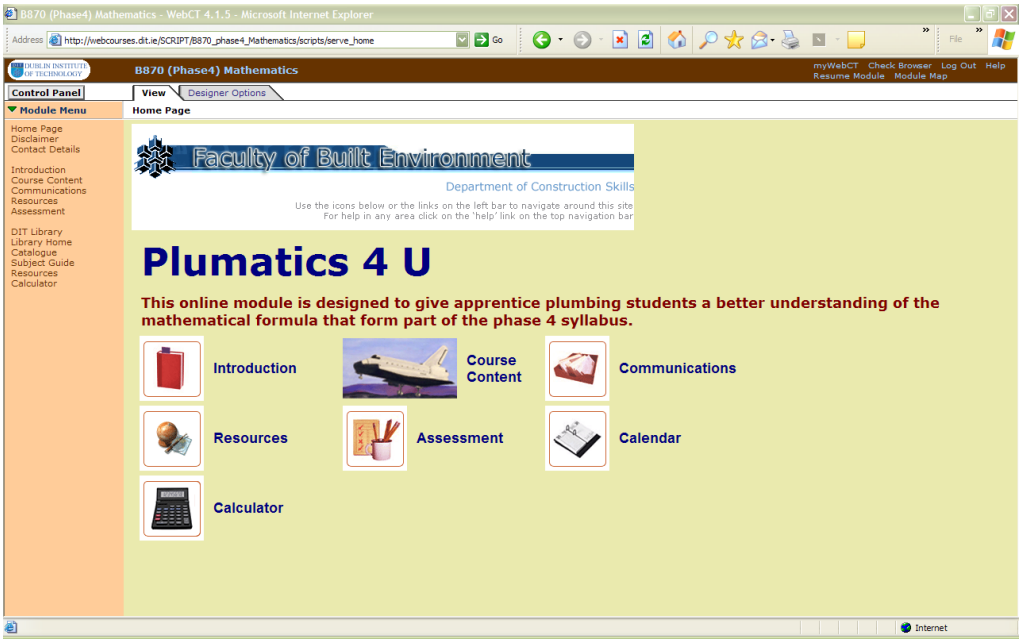
Total number of apprentices registered by FÁS indicating their phases and trade as of April 2005.

Total Number of Live Apprentices by Trade & Phase								
Trade	**Phase 1**	**Phase 2**	**Phase 3**	**Phase 4**	**Phase 5**	**Phase 6**	**Phase 7**	**Total**
Cabinet Maker	155	54	172	65	151	64	108	769
Wood Machinist	19	0	12	8	17	9	17	82
Originator	2					1	14	17
Printer	0	16	2	0	18	0	21	57
Carton Maker	2	0	1	0	0	0	0	3
Bookbinder	1	0	0	0	5	0	4	10
Electrician	1395	719	1852	428	1483	557	1174	7,608
Instrumentation Craftsperson	3	10	5	17	13	0	18	66
Electrician (Instrumentation)	25	12	48	0	35	5	18	143
Motor Mechanic	218	139	318	110	335	125	248	1,493
Agricultural Mechanic	49	0	40	0	34	0	70	193
Heavy Vehicle Mechanic	61	56	78	48	125	32	92	492
Vehicle Body Repairer	97	28	61	29	112	31	14	372
Fitter	96	77	92	63	133	79	263	803
Toolmaker	26	15	18	9	34	17	49	168
Aircraft Mechanic	9	17	24	0	76	48	16	190
Refrigeration Craftsperson	51	41	39	31	76	16	40	294
Sheet Metal Worker	41	28	41	16	58	15	63	262
Metal Fabricator	119	95	126	51	161	53	177	782
Floor/Wall Tiler	27	11	33	15	18	0	7	111
Carpenter/Joiner	1729	781	1548	423	1050	331	765	6,627
Painter/decorator	108	50	65	31	87	31	92	464
Plumber	1176	422	850	205	925	188	319	4,085
Bricklayer	647	198	279	141	269	105	235	1,874
Plasterer	260	94	303	46	141	29	64	937
Construction Plant Fitter	67	12	50	31	72	31	87	350
Total	6,383	2,875	6,057	1,767	5,428	1,767	3,975	**28,252**

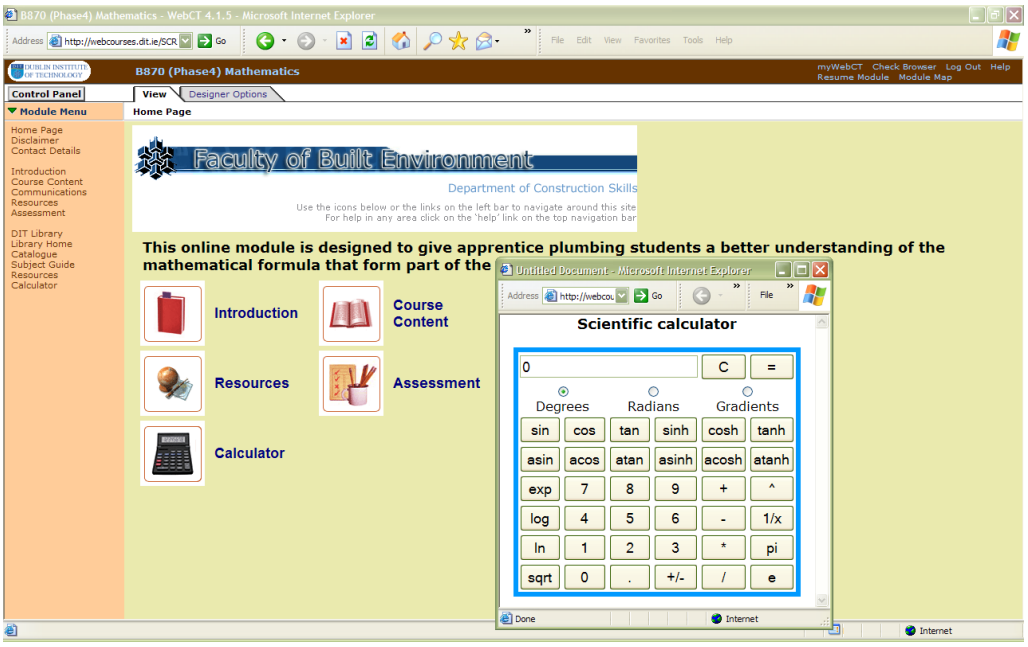
Appendix B

Screen Shots of Plumatics 4 U web site.

Selected screen shots from Plumatics 4 U WebCT site. The site has fifty pages of original content specially designed and written for Phase 4 student plumbing apprentices. There is an online calculator and help function also available for users. Each section includes explanations and worked examples followed by self-tests. There are one hundred and twenty sample questions for students to attempt.

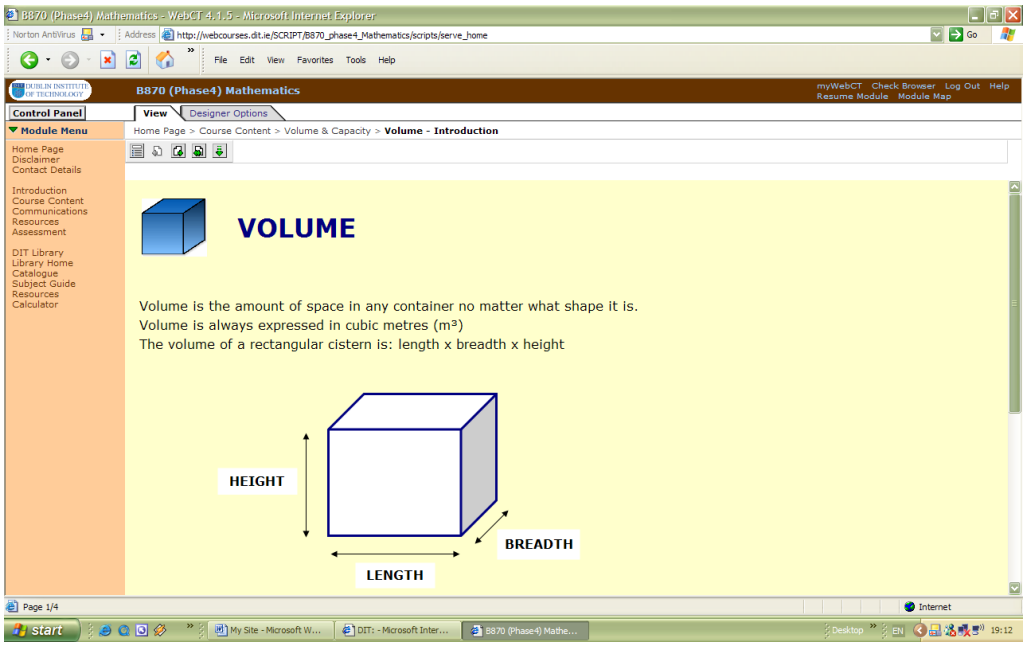


The home page of Plumatics 4 U WebCT site.

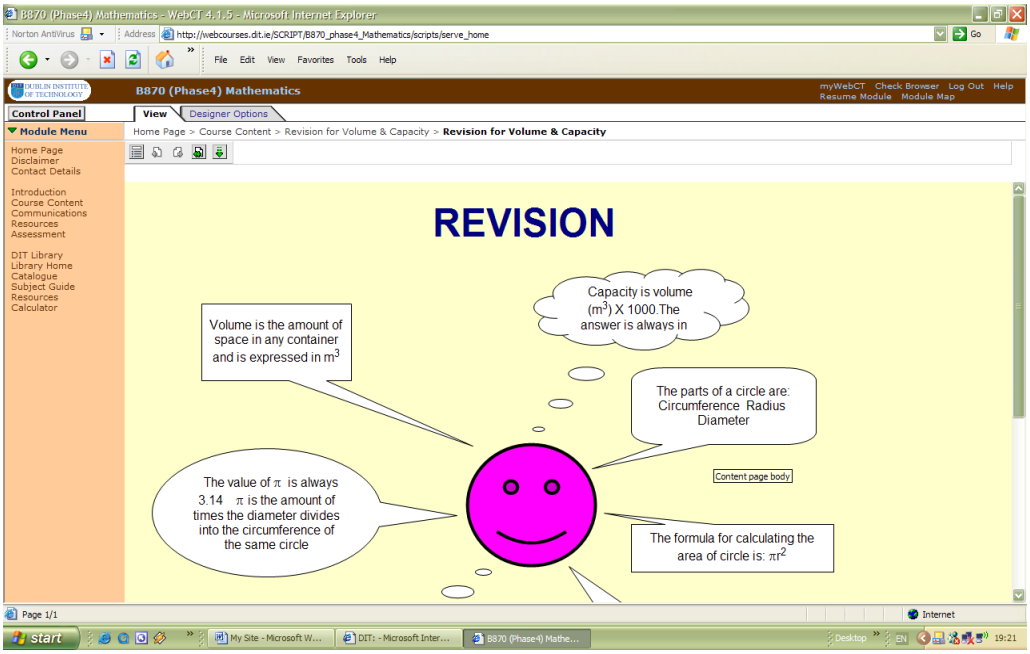


The online electronic calculator.

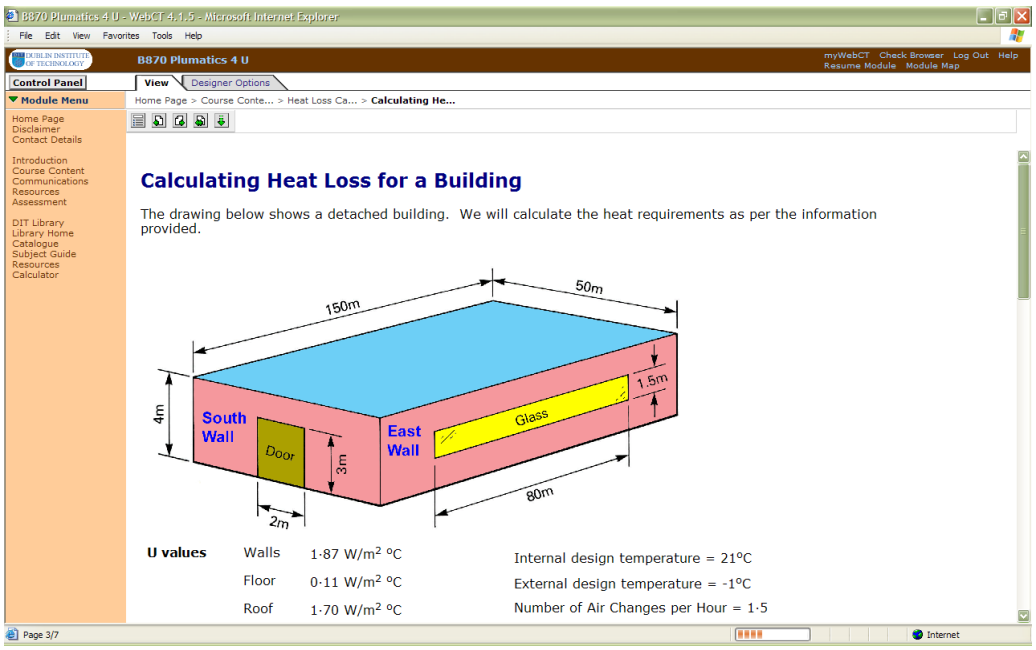
The course content showing the ten sections.



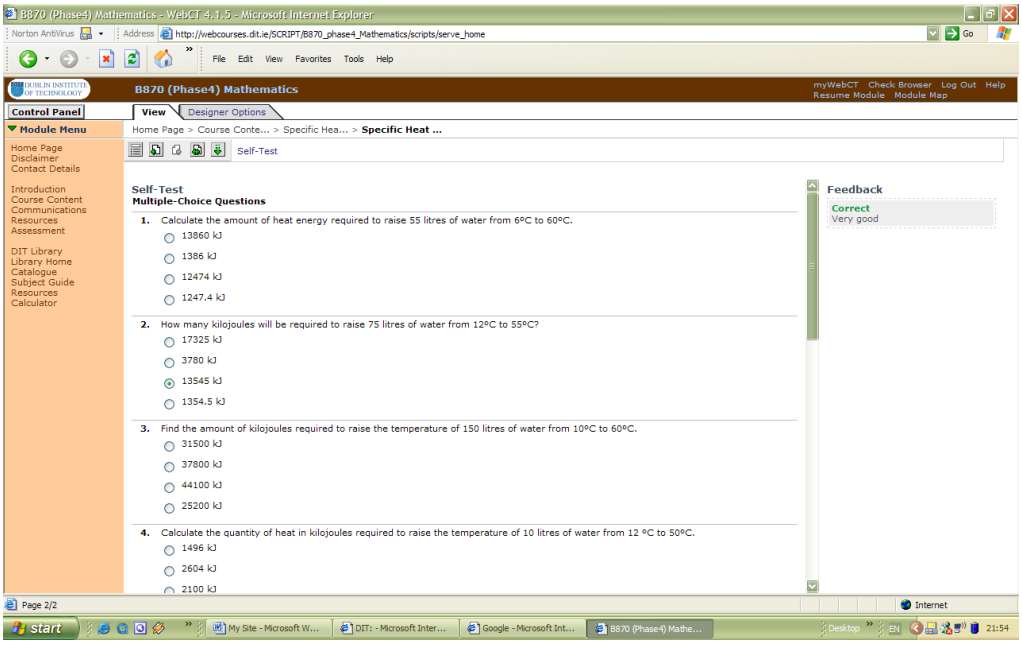
Screen shot from the volume and capacity section.



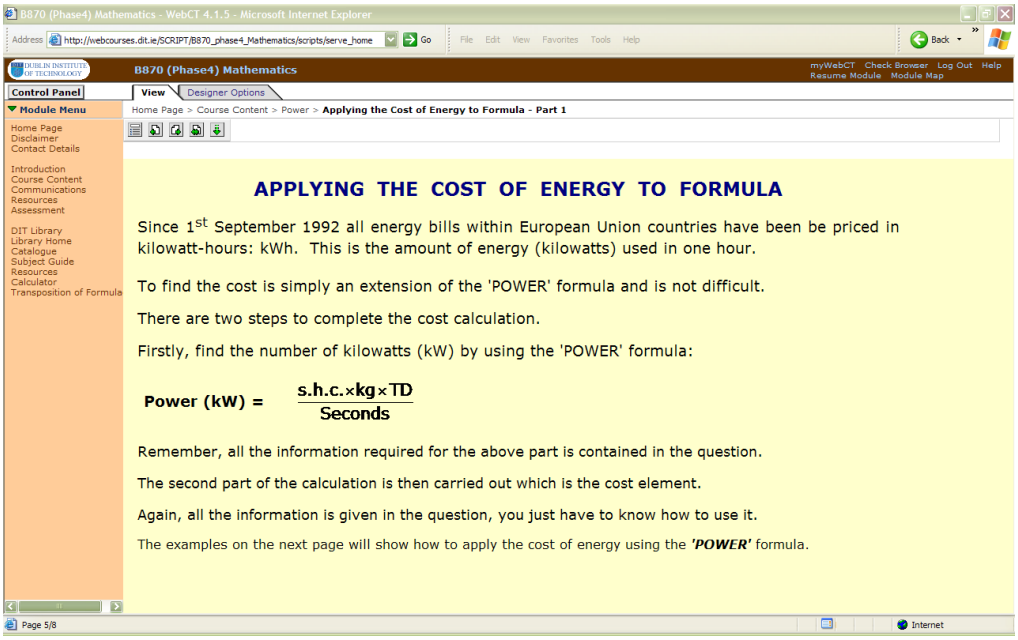
An example of a revision section.



Drawing explaining heat loss calculations for a building.



An example of a self-test.



Explaining how formula is used in applying cost to energy.

Appendix C

Letter sent to Head of School, informing him of my thesis proposal and requesting the support of management and staff. A copy of this letter was also sent to both the Head of Department and the Assistant Head of Department.

Mr Phil Murray
Head of School of Construction

17th October 2005

Dear Mr Murray

As you are aware I am commencing the final year of my Masters (MA) in Third Level Learning and Teaching under the guidance of the Dublin Institute of Technology Learning and Teaching Centre.

The title of my thesis proposal is:

Can blending face-to-face teaching with e-learning support the development of Phase 4 apprentices in mathematics? A formative evaluation research study.

My supervisor for this thesis is Ms. Róisín Donnelly from the Learning and Teaching Centre, Mount St.

During the course of my research it will be necessary to interview staff and students and also use comparative analysis techniques relating to Phase 4 examination results for apprentice plumbers.

In order to carry out this work to the best of my ability I am requesting the support of the management and staff of the Department of Construction Skills and Head of School which has always been there in the past and which I trust will also be forthcoming in the future.

Should you require any information regarding the research please contact me.

Yours sincerely,

_____

Peter Hinch

Appendix D

Ethics statement drawn up for students who participated in the research.

Ethics Statement

The WebCT module which you have access to, is part of a research study to determine if a blended learning approach of online material combined with face-to-face teaching can help improve the mathematical performance of Phase 4 apprentice plumbing students.

Any information given by participants is strictly confidential and individuals will not be identified in the reporting of any findings. Should any student wish to cease participating in this study, for any reason whatsoever, they are free to do so. All findings will be reported honestly and the dignity, integrity and privacy of participants will be observed at all times.

The permission of the Head of the School of Construction and the Head of Department of Construction Skills has been obtained prior to the commencement of this research study.

It is hoped that this research study will be of benefit to student apprentices and will lead to the development of future resources that will enable them to progress throughout their careers.

_____

Peter Hinch
15th February 2006

I have read the above ethics statement and agree to take part in this research study. I understand that I can withdraw from this study at any time should I so wish.

Student signature:_____

Appendix E

Students registered with the Disability Service in the Dublin Institute of Technology.

Academic Year	Students with disabilities
1998 – 1999	68
1999 – 2000	94
2000 – 2001	133
2001 – 2002	175
2002 – 2003	220
2003 – 2004	287
2004 – 2005	400
2005 – 2006	500
2006 – 2007	620

Disability	Approximate Percentage Breakdown
Dyslexia – Dyspraxia – General learning difficulties	78%
Physical disabilities	7.4%
Mental health difficulties	4.4%
Hearing loss	4.4%
Medical condition (including epilepsy)	2.6%
Visual difficulties	1.6%

Appendix F

Field notes from observation sessions.

Please note that forty (40) students took part in the research study which represents a figure of 100%.

Numbers of students who needed support logging-in to Plumatics 4 U web site				
	Group 1	**Group 2**	**Group 3**	Percentage of students who needed support
Week 1	10	9	9	70% (28)
Week 2	6	7	5	45% (18)
Week 3	3	5	3	28% (11)
Week 4	2	3	2	18% (7)
Week 5	2	3	1	15% (6)

Pairs of students who collaborated using the Plumatics 4 U web site			
	Group 1	**Group 2**	**Group 3**
Week 1	2	1	3
Week 2	4	2	4
Week 3	4	2	4
Week 4	5	3	5
Week 5	5	4	5

Appendix G

Transcript of student focus group session.

Student Focus Group Session

A focus group session consisting of eight student apprentices met on Friday 10th March 2006 at 11.00 a.m. Four of the group had the Leaving Certificate and four the Junior Certificate. Several days before this meeting I explained to the group that I wished to use a cassette recorder to tape the proceedings and asked for the agreement of the group on this matter. They all agreed to me taping the session and on the day of the meeting I once again clarified the situation regarding the use of recording equipment.

Occasionally during the focus group session the students strayed off the topic and under the circumstances I was reluctant to be too assertive and force them to return to the theme. I therefore let the conversation evolve and when an appropriate situation presented itself asked a question that returned us to the topic. The transcript below only refers to the discussion relevant to the use of e-learning as a learning and teaching method.

Researcher: Having had the experience of using the Plumatics web site, do you think there is a future for e-learning in apprentice education?

Student A: *It's good.*

Student B: *I thought it was ok. Yeah, I liked it.*

Student C: *It's good because it helps you go through the stuff.*

Student D: *It helps you remember formulas.*

Student A: *Yeah, it tells you the formulas.*

Researcher: Do you think it's of more use to someone with a Leaving Certificate than to someone with a Junior Certificate?

Student C: *It depends whether they are good at maths or not.*

Student E: *I don't think it makes any difference what exam you have. If you want to learn you just do it.*

Student F: *We did lots of maths with out teacher but if we had someone different we might have had to use the site more.*

Student A: *If we had not done so much with our teacher it would have been great.*

Student B: *It would be good for anyone doing referrals as well.*

Student E: *Yeah, if you're out of here for a few months and you don't have the formulas in your head at all.*

Student A: *It gets you kind of going again, because the maths is a big part of the course. If you have a problem with maths it's good but if you're someone who doesn't really have a problem with maths and doesn't find it difficult then they may not need it. But if you have a problem it's good because it's very easy to use.*

Researcher: Did any of you access the site outside of the classroom sessions?

Student G: *Yeah, I did. I used it at home.*

Student A: *So did I.*

Student H: *I tried to get on the site from home but couldn't.*

Student B: *I used it in the library.*

Student D: *I got to use it at home – it was good.*

Student C: *I don't have the Internet at home.*

Researcher to Student C: If you had the Internet at home would it have made any difference?

Student C: *Yeah. I would have used it a lot more.*

Student E: *If I had the Internet I'd have logged on.*

Researcher: What did you think of the content?

Student C: *It was good. I followed it ok.*

Student D: *I'd like to see more subjects on the web because some teachers don't give you enough notes.*

Student A: *I liked the self-tests, I thought they were good.*

Student B: *Yeah I liked the self-tests too. The examples were good. I would have liked to print them off the web.*

Researcher: Which section of the web site did you find most useful?

Student E: *I thought the heat loss section was best.*

Student A: *Yes, I liked that section.*

Student B: *I thought the power section was good, especially the parts that showed how to calculate the cost.*

Researcher: What about the other sections, has anyone any opinions about them?

Student A: *The transposition part was good too.*

Student C: *I liked the transposition part too.*

Researcher: In that case would you be prepared to print off notes for yourself?

All students: *Yes – Definitely.*

Researcher: Would the cost of printing notes be an issue?

All students: *No. It wouldn't be an issue, no. It wouldn't be expensive, no.*

Researcher: With your exams coming up next week, will any of you look at the site or have you had enough studying and want a break?

Student B: *I'll definitely look at it this weekend.*

Student G: *So will I.*

Researcher: If you come back here for Phase 6 would you like to see more use of WebCT for different subjects?

Student B: *Yeah, I would.*

Student A: *Definitely.*

Student G: *It would be great for revision.*

Student B: *Yeah, if there were lots of subjects it would be great.*

Student B: *The lads I know in Phase 6 say it's heavy stuff so any extra help you get is needed.*

Researcher: Well, I want to thank you all for participating in this research project. It was designed to help Phase 4 students, especially those who may have a weakness in maths. By being part of this study you have made a significant contribution to the area of e-learning as it impacts on apprenticeship education. So, once again, thank you all very much.

Students: *No problem. You're welcome*.

Appendix H

Transcript of staff focus group session.

Staff Focus Group Session

At the start of the focus group I outlined the rationale for this research study and gave details of the quantitative and qualitative methods used in the gathering of data and analysis material. I also gave each group participant a two page handout showing details of preliminary findings to date in order to stimulate discussion. This handout is shown at the end of this transcript. The dialogue below begins at this point.

Researcher: I want to hand out this material that gives you an outline of the background to this study and indicates some pre-research and post-research findings. If you look at the pre-research graph or pie chart at the top of the page you will see that the number of scripts analysed was 160 which was in the ratio of 60% Leaving Certificate students and 40% Junior Certificate students. I analysed 288 maths questions and found that of those with a Junior Certificate 39% failed at least one maths question. On conclusion of the research I carried out the same analysis with the student group and found that the failure rate dropped to 29% when exactly half the students had a Junior Certificate. The improvement could not be described as dramatic, in fact at one stage I wasn't sure if there would be any drop at all. I hindsight if there was a dramatic drop I probably would have been worried. However, there was an improvement which is shown in the bar chart at the bottom of the page.

One of the factors which made this research interesting was that I asked the Phase 6 students to indicate what their preferred method of revision would be and most opted for one-to-one or group tuition and only 9% considered e-learning or Internet based learning as an option. But when the research with the forty Phase 4 apprentices finished I asked them a similar type question which was 'would they like to participate in e-learning again having had the experience of WebCT?' As you can see 84% said they would like to participate in e-learning again. What I would like to know from yourselves in this group is do you think that there is any future for e-learning for the apprentices in the plumbing section?

Lecturer C: *Well, with 84% of the students indicating that they would like to do it again, this surely answers the question.*

Researcher: But is that justified by a 10% increase in student performance? They might like to participate in e-learning but is it benefiting them? That's the real question.

Lecturer C: *Well, 10% is not a bad improvement. If you were to get 10% on your savings you would be very happy.*

Lecturer H: *Most of them still seem to need one-to-one. Walking around the class looking over their shoulder seems to be the only way to help some of them. Certainly for the weaker ones, they still need the one-to-one.*

Lecturer S: *The WebCT might be a great back up to the one-to-one. That fact that they can go home and do it.*

Researcher: Is there an opportunity here for giving students an extra option and maybe even helping students who have to sit referrals in theory examinations.

Lecturer G: *One of the things that I'd like to know is what percentage of apprentices had the option of accessing the web site from home?*

Researcher: Following interviews with 144 Phase 4 apprentices and questionnaires from 106 Phase 6 apprentices (that's 250 students in total) 74% have access to the Internet at home. Now that does not mean they all have broadand.

Lecturer M: *I don't think that broadband is essential for these e-learning sites. A dial-up connection is pretty ok.*

Lecturer T: *I still think the whole thing with apprentices in general is that if you brought them into a room and physically showed them how to use the Internet and then gain access to the web etc. I think more of them would use it. Apprentices in general are very scared of any new suggestions or ideas and most of them would be unwilling to try something new without supervision.*

Researcher: My original intention in carrying out the research was to give the apprentice participants a reasonable induction of maybe an hour or two and them let them access the site as they so wished. But when I found that 74% of the participants had the Internet I was concerned that those who did not might be the very ones who needed it. So, then I decided to have a weekly session in the computer laboratory. As a result of this the participants were logging on and off at all sort of different hours. By the end of the research there were 3700 hit on the site. That doesn't mean that the students logged on 3700 times, every time you go from page to page it's called a hit. I see this really as an extra option I don't think it will never replace one-to-one teaching.

Lecturer K: *It's a big extra option. It's a huge addition to what they have at the moment and a tremendous facility for the students.*

Lecturer M: *There are a number of things you have to do in introducing e-learning. You have to get the commitment of the students. A lot of apprentices in Phase 4 are really not interested in maths. You have to condition them to understand that they really need this sort of information.*

Researcher: What sort of feedback did you get from the apprentices regarding the site? I ask this because sometimes they will tell me what I want to hear and this may not reflect their true feelings.

Lecturer K: *Any feedback I got from the students was very positive and they were very impressed with it.*

Lecturer C: *What sort of comments did you get from the questionnaire with the Phase 4 students?*

Researcher: Well, of the forty students who took part in the research only one expressed negative feedback. When they were asked would they recommend this web site to other apprentices thirty-eight said 'Yes'. However, what I would like to know is regardless of this type of comment does a reduction from 39% to 29% in the failure rate of maths questions justify e-learning?

Lecturer T: *Would it be fair to say in general that apprentice learning can be quite slow? Because one thing I'd be aware of with students is they don't know how to study. Not just in relation to maths but in any subject. They seem to find it very hard to formulate a study method for the eleven weeks they're here with us. And I'm sure we've all seen it where an apprentice comes in on week nine when the revision starts and decides to start studying then. But I think that students who are focused are more open to new methods of study particularly something that's visually enlightening to them. I sometimes think that the day of the one-to-one conversation is dying and that they'll sit in front of a screen for hours and it doesn't seem to bother them. So I think this sort of initiative has a great future.*

Lecturer S: *I would myself as well. Providing that there is a good introduction to it.*

Lecturer M: *One thing you have to remember about our apprentices is that they pick the trade because it's physical and it's their academic abilities that lead them in that direction. So right from the very start they're sort of*

struggling as far as the academic side is concerned. We really have to educate them as to the necessity of why you have to study.

Lecturer G: *Is your objective in carrying out this research to try and make e-learning an additional option to improve results?*

Researcher: Well, I see the maths site as a sort of pilot and I would like to see e-learning expanding out to include revision notes for Phase 4 and 6 apprentices. I often think that when we are teaching it is essentially one-way communication and students have to work at our pace. And even if you ask for questions, some students may wish to ask you something but are afraid or embarrassed to do so. But if they log on to a web site they can work at their own pace. So in that sense it's an extra add-on tool for them to use.

Lecturer G: *I think a lot of apprentices have low self esteem and their attitude to things like maths has to change. Many student apprentices feel that they are not good at maths and no matter what tools you give them they are never going to be good at maths. If you can address their attitude to maths I believe that's the secret.*

Researcher: It's interesting to note that many apprentices are of the opinion that the level of mathematics is Leaving Certificate standard. I don't believe it is. I think that the type of calculations in the apprenticeship programme is closer to applied maths which they are not used to. I have sent a copy of the Phase 4 syllabus to an inspector in the Department of Education and Science to seek an opinion on the standard.

Lecturer G: *I certainly don't think that the maths we do with the students is Leaving Cert. level. It is more like applied maths. I think that to help them understand the maths it should start as simple as possible. There is also*

the possibility that many young people could have had a negative experience in school regarding maths and there could be some obstacle there that's preventing them from learning. Again, I think this manifests itself as a negative attitude.

Lecturer K: *Any additional resource can only help the students. Where we have apprentices with attitude problems we often don't have the time to help them on a one-to-one basis. But we can say 'its there, so use it' and they have to take responsibility for their own learning. If they use it, great. If they don't use it you haven't taken anything away from them. You've given them an extra option. It can only be good.*

Lecturer T: *A remark that a lot of apprentices make to me is 'I don't understand the maths and I'm not even going to try it'. On day one they come in and openly say that. Now we all know that if an apprentice is down €10 in his or her wages they know to the minute how much time they were docked. Watch them with their phones and they're doing magical wonders with them. They have the capabilities to learn provided it's focused in the right way. And as we said earlier when you ask at the end of the class for questions and all you get is silence, then the web site that you have set up is proving otherwise if there's that kind of hits coming on to it. The apprentices might think 'there's no one going to laugh at me for looking for this'. When they are alone they might be quite happy to study at their own pace.*

Lecturer K: *I did an introductory course on WebCT and it was recommended that people using it need a full day in week one learning how to operate the system. It's no use drip feeding students or giving them access on week six. It's too late then.*

Researcher: What you say is very true and access and support are vital resources for any e-learning programme, if it is to succeed. I want to thank you all for your support and co-operation during this research study. When it is complete I will let you know what the conclusions are and maybe we can continue to develop new initiatives such as e-learning to help student apprentices in the future. So thank you all very much.

All: *You're welcome.*

Handout Provided to Staff at Focus Group Meeting

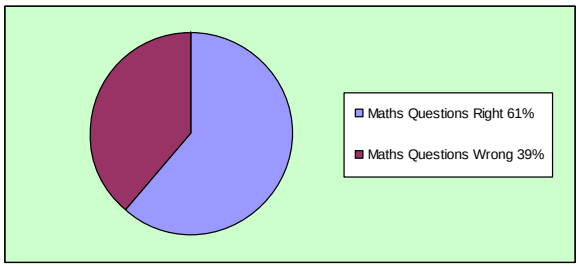
Junior Certificate Student Apprentices

Pre-Research Analysis

Number of Scripts Analysed: 160

Number of Maths Questions Analysed: 288

Percentage of Apprentices with Junior Certificate: 40%

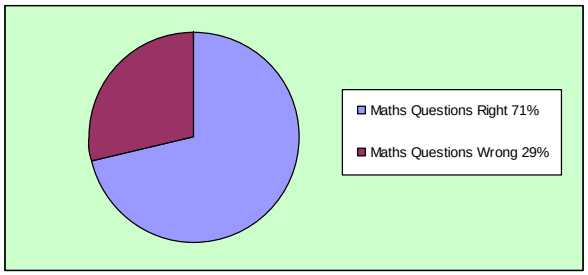


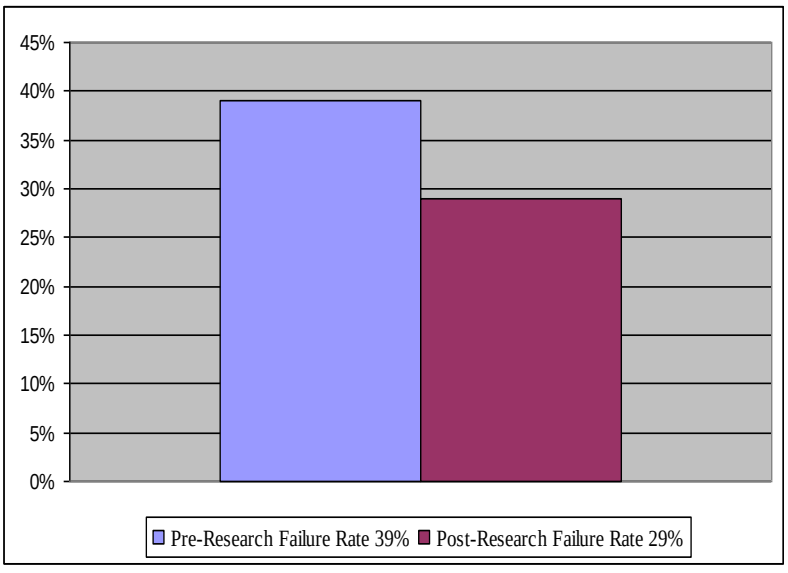
Post-Research Analysis

Number of Scripts Analysed: 120

Number of Maths Questions Analysed: 240

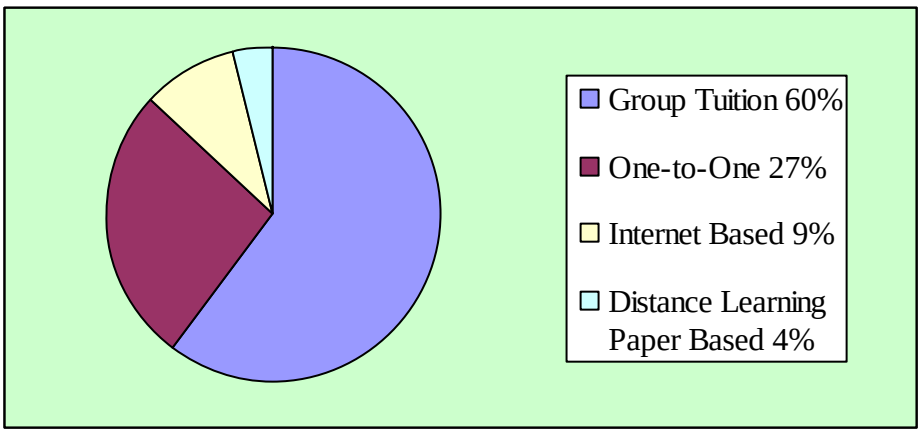
Percentage of Apprentices with Junior Certificate: 50%





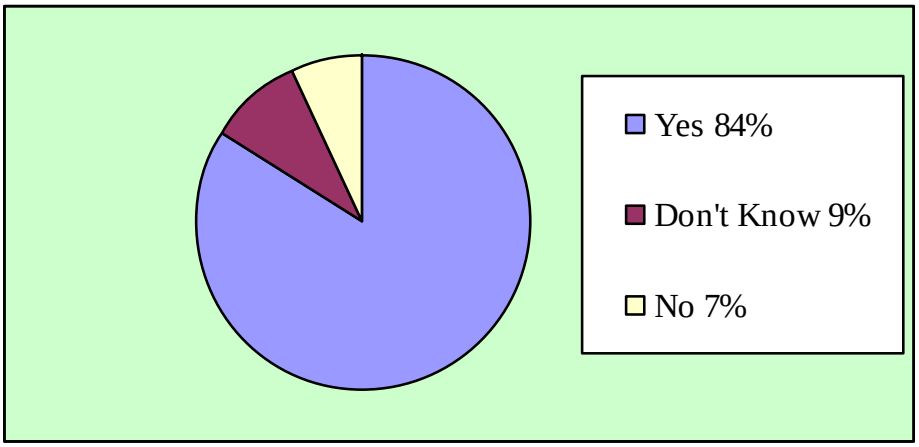
Pre-Research Analysis

Student's preferred method of revision



Post-Research Analysis

Student's answer to question *'Would you like to participate in e-learning again?'*



Appendix I

Questionnaire used with Phase 6 apprentice plumbing students.

Questionnaire for Phase 6 Student Apprentices

This questionnaire is part of a research study being carried out to ascertain the level of mathematics pertaining to Phase 4 plumbing apprentices. It forms part of an MA thesis in Third Level Learning and Teaching. All information given is strictly confidential and will not be used for any purpose other than that for which it is intended.

Please place a tick ✓ in the appropriate box

Q. 1 Please indicate where you attended the Phase 4 plumbing programme

DIT ☐ Blanchardstown IT ☐ Dundalk IT ☐

Athlone IT ☐ Cork IT ☐

Q. 2 Did you refer in any theory tests in Phase 4?

Yes ☐ No ☐

Q. 3 Please indicate which Certificate you hold

Junior Certificate ☐ Leaving Certificate ☐

Q. 4 Was there any support structure, besides the timetabled classes, offered to you during Phase 4 regarding the theoretical elements of the programme?

Yes ☐ No ☐

Q. 5 If the answer to question 4 was yes please indicate the type of support available to you

On Line support ☐ After class tuition/support ☐

Other (please specify) _____

_____

_____

Q. 6 If support was available to you outside the regular classroom sessions, would you have availed of it?

Yes ☐ No ☐ Don't Know ☐

Q. 7 If additional support was available which method would you prefer?

Face-to-face tuition on a one-to-one basis ☐

Face-to-face tuition in a group setting ☐

Online learning via the internet including support ☐

Distance learning using paper based material ☐

Q. 8 Would you describe the mathematical element of the Phase 4 programme as

Difficult ☐ Easy ☐ About right ☐

Q. 9 Do you think that there is a need for additional support in craft mathematics for student apprentices in Phase 4?

Yes ☐ No ☐ Don't Know ☐

Q. 10 Do you have access to the Internet at home?

Yes ☐ No ☐

Thank you for taking the time to complete this questionnaire.

Your support is much appreciated.

Peter Hinch – October 2005

Appendix J

Breakdown of Phase 6 questionnaire results.

Phase 6 Questionnaire Results

	DIT	ITB	DKIT	AIT	CIT
Question 1	54	40	3	4	5
	51%	38%	2%	4%	5%

	Yes	No
Question 2	19	87
	18%	82%

	Junior Certificate	Leaving Certificate
Question 3	40	66
	38%	62%

	JC who failed theory exam.	LC who failed theory exam.
Data Transformation of Q 2 & Q3	12	7
	30%	11%

	Yes	No
Question 4	27	79
	25%	75%

	Night Class	After Class
Question 5	3	3
	3%	3%

	Yes	No	Don't Know
Question 6	61	16	29
	58%	15%	27%

	One-to-one	Group	E-Learning	Distance
Question 7	29	64	9	4
	27%	60%	9%	4%

	Difficult	Easy	About Right
Question 8	37	14	55
	35%	13%	52%

	Yes	No	Don't Know
Question 9	71	17	18
	67%	16%	17%

	Yes	No
Question 10	68	38
	64%	36%

Appendix K

Questionnaire used with Phase 4 apprentice plumbing students.

Questionnaire for Phase 4 Student Apprentices

This questionnaire is part of a research study currently being carried out to ascertain the level of mathematics of Phase 4 plumbing apprentices. It forms part of an MA thesis in Third Level Learning and Teaching. All information given is strictly confidential and will not be used for any purpose other than that for which it is intended.

Please place a tick ✓ in the appropriate box

Q. 1 Having completed the e-learning mathematics module, how would you best describe the experience?

Very Worthwhile	Worthwhile	Not worthwhile
☐	☐	☐

Q. 2 How would you best describe the level of difficulty of the Plumatics 4 U web site?

Too easy	About right	Too hard
☐	☐	☐

Q. 3 Would you describe the Plumatics 4 U web site as being relevant to the Phase 4 apprentice plumbing programme?

Yes	No	Don't know
☐	☐	☐

Q. 4 In relation to the self-tests, which of the following statements would you agree with? (Please tick one box only)

1. There were too many self-tests. ☐
2. I would have liked more self-tests. ☐
3. The self-tests were not necessary. ☐

Q. 5 Regarding the worked examples on the site, which of the following statements would you agree with? (Please tick one box only)

1. The worked examples were helpful. ☐
2. There could have been more work examples on the site. ☐
3. The worked examples were not necessary. ☐

Q. 6 Would you describe this e-learning resource as useful for Phase 4 apprentices?

Yes	No	Don't know
☐	☐	☐

Q. 7 Would you recommend this particular module to fellow apprentices?

Yes	No	Don't know
☐	☐	☐

Q. 8 Would you like to participate in e-learning in this subject in the future?

Yes	No	Don't know
☐	☐	☐

Q. 9 Regarding question 7, could you give a reason for your answer?

_____

_____

_____

_____

Q. 10 Did you feel that support was available to you during the e-learning module?

Yes ☐ No ☐ Don't know ☐

Q. 11 Did you access the Plumatics 4 U web site outside the Wednesday morning class session?

Yes ☐ No ☐

Q. 12 If your answer to question 11 was 'Yes' could you indicate where you accessed the site from?

Home ☐ Within the college ☐ Internet café ☐

Q. 13 Do you have access to the Internet from home?

Yes ☐ No ☐

Q. 14 Please indicate your highest second level educational qualification.

Junior Certificate ☐ Leaving Certificate ☐

Thank you for taking the time to complete this questionnaire.

Your support is much appreciated.

Peter Hinch – March 2006

Appendix L

Breakdown of Phase 4 questionnaire results.

Phase 4 Questionnaire Results

	Very Worthwhile	Worthwhile	Not Worthwhile
Question 1	19	20	1
	47%	51%	2%

	Too Easy	About Right	Too Hard
Question 2	4	35	1
	10%	88%	2%

	Yes	No	Don't Know
Question 3	37	0	3
	93%	0%	7%

	Too Many	Wanted More	Not Necessary
Question 4	4	35	1
	10%	88%	2%

	Helpful	More Required	Not Necessary
Question 5	32	7	1
	79%	19%	2%

	Useful	Not Useful	Don't Know
Question 6	35	1	4
	88%	2%	10%

	Yes	No	Don't Know
Question 7	38	1	1
	96%	2%	2%

	Yes	No	Don't Know
Question 8	34	3	3
	86%	7%	7%

	Yes	No	Don't Know
Question 10	37	1	2
	93%	2%	5%

	Yes	No
Question 11	33	5
	88%	12%

	Home	College	Café
Question 12	24	11	3
	63%	29%	8%

	Yes	No
Question 13	27	13
	67%	33%

	Junior Certificate	Leaving Certificate
Question 14	20	20
	50%	50%

	Junior Certificate With Internet	Junior Certificate Without Internet	Leaving Certificate With Internet	Leaving Certificate Without Internet
Data Transformation of Q 13 & Q14	15	5	14	6
	75%	25%	70%	30%

Appendix M

Phase 4 students' comments from question nine of questionnaire.

Student's comments from question nine.

- Because I don't think they would look at the site. (Student 4/1 A)
- I would recommend it because it was helpful. You could take your time over it at home. (Student 4/1 B)
- It's good learning! (Student 4/1 C)
- Great learning facility. (Student 4/1 D)
- Helps study, shows formulas and formats of how they're done. (Student 4/1 E)
- If they are weak at certain maths they can learn by going on the site when at home. (Student 4/1 F)
- It can only help you, so why not? (Student 4/1 G)
- I would definitely recommend this module as I found it to be a great study aid and a good interactive way of learning which I think everyone would agree with. (Student 4/1 H)
- It was very helpful to me in all my tests. (Student 4/1 I)
- Just because it's a different approach. (Student 4/1 J)
- Found it very good for when I was studying. (Student 4/2 A)
- Because it's a good web site. Gives you good information and pictures are good. (Student 4/2 B)

- To help them learn. Makes it easier. (Student 4/2 C)

- Yes. Because you can go home and have test questions there. (Student 4/2 D)

- I think it is very helpful. (Student 4/2 E)

- It's good that the site can be accessed from outside the college. You can try the questions and check the answer. (Student 4/2 F)

- Because some people struggle with maths and would be too embarrassed to say anything publicly. (Student 4/2 G)

- Very helpful if you are having difficulty with a particular subject that you can go home and look over things on the computer. (Student 4/2 H)

- Very helpful to have answers worked out. (Student 4/2 I)

- Because it would be helpful to them also. (Student 4/2 J)

- Very helpful. (Student 4/2 K)

- I found it helpful so I'm sure someone else could benefit too. (Student 4/2 L)

- It was a very easy way of learning the stuff. (Student 4/3 A)

- Yes, tell them to log on and check it out. (Student 4/3 B)

- It's easier to learn when equipment is on a screen in front of you and with Internet access you can do it at your own leisure. (Student 4/3 C)

- Makes it easier to study. (Student 4/3 D)

- Because if people are struggling with their maths it can help them as they can use it outside of college hours. (Student 4/3 E)

- Work hard. (Student 4/3 F)

- It helps for referrals and to get your head around the maths. (Student 4/3 G)

- Very helpful. (Student 4/3 H)

- For people with difficulty with maths a good way of studying on a different media. (Student 4/3 I)

- Because if you struggle with maths it's very helpful. (Student 4/3 J)

- Because it's helpful. (Student 4/3 K)

- I'd recommend this module because some apprentices might find it useful and a learning experience for the tests, as I have. (Student 4/3 L)

- In the case of referrals this web site would be a great help. (Student 4/3 M)

- Quick way to revise. (Student 4/3 N)

- Yes it is very good because you can learn from it easy because the self-tests drill it into your head. (Student 4/3 O)

- I would definitely recommend this because it is very helpful. Good for going over on the build-up to your final theory exams. (Student 4/3 P)

Appendix N

Student Instructions for Plumatics 4 U web site.

Instructions specially written for student apprentices when accessing the Plumatics 4 U WebCT site. These instructions are in addition to the 'Students' Frequently Asked Questions' handout provided by the Dublin Institute of Technology Learning Technology Team.

Student Instructions

Plumatics 4 U

B870 (Phase4)

Mathematics

For Plumbing Apprentices

Using WebCT

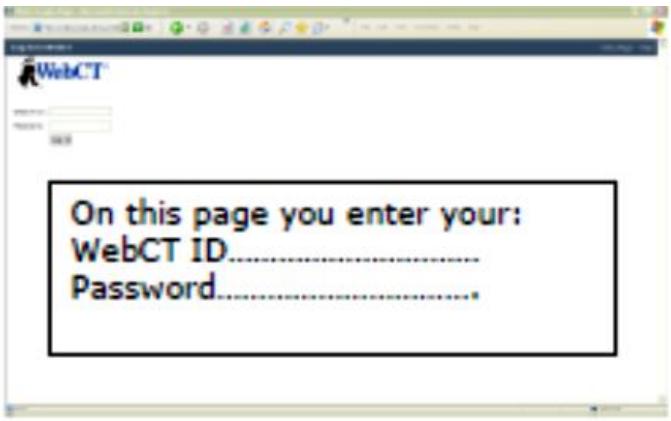
Student Instructions

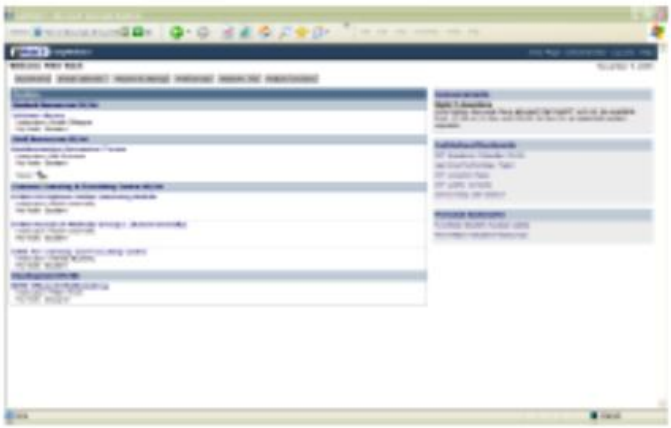
Connect to the Internet and in any search engine (i.e. Google, Yahoo or MSN) type dit.ie

You may be brought to a screen with several DIT links. If so click **Dublin Institute of Technology: DIT: Welcome**
and you should now see the screen on the left.

Click on the WebCT box.

You should now see this screen.
Click "Log in to myWebCT"





Having entered the correct ID and Password you will see a screen similar to the one on the left.

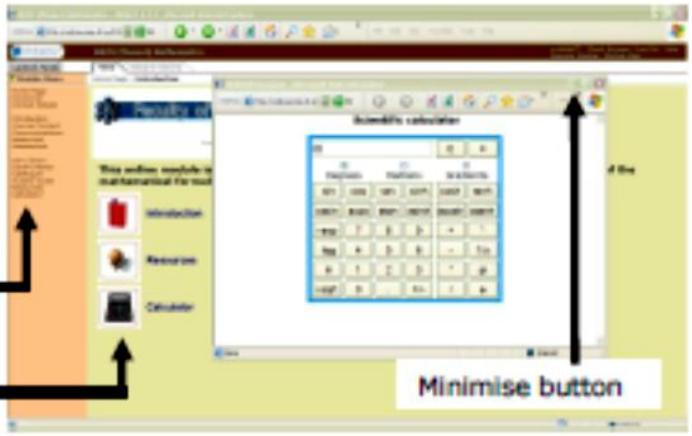
You should click on the course:
B870 (Phase4) Mathematics

You should now be on the homepage of the Plumatics 4 U module.

Clicking on 'Introduction' will give an outline of the course.

The content can be viewed by clicking on 'Course Content'.

To help you in performing calculations an online Scientific Calculator can be accessed. There are 2 ways of making the calculator appear on screen.
(1) By clicking the word 'Calculator' on the left hand side of the screen.
(2) By clicking the 'Calculator' icon.



Either of the above actions will cause the calculator to pop-up as shown above. If you click anywhere outside the calculator box this will cause the calculator to minimise. You can also do this be clicking the minimise button on the calculator.

When the calculator minimises it goes to the bottom of the screen and is named 'Untitled Document'. To restore the calculator simply click on 'Untitled Document' at the bottom of the screen. Please note that when the calculator is minimised it cannot be restored by clicking on either option 1 or 2 above.

Another item that may be of use to you is the 'Help' function. This is available at all times and can be accessed by clicking on 'Help' on the top right hand part of the screen.

Please note that you cannot do any damage to this programme when using it. So feel free to work through it as you wish. Also, WebCT is protected by the DIT security system and will not infect your computer with any virus.

Sometimes computers with Norton Internet Security cannot access the 'Calculator' or 'Help' function. If this is the case you could try turning off 'Ad Blocking' in Norton when using WebCT.

Appendix O

Letter to Staff Regarding WebCT Information Session.

Letter sent to Head of School, Head of Department, Assistant Head of Department and all teaching staff in the plumbing department informing them of my intention to conduct an information session with regard to my master's dissertation and also demonstrating the content of the WebCT Plumatics 4 U e-learning resource.

14th November 2005

Dear Colleague

As part of my Master's Degree studies I would like to give an information session to staff who may be interested in my chosen topic which involves the use of WebCT.

The session will take place on Wednesday 7th December in the Conference Room at 11.45 a.m. A member of the Learning Technology Team will also be in attendance to answer any queries about WebCT.

I anticipate that the proceedings will take approximately 45 minutes.

If you are in a position to attend I would be delighted for you to come along.

Many thanks,

_____

Peter Hinch