Science and Mathematics Education Centre

The Impact of Blended Learning in Improving the Reaction, Achievement and Return on Investment of Industrial Automation Training

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Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgement has been made.

Signature

Date: September 2008

Abstract

There has been a significant increase in the level of remote or distance learning using the Internet, often referred to as e-learning or online education. E-learning is often combined with classroom instruction and on-the-job training and this is referred to as blended learning. The purpose of this research is to investigate the impact blended learning has in improving engineering training in the engineering field of industrial automation. This is especially in improving the reaction, achievement and return on investment of learners compared to that of only the traditional classroom or e-learning approaches. One of the gaps in current research is the examination of the impact of blended learning in improving engineering training. The research revealed significant growth in the use of e-learning for engineers and technicians. There would however appear to be a large number of engineers and technicians who were disappointed with their experiences of e-learning. Significant concerns were also identified in the efficacy of e-learning and the lack of hands-on experience in this form of training for engineers and technicians. Suggestions are made as a result of the research into addressing these issues.

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1.1 Introduction

Over the past decade, there has been a proliferation of remote or distance learning using the internet (often referred to as e-learning or online education) in the technology and industrial automation education areas (E. Allen & Seaman, 2006; Bersin, 2004; Bonk & Graham, 2006; Ma & Nickerson, 2006; Rossett, 2001). Typical approaches for e-learning are web-based (asynchronous) and streaming of video with a live instructor (synchronous) over the internet (Rossett, 2001). Some years ago, Kazmer and Haythornthwaite (2004) quoted from Pew Internet and American Life Project (*The internet and education*, 2001) that “On any one day, at least one million people in the U.S. are online taking a course” (p. 7). Claims have been made by early pioneers such as Whalen (2000) on the improved learning achieved and cost effectiveness and by extension, return on investment (ROI) of this form of training compared to that of traditional classroom-based training. Zhang, Zhao, Zhou, and Nunamaker (2004) indicated that learning using information technologies was rapidly growing due to the increasing demands for quicker time to gain competency in a subject and the issues of globalisation and accelerating competition.

Kanyongo (2005) referred to L.J. Smith (2001) who listed the benefits of e-learning as being “accessibility, flexibility, participation, absence of labeling, written communication experience and experience with technology” (p. 1). On the other hand, L.J. Smith (2001) listed the problems for e-learning being that of “team building, security of online examinations, absence of oral presentation opportunities and technical problems” (p. 1). Brown and Lahoud (2005) noted the remarks of Moore and Kearsley (1996) that courses delivered at a distance can be as good as that of traditional classroom instruction. They felt that the key to a good quality course is the way it is designed and delivered. After an extensive review of the literature, Lorenzo and Moore (2002) supported this assertion, by saying that online learning can on occasion be better than traditional classroom learning.

There has been some conjecture about the best blend between online education and traditional classroom instruction (Banks, 2004). Blended learning (Bersin, 2004; Mackay & Stockport, 2006) is a combination of the different training media such as classroom instruction, on-the-job training and e-learning. Banks referred to Brookfield (1990) and Berge and Schreier (1998) who noted that traditional education models were constructed around the concept of "one place, learning at one pace, following one path, and at one time" (p. 6). He drew on van Dam (2001) who noted that online education has the potential to remove these limitations but would find it difficult to duplicate what works really well in the classroom. Simonson (2003) believed that for online learning (or distance education) to be successful, it is critical that distance education systems are designed to allow similar learning experiences for both distant and traditional classroom-based students.

The research described here was an investigation on whether a combination of e-learning and classroom learning, or blended learning, would improve the reaction, learning achieved and ROI of training in the engineering field of industrial automation compared to that of either only classroom training or e-learning. The associated costs and benefits to a corporation in improving its bottom line in terms of technology and industrial automation training as compared to classroom-based education was also examined. Research done so far in a more general environment such as information technology, as opposed to a specific engineering discipline such as industrial automation, indicated that blended learning has the same effectiveness in terms of learning achievement as traditional classroom learning (Banks, 2004; Boyle, Kolosh, L'Allier, & Lambrech, 2003).

Bersin (2004) emphasised the importance of blended learning by concluding:

> Today we are at a point where every significant training program should use a blended approach. Traditional page-turning courseware is no longer sufficient. Training professionals should always think about providing two or three ways for learners to obtain the information and skills they need (Bersin, 2004, p. 7).

Harding, Kaczynski, and Wood (2005) noted that in blended learning "…the conveniences of online courses are gained without the loss of face-to-face contact" (p. 56). Instructors want to introduce blended learning to help students who are unable to cope with only online learning; offer additional support to weaker students; wish to introduce students to technology; help students who have time and distance restrictions in attending classroom-based courses and for university financial and staffing reasons. As Singh (2003) pointed out; the term blended is based on the idea that learning is not a one-off one-time phenomenon but a recognition that learning is a continuous ongoing process.

Much research has concluded, perhaps glibly, that e-learning is considerably less expensive than classroom (or instructor-led) training, and thus has a considerably better ROI for each additional course participant (Rossett, 2001; Whalen & Wright, 2000). M. Allen (2003) suggested that e-learning could result in savings of at least 40% in costs compared to classroom instruction. The reasons are not hard to find – in e-learning there are minimal expenses incurred in travel and every additional participant is at a minimal marginal cost.

Joy and Garcia (2000) have warned that much of the research in instructional technology has shown that there is no difference in "learning effectiveness between technology-based and conventional delivery media" (p. 33). But they felt that much of the research in comparing e-learning and classroom instruction is defective as it has ignored the other confounding variables, as discussed later in the delivery media debate in section 2.7. At the end of the day, they noted that technology-based training (such as e-learning) is not necessarily better than traditional training mechanisms. As they concluded: "learning effectiveness is a function of effective pedagogical practices. Accordingly, the question …..ought to be: 'What combination of pedagogical strategies and delivery media will best produce the desired learning outcome for the intended audience?' " (p. 33). This is precisely the focus of this research in examining the best combination of the various components of blended learning in an industrial automation context; not simply a comparison between e-learning, blended learning and classroom instruction hoping to identify the best medium.

Industrial automation was the environment in which the research was based and is defined as “the use of computers to control industrial machinery and processes, replacing human operators” (*Automation*, 2007). It has been selected as the author is familiar with the field and it was a rapidly growing industry (in 2007) where modern technologies in training such as e-learning and blended learning would be particularly suited.

There have been some cautions sounded about the success of e-learning with Zemsky and Massy (2004) indicating at the time of writing, that there was still no tangible market for e-learning, students have been unenthusiastic about it and it is felt that it would not change the way we teach and learn.

In this introductory section, a review will initially be given of the e-learning and blended learning markets, and applications followed by training and corporate productivity issues, experiential learning and the thesis of this research.

1.1.1 A Fast Growing Market

Van Dam (2004) quoted from a report from the respected IT research organization, Gartner, which indicated that the e-learning market would exceed US$35 billion in 2005. Whilst the statistics quoted in this section relate to the general education market (e.g., universities and schools) as opposed to the corporate market which was the focus of the research, they are nevertheless worth examining, as they are related.

Flores (2006), Chief Executive Officer of the USA Distance Learning Association, indicated the following statistics in support of the growth of online learning. The number of internet users which exceeded 1 billion in 2005, has grown quickly from 45m in 1995 and 420m in 2000. The education and training market on a worldwide basis was estimated at $2 trillion with e-learning taking approximately 10% of this. Effectively, this means that the worldwide e-learning market was estimated to reach $1,891 million by 2008. In the non-profit arena, management and technical services organisations showed an increase in usage from 33% (2004) to 45% (2006) (*E-learning in nonprofits and associations*, 2006).

E.I. Allen and Seaman (2006) in their fourth annual report on the state of online learning in the USA higher education for 2005 (for the Sloan Consortium), commented that despite the expectations of a saturation in online enrolments, based on the rapid growth over the past four years (E. Allen & Seaman, 2004), there was still no levelling off with an additional 800,000 additional (online) students and nearly 3.2 million taking at least one online course during the autumn of 2005, off a base of 2.3 million for the previous year. The results showed that the bulk of online students were still overwhelming undergraduates. The proportion of graduate-level students was slightly higher in online education giving some credence to the suggestion that online students are older and have other personal and career commitments. Finally, an increasing margin of the leaders in the educational institutions (62% for 2005 versus 57% for 2003), believed that the quality of online education was equal to or superior to face-to-face instruction.

E.I. Allen, Seaman and Garrett (2007) examined blended learning (as opposed to solely online learning) based on three years of responses from over 1,000 colleges and universities in the USA. They also included results from over 2,000 adults in the USA "interested in post secondary education in the next three years" (p. 1). Despite it being apparently easier to structure due to the existence of traditional classroom instruction, blended courses were still not more numerous than online courses. Overall, 38% of respondents agreed that blended learning courses had more potential than online courses in 2004; down from 46% in 2003.

In reporting on a recent survey of 150 USA and 118 UK learning professionals on blended learning by the company, Balance Learning, Sparrow and Hicks (2004) observed that the respondents noted that blended learning programs comprised a mixture of instructor-led training, customised e-learning, workbooks and workplace assignments. It indicated that 77% of USA-based organisations used blended learning and that it accounted for 16% of all training in the USA, and was expected to expand to 30% by 2006. Instructor-led training was assessed as being the least effective training method and was anticipated to decrease to 38% in 2006, from 50% in 2004, in both the USA and UK.

Phoenix University, a mainly online university, in 2004 had over 100,000 students worldwide and expected to see future growth of 50% to 60% (L. Anderson, 2004).

Williams (2006) believed that many training companies were examining the global corporate learning market (estimated at $13.2bn) as the ultimate target for e-learning. O'Leonard (2004) referred to the 2003 Training Magazine survey which found that 17% of corporate training used e-learning. The trends indicate that this can only be increased in 2007.

Sitzmann et al. (in press, p. 3) quoted a survey done by Trierweller & Rivera (2005) who noted that the "majority of learning executives anticipated increasing use of online platforms to deliver higher education to their employees." Indeed, Dixon (2007, pp. 26-27) remarked that "many executives are already refusing to attend on-site training, insisting on remote learning where possible." Perhaps this is one of the reasons why there is an increasing use of e-learning.

Whilst the picture painted above appears to indicate that e-learning has been widely accepted, there have been some setbacks with the Financial Times' subsidiary, FTKnowledge, and a well known European university, INSEAD, both shutting down their online learning initiatives due to lack of response (L. Anderson & Bradshaw, 2003). Similarly, despite a much publicised launch of Harcourt General's online college, it also closed down in 2001 with only 20 to 30 students, despite targeting 20,000 over five years (Antonucci & Cronin, 2001; "Harcourt virtual college shuts down," 2001).

1.1.2 Universities and Schools Embrace E-learning and Blended Learning

Whilst the focus of this research was on blended learning in a corporate context, it was nevertheless instructive to review examples of how staff and students at universities and schools approached and applied e-learning and blended learning, as this gave some guidance of trends in other markets due to the commonality of people and technology.

Minton, Boyle, and Dimitrova (2004), in a case study, compared the attitudes of mature and traditional university students to e-learning and noted mixed reviews of e-learning and blended learning. Both groups did not have a good image of e-learning – the mature students felt it was working through boring tutorials and the traditionalists understood it to be a "teacher's head on a TV screen" (p. 45). Some of their findings were that mature students did not feel that e-learning could replace a lecture and wanted the personal interaction with real teachers. Traditional students were uninterested in lectures being placed online, feeling that they would simply miss them and they appreciated the social experience of attending lectures. This was in contrast to mature students who believed that coursework, as opposed to lectures, gave them structure to what they were undertaking at university. Overall e-learning was regarded by both groups negatively if it is considered separately from university. As part of university however, it was regarded as a useful adjunct. There was a strong feeling that the use of technology should be increased in terms of sharing of information and resources, providing immediate electronic and technical support.

Pauli (2007) quoted Dalziel (Director of Macquarie University's E-learning Centre of Excellence) who commented: "Universities and schools use e-learning to complement existing teaching techniques, provision more activities, and to provide flexibility for students who are now also in the workforce" (p. 32). Dalziel noted that the quality of e-learning was equivalent to that of traditional forms of education. He indicated that the ability to collaborate, discuss and have synchronous lectures online made e-learning more enjoyable.

In a survey examining e-learning approaches by students and faculty members in process and chemical engineering at European universities (Gauss, Jimenez, Urbas, Hausmanns, & Wozny, 2004), staff were more positive than students; hence it was suggested the driving force for innovation must come from the university staff. Computers were used on average for 29 hours per week with 35% of respondents engaged in web-based learning modules followed by 10% in virtual courses. There were no details on the definitions here; but presumably "web-based" referred to asynchronous and "virtual courses" to synchronous learning.

Pauli (2007) also noted comments from Deden from Open Universities Australia who said:

> E-learning offers convenience, meaning adults with multiple responsibilities can fit online study into their lives more easily, because they do not have to commute to campus for an hour lecture in the middle of their workday, or drag themselves to campus after work. The amount of study is the same, but the individual has the power to choose when and where it occurs; however, study is not exclusively a solo performance despite this flexibility. Most online courses include asynchronous group discussions on important topics, while some even involve group projects (Pauli, 2007, p. 32).

Ruth (2006) suggested that traditional universities could use a blended learning approach to increase their numbers without a comcomitant increase in infrastructure costs, because of the relatively difficult job of replicating the for-profit universities approach and attracting more full-time hitherto reluctant university staff into e-learning.

Sitzmann, Kraiger, Stewart, & Wisher (in press) quoted Symonds (2003) who remarked that the USA Army used "online instruction as a retention tool, with over 40,000 soldiers in 50 countries pursuing advanced degrees online".

Further down the educational chain, Cavanagh (2006) remarked that online courses are becoming part of the normal school student's courses as part of a blended learning offering. Online assignments are being done both at school and at home. He reported that the USA Federal government estimated that there were 330,000 school enrolments nationwide for online courses in 2002/3. There was an interesting choice of both college and school online courses being taken as well. One of the reasons driving students to take online courses was to improve their chances of college admission especially if they were from poor or rural areas or were struggling in a particular subject. In most of these cases, communications between student and teacher appeared to be asynchronous by email/web and occasionally by phone. Apparently, students' schools accept online courses and do not discriminate on their academic transcripts between online and traditional classes. This has raised some concerns with some universities in California, for example, where online providers are being screened for academic rigour. A few other issues that have arisen with online education are the different perspectives brought to the subject by students drawn from a wider catchment area than in a traditional school (e.g., Northern Illinois against Southern Illinois). Students find less pressure in their interaction in online education as against that from face-to-face discussions in a traditional high school.

Donnelly (2007) and Ferrari (2007) cautioned enthusiasts of computer technology by noting recent damning research revealing little if no improvement in a school student's achievement levels despite having significant levels of usage of computers and software. Donnelly referred to two German researchers, Fuchs and Woessmann, who did a wide ranging world study and who noted that once the variables of family and school background were controlled, there was a negative correlation between computers at home and the student's performance in maths and reading. They also found that there was no relationship between computers at school and the student's performance. As an aside, Humbert of Grenoble Graduate School of Business (L. Anderson, 2004) observed that students preferred a blended approach as opposed to only e-learning courses.

1.1.3 Many Different Applications of E-learning and Blended Learning

It was important to place the blended learning research presented here in a wider context of other applications as there are many similar techniques and challenges due to the common e-learning technologies used.

In the accounting world, Andrews and Freeman (2001) noted that using e-learning for training has allowed for a more dynamic relationship between clients and professional advisers. Using e-learning has also allowed for far more industry specific, competency-based and economical training due to a wider variety of materials available to a larger market and more targeted to an individual's learning style and prior knowledge. They did point out though that e-learning was more widely accepted by staff under 40 years of age.

The Training Journal ("KnowledgePool trains 15,000 civil servants to support IT upgrade," 2004) noted a large blended learning application conducted by KnowledgePool, involving 300 instructor-led seminars, e-learning and live coaching to upgrade 15,000 employees at the UK's Home Office to Windows XP and Office XP from earlier versions of the Microsoft product range.

Chromavision Medical Systems ("Diagnostics: Company launches its new internet-based remote-access program," 2005), indicated that they were providing a remote-access program through the internet to make their laboratories available to those who needed to do disease analysis remotely. This allowed pathologists to perform remote image analysis and obtain an accurate characterisation of their patient's cancer tumours. This remote lab approach has reduced the need for equipment, thus reducing capital expenditure and lower support costs as there are fewer labs. It can be seen that this approach could be used to give improved training as well using these facilities.

The Power magazine ("E-learning modernizes apprenticeships," 2005) suggested that with the current growing shortage of apprentices, e-learning could provide tools for evaluation and thus remove the burden from supervisors who find this a difficult process.

Kanyongo (2005) described an eight-week statistics e-learning course for school teachers working towards certification as principals. He concluded that teaching statistics online is as effective as classroom teaching provided the course promotes a learner-centred, as opposed to a teacher-centred approach. The post-course questionnaire scores for the e-learning class were slightly below that of the equivalent classroom teaching, but with two scores greater for e-learning; that of the instructor being "willing to meet with students outside of class time" (p. 8) and "the instructor significantly increased my understanding of the subject matter" (p. 8).

Diaper (*Polycom desktop video plays key role in improving scientific research*, 2005) of the CCLRC's Rutherford Appleton Laboratory, remarked that video conferencing had been enormously helpful in bringing remotely located engineers and scientists together for ad-hoc meetings (and presumably, training sessions) with experts located throughout the world and allowed participants to join meetings for short periods of time as they deemed appropriate.

Wolf (2006) noted that RadioShack, a large (mainly) USA supplier of consumer electronics equipment, has offered a large number of self-paced online courses which run for two to four weeks with courses on wireless, digital photography and satellite radio.

Cole (2006) noted that e-learning was even proving useful for sports stars such as a player from the New York Mets baseball team, Dan Murray, who was completing his bachelor's degree through Drexel University.

Lee (2006) discussed the e-learning initiatives in other non-English speaking countries such as Korea, in the corporate market where the number of employees who took part in internet training supported by the government increased from 19,653 in 1999 to 804,241 trainees in 2004. He felt that a few of the problems with implementing e-learning in Korea have been uniformity and its fairness to all potential participants. He cited Jo (2006), who felt that the courses being developed are too basic or overlap extensively with each other. As far as fairness was concerned, the main beneficiaries of e-learning tended to be the office administrative staff of large corporations with small companies (less than 150 workers) making up only 2.9%.

Robins (2006) described a synchronous application for Six Sigma quality training presented by the Institute of Industrial Engineers (IIE, Norcross, Georgia). The course was over 10 weeks and required applying the learning materials to an on-the-job project. The use of voice over the internet protocol (VoIP) technology allowed both learners and instructors to communicate in real time via the computer at a low cost compared to the more expensive POTS ("plain old telephone system"). Robins believed that there were advantages of synchronous over traditional pre-recorded e-learning, besides the obvious of having an instructor present simultaneously. These advantages include using the web browser of students to follow that of the instructor to interesting web sites, watching video clips and being able to share software applications simultaneously such as Excel on either the instructor's machine or that of the learner. Finally both learners and instructor could go to a remote laboratory to see the classroom theory put into practice. This application could be considered to be blended learning as both e-learning and on-the-job training were the key components. This approach is believed to be a powerful way of training engineering personnel and a proposed software package using aspects of this (which has subsequently been written but is outside the scope of the research) is detailed in Appendix D.

Friedman (2006) pointed out that video conferencing was breaking down barriers and costs in teaching young children mathematics. He quoted an example of a company called Growing Stars, where teachers based in India taught mathematics online to children in the USA as part of a tutoring business. They were able to speak to each other, type messages and sketch out problems on a joint whiteboard displayed on each other's computer screens. This service was provided at $15 to $20 /hour – less than the cost of $40 to $100 that local face-to-face tutors would charge.

Trotter (2007) suggested a novel way of providing just-in-time learning using computer-aided design (CAD) drawings as the basis of an e-learning course. He gave an example of how this training could benefit in showing how a mechanical assembly can be taken apart and reassembled. The traditional approach has been to prepare material for two-dimensional service manuals taking an average of 160 hours for a graphic designer to remodel parts where the dimensional data was not available. With the proposed approach, this time could be reduced to five minutes. The steps required in creating an interactive lesson were first for an instructional designer to plan the lesson, then to locate the required CAD design data, and finally to import this into a three-dimensional authoring package.

1.1.4 Training and Corporate Productivity

The research described in this thesis is about e-learning and blended learning as applied to engineering training. It is however important to place the need for training into context as an important driver of our economic well-being. A number of authorities are referred to below to demonstrate the varied benefits for providing training in the corporate environment. Banks (2004, p. 22) drew on O'Sullivan

(1976) who pointed out that "without transfer of knowledge from one person to another, or from one person to many people, work could not be effectively performed. In order for human beings to be productive and/or to perform, some form of training was utilized". Flores (2006, p. 9) quoted Welch, former General Electric Chairman and CEO, who said: "An organization's ability to learn, and translate that learning into action rapidly, is the ultimate competitive advantage".

Levett (Gerber & Lankshear, 2000), in noting the changes sweeping through society in the early twenty first century, stated: "appropriate flexible educational programs are required by employers, the employed and the unemployed throughout their lifetimes…All citizens need lifelong learning in these fast-changing times, in order to acquire and maintain knowledge, understanding and social sensitivity that will be useful both for work and for living" (p. 41).

Anderson (2000) referred to IDC, an international IT research organisation, who remarked that corporate CEO's realize that upskilling and training of employees was normally a top priority and critical to survival of their companies. An article in Works Management ("Train to succeed," 2003) stated that training was a key part in achieving high levels of productivity from one's assets. If one's people do not understand how to exploit an asset's full capability, then the best return on investment will not be realized. Similarly, downtime can be minimised by a well trained workforce acting quickly to troubleshoot and then to remedy problems with defective equipment. Aitkenhead (2002) noted that training needed to provide three items: greater cognitive skills to perform better, improved motor skills to support good practical performance and the ability to make "reasoned judgements" (p. 376).

O'Brien and Hall (2004, p. 935) referred to the work done by a number of researchers (Roche, Frank, & Teasy, 1992; Stevens & Mackay, 1999) in emphasising the importance of training "to company competitiveness and employee motivation." This is supported by Stewart (2002) who noted that employees are locked into organisations with "knowledge handcuffs" (p. 28), whereby they get opportunities for learning and improving their knowledge. Fitz-enz (2000), sometimes referred to as the Father of Human Capital Benchmarking and Performance Assessment, pointed out that when an organisation provides training and development to their employees, “you make a deposit in their loyalty bank” (p. 99). O’Brien and Hall felt that many companies (especially small and medium enterprises) unfortunately do not send their employees on training courses due to the lack of time, cost and lack of appropriate courses, and that e-learning could address these issues.

Brinkerhoff (1988) cautioned that corporate training must go beyond simply producing “learning changes with efficiency and efficacy” (p. 5), but also “result in some benefit to the organization” (p. 6). Rae (1991, p. 4) added to this: “..we must know the extent of the efficiency and effectiveness of that training.” J.J. Phillips (1991) urged training evaluation and measurement to be conducted on all programs with an emphasis on results. This is one of the themes of this research to demonstrate a return on investment on any training provided.

O’Leonard (2004) stated that there are four major business drivers for corporate training programs. These included: driving “customer success” which enables customers to more effectively apply the products the company sells; “increase sales” which enables the user to thoroughly understand the product or service and thus leads to more sales; “make money” where training is simply sold as an objective in itself and finally; “Gain Product Feedback” where a firm receives feedback on the use of its products by its customers.

Despite the previous positive comments about the benefits of training, one still has to be wary about inappropriate training. Schank (2002) pointed out that the amount of unnecessary or unproductive training (including e-learning) that pervaded the modern business enterprise was significant.

In the context of this research, one of the challenges with the training as applied to engineers and technicians is the diminishing number available due to aging and inadequate replacement by the younger generation. North America has a particular problem with an aging engineering workforce and needs serious attention and a recent survey by Wilkins (2007) pointed out that in the developed countries such as the USA and the UK, the engineering and technical workforce is getting older and consequently retiring. He felt that manufacturing and engineering does not appeal to the young person today and this is adding to the shortage of good quality entrants to the workforce where the skills requirements in these jobs are far higher than in the past. He pointed that retention is as important to manufacturers today as recruitment. He proposed a strategy of capturing organisational knowledge and experience of their workforce and implementing a coherent and effective training program. Most of the respondents (65%) of his survey indicated average training of 40 hours per annum and he remarked that this was inadequate. He did not indicate what a desirable number of hours of training would have been.

The question of how best to structure training in achieving maximum impact for engineers in interactivity by using an experiential learning approach is examined in the next section.

1.1.5 Learning by Doing or Experiential Learning

A phrase recently coined is e-learning2 (or ee-learning) or experiential learning (Trevitte & Eskow, 2007). As Eskow explained: "In experiential learning, the distinctive attributes of an everyday scene – its activities and settings, its obligations and entitlements, its excitements and boredoms, its spaces and places and people and the problems they deal with – serve as the primary textbook of learning" (p. 1). He noted that ee-learning can bring the world and the classroom together using the computer and associated technology as the enabling medium. He stated further that the real world experiences cannot be duplicated in a simple lecture or classroom. Even a video game is limited.

As an extension to this experiential view of the world, in an engineering context, one of the challenges with e-learning is the lack of interaction with the instructor and the difficulty of using real tools to demonstrate and provide practical hands-on exercises (such as working with real equipment in an industrial automation environment) for the participants (Cooper, 2000; Cooper et al., 2003).

Schank (2002) pointed out the poor quality of e-learning that many users commented on. In this research, it would be useful to build up a comprehensive list of features and approaches which make e-learning successful (and memorable) for industrial automation training. This would be particularly pertinent when practical hands-on and interactive industrial automation type training is provided, where the participant is trained using real equipment, as there is a degree of tacit knowledge necessary here (compared with explicit knowledge) as outlined by Nonaka (1998) and discussed in section 2.10, and this makes an interactive learning-by-doing approach all the more important.

Although Shank (2002) was thinking along more general lines, he stated that learning by doing was an essential part of the learning experience:

> Learning by doing works because it strikes at the heart of the basic memory processes that humans rely upon. We learn how to do things and then learn what we have learned is wrong or right. We learn when the rules apply and when they must be modified. We learn when our rules can be generalised and when exceptional cases must be noted. We learn when our rules are domain bound or when they can be used independently. We learn all this by doing, by constantly having new experiences and attempting to integrate these experiences into existing memory structures (Schank, 2002, p. 5).

It was hoped that this research would demonstrate that in using a synchronous approach to e-learning with a hands-on experience with lab equipment that Schank's assertion above, of the importance of experiential learning would be validated.

1.1.6 Thesis of this Research

The thesis of this study, was that blended learning can improve the reaction, achievement and return on investment (ROI) of industrial automation training compared with using only classroom or e-learning. The particular example of blended learning in this research comprises synchronous video conferencing and classroom instruction with an emphasis on a hands-on experience or "learning by doing" in industrial automation.

In the following sections, the various terms used such as e-learning, industrial automation, and ROI are initially defined and then some myths on distance learning and e-learning are noted. The background research on blended learning is discussed followed by the research hypotheses, the methodology, and then the main contributions made by the research. Finally, the thesis structure is detailed with the resource requirements (to get sufficient respondents) listed. This chapter is concluded with a brief mention of ethical considerations, limitations in the work, and the researcher's background.

1.2 Definition of Terms

The following discussion comprises a clarification of the terms used in the research, listed in what the author believes is a logical sequence (rather than in alphabetical order). These are discussed in more detail in the literature review in Chapter 2.

1.2.1 Five Evaluation Levels for Measuring Efficacy of Training

There are five evaluation levels listed by J.J. Phillips (2004) that are used in the measurement process for assessing the efficacy of training, as discussed in detail later. The first four levels are based on Kirkpatrick's (1998) model. These levels are:

Level 1	Reaction and planned action. This measures participant satisfaction with the course and captures planned actions.
Level 2	Learning. This measures changes in knowledge, skills and attitudes.
Level 3	Application. This measures changes in on-the-job behaviour.
Level 4	Business Impact. This measures changes in business impact variables.
Level 5	Return on Investment (ROI). This compares program benefits to the costs.

1.2.2 Training

Gamble (2005) stated that training was the transfer of knowledge from one person to another. She referred to Craig (1996) who remarked that training was an investment in human assets and a technique to raise a company to new levels of productivity.

Training includes classroom activities (instructor-led), distance learning, e-learning, on-the-job training and assignments. Gamble (2005) stated that "(blended) training is the process by which (blended) training material is presented to the learner" (parentheses placed in by the author). Robinson and Robinson (1989) focused, more appropriately for this research, on the acquisition of skills when they drew on Nadler and Wiggs (1986, p. 5) definition of training as techniques that would "focus on learning the skills, knowledge and attitudes required to initially perform a job or task or to improve upon the performance of a current job or task."

1.2.3 Learning

Gamble (2005) noted that (blended) learning referred to the "absorption of the (blended) training material by the learner" (parentheses placed in by the author). Whitney (2007) pointed out that there are important distinctions between the terms learning and training. She felt that the generally understood viewpoint was that learning is a long-term process associated with development, in contrast to training which focuses on acquisition of technical skills.

1.2.4 Distance Learning

Hentea, Shea, and Pennington (2003) drew on the Instructional Technology Council's definition of distance learning as: "the process of extending learning, or delivering instructional resource sharing opportunities, to locations away from a classroom, building or site, to another classroom, building or site by using video, audio, computer, multimedia communications, or some combination of these with other traditional delivery methods" (*ITC's definition of distance education*). The term distributed learning is sometimes used interchangeably with distance learning (Muzio, 1999).

The ASTD (Kaplan-Leiserson, n.d.; Neal & Miller, 2005) defined distance education as:

> an educational situation in which the instructor and students are separated by time, location or both. Education or training courses are delivered to remote locations via synchronous or

> asynchronous means of instruction, including written correspondence, text, graphics, audio- and videotape, compact disk-read only memory (CD-ROM), online learning, audio- and video conferencing, interactive television, and facsimile (FAX). Distance education does not preclude the use of the traditional classroom. The definition of distance education is broader than and entails the definition of e-learning (Kaplan-Leiserson, 2005, p. 3).

Larreamendy-Joerns and Leinhardt (2006, p. 568) quoted Holmberg (1986, p. 26) in "distance education includes the various forms of study at all levels which are not under the continuous, immediate supervision of tutors present with their students in lecture rooms or on the same premises, but which, nevertheless benefit from the planning, guidance and tuition of a tutorial organisation." They remarked further, that distance education has migrated rapidly over the past decade from the edge to the centre of the university.

Bernard (2004) noted from Keegan's (1996) definition of distance learning which has been widely quoted in the literature and has "five qualities to distinguish it from other forms of instruction: a) the quasi-permanent separation of teacher and learner; b) the influence of an educational organization, both in planning, preparation and the provision of student support; c) the use of technical media; d) the provision of two-way communication; and e) the quasi-permanent absence of learning groups" (p. 3/65). Rekkedal and Qvist-Eriksen (2003) supplemented Keegan's distance learning definition with "the use of computers and computer networks" and "the provision of two-way communication via computer networks" (p. 3/65), to ensure e-learning is covered.

Flores (2006, p. 1) provided a well known definition of distance learning: " Distance learning is the acquisition of knowledge and skills through mediated information and instruction, encompassing all technologies and other forms of learning at a distance." The simplicity of this operational definition made it appealing for the discussions that follow. Note that all the definitions have e-learning as a component.

1.2.5 E-learning

As Neal remarked (2006), we have learned from a young age almost exclusively in a classroom environment, so e-learning with its rapidly changing technologies is challenging. Another term used synonymously with e-learning was online training. Larreamendy-Joerns and Leinhardt (2006) quoted the University of Illinois Faculty Seminar (*University of Illinois Faculty Seminar*, 1999) where online training was taken to be "instruction through a connection to a computer system at a venue distant from the learner's personal computer".

The term "Web-based instruction" is also used and was quoted by Sitzmann et al. (in press) from Khan where he referred to it as: "a hypermedia-based instructional program which utilizes the attributes and resources of the World Wide Web to create a meaningful learning environment where learning is fostered and supported" (Khan, 1997, p. 6) which is a form of asynchronous e-learning. The two forms of e-learning using asynchronous and synchronous forms are distinguished in the following section.

Asynchronous E-learning

Asynchronous e-learning is where learning does not occur simultaneously with live instruction; for example Hall (2002) indicated diagramatically in Figure 1.1, with a student taking a web course which is self-paced and does not require simultaneous interfacing between the instructor and learner.

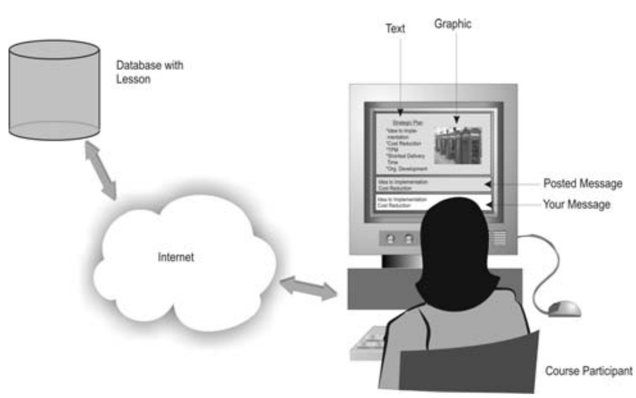

Figure 1.1. Asynchronous e-learning.

Synchronous E-learning

Synchronous e-learning, illustrated in Figure 1.2, is where communication occurs at the same time between individuals and instructor and information is accessed instantaneously. Examples from Hall (2002) included real time video or audio conferencing or chatting in real time. Synchronous e-learning will be the basis of the blended learning examined in this research. The current internet infrastructure is increasingly able to support this form of e-learning's significant bandwidth requirements especially for real time industrial automation training using equipment.

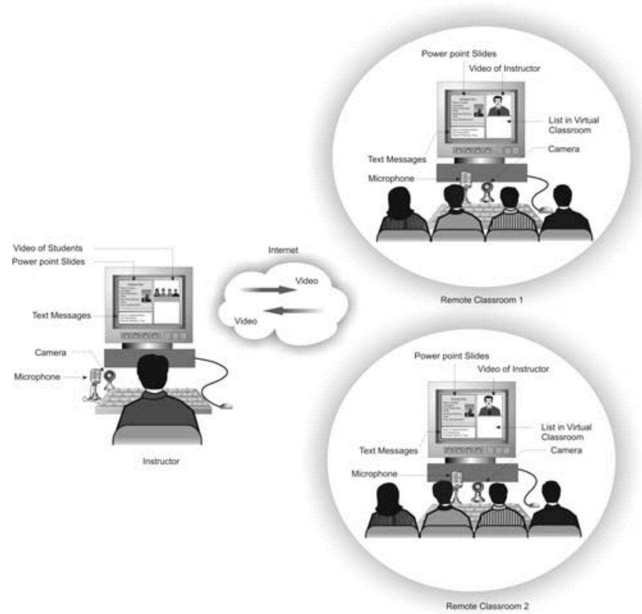

Figure 1.2. Synchronous e-learning.

1.2.6 Classroom Training

Hall (2002) made the point that traditional training was classroom-based and was mainly instructor-led. It is also referred to as face-to-face learning. Classroom training is still the dominant form of corporate training today (Tai, 2005). Neal (2005) suggested that classroom education is valuable for young children and young adults where face-to-face education is required due to their possible lower maturity and self-discipline levels.

1.2.7 Blended Learning

Bersin (2004) indicated that blended learning was the combination of different training "media" (technologies, activities and types of events) to create an optimum training program for a specific audience. Harding et al. (2005) noted that blended essentially combines e-learning with other "more traditional types of learning" (p. 56). Miller, Jones, Packham, and Thomas (2004) quoted Singh and Reed (2001) who defined blended "e-learning as a learning experience that combines off-line and on-line forms of learning whereby on-line learning means "over the Internet" and offline learning occurs in a traditional classroom setting". This is perhaps a restrictive definition; but this is how blended learning has been commonly understood in the popular media.

Murray (Hyder, Kwinn, Miazga, & Murray, 2007) suggested that blended learning was a combination of synchronous and asynchronous experiences. He suggested that it was also a mixture of online and face-to-face training and to approaches to "course design and delivery that combine different modalities, for example, self-paced Web-based training, followed by classroom instruction, accompanied by printed job aids, and supplemented by virtual classroom follow-up sessions" (Hyder et al., 2007, p. 1).

Humbert and Vignare (2004) of the Rochester Institute of Technology defined blended learning as "any course in which approximately 25% to 50% of classroom lectures and the remaining seat time is replaced by instructor-guided online learning activities. The model, at its core, integrates the best practices of distance learning (i.e. online interaction and feedback) with the best practices of classroom learning (i.e. hands-on demonstrations)" (p. 2). Seat time used in the above context, refers to the duration of the learning experience.

Driscoll (2002) suggested four different concepts for defining blended learning. These are the combination of:

- Any form of instructional technology (e.g., web-based and CDROM-based) with classroom instructor-led training. She claimed that this was the commonly accepted definition.

- Different modes of web-based technology such as synchronous, asynchronous, collaborative learning to achieve an educational objective.
- Different pedagogical approaches (such as constructivism, behaviourism) to produce an optimal learning outcome
- Instructional technology with actual job tasks to interweave learning and one's job

Isackson (2002) noted the importance of blending methods and strategies and the avoidance of "tossing" together the different modalities. Morrison (2003) noted that all learning from babyhood, the school classroom to the corporate environment has been essentially blended; so the concept was not particularly new. He preferred to refer to the strategic use of learning delivery channels as opposed to blended learning.

Henderson (2003) felt a blended approach represents a successful compromise between classroom and e-learning. Building on what Bersin (2004) indicated above, Masie (2002) stated that blended learning was the combination of two or more distinct methods of training such as classroom instruction with on-line instruction or simulations with structured courses.

As can be seen above, there is some degree of gradation between classroom, e-learning and blended learning. A suggested set of definitions from E.I. Allen et al. (2007) for traditional, face-to-face, web-facilitated, blended and online courses is as follows:

- A traditional course is where no online technology is used.
- A web-facilitated course is where web-based technology is used for 1% to 29% of what is essentially a face-to-face one.
- Face-to-face learning is where 1% to 29% of the content is delivered online.
- A blended course is where 30% to 79% of the content is delivered online; with the remainder used for face-to-face delivery.
- An online course is where 80% and over of the content is delivered online.

For the purpose of this research, a precise definition of the components of blended learning is required and this is defined as two-thirds synchronous e-learning and one-third classroom-based instruction (in terms of time allocation) and is taken as per Banks' research (2004), as his work has been used as the basis for much of this research. It also complied with the definition sourced from E.I. Allen et al. (2007), which is endorsed by the respected Sloan Consortium.

1.2.8 Industrial Automation

Industrial automation, shown in Figure 1.3, the environment on which the research described in this thesis was based on, is, according to the online encyclopaedia Wikipedia (*Automation*, 2007), defined as the "use of computers to control industrial machinery and processes, replacing human operators." The main advantages are lower costs in accomplishing the same tasks, repeatability, improved quality control and closer integration to the business systems of the enterprise. Industrial automation is effected with industrially hardened computers referred to as programmable logic controllers (PLC's) which are connected to sensors (such as flowmeters and temperature probes) and which control sets of outputs such as valves and actuators with a computer program. Human machine interfaces (HMI's) are connected to the PLC's and allow the operator to view the process and to control it. The HMI's are also referred to as SCADA (supervisory control and data acquisition) terminals as they allow the operator to control and acquire data from his computer display or interface unit (*Automation*, 2007).

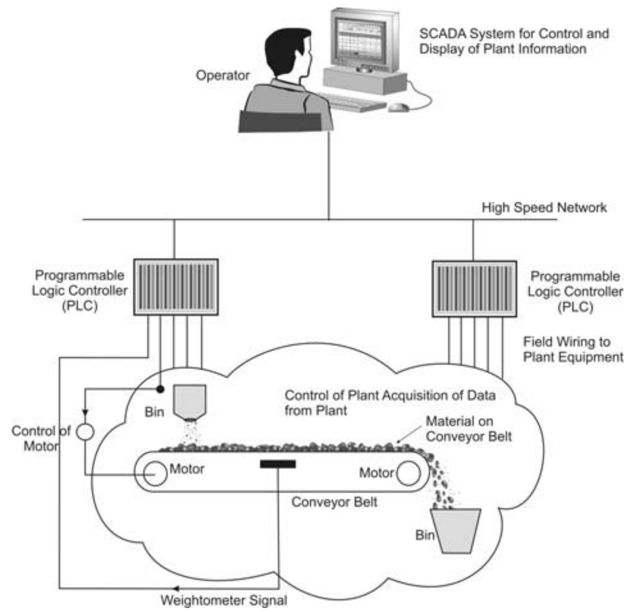

Figure 1.3. Industrial automation system.

1.2.9 Return On Investment (ROI)

A key driver in using e-learning and blended learning is reduced costs. For example, the Cisco company (Kelly & Nanjiani, 2005) calculated that for every dollar invested in an e-learning portal, in 2003, for their resellers, a $16 benefit accrued. Savings and profitability can be assessed by using the return on investment (ROI) calculation to quantify the savings. ROI is defined in accounting terms as earnings divided by the investment in achieving these earnings (Anthony & Reece, 1979). Most research (J. J. Phillips, 2004) concluded, that e-learning (a key component of blended learning) was considerably less expensive than classroom (or instructor-led) training, and thus had a considerably better ROI for each additional course participant. In e-learning there are minimal expenses incurred in travel and every additional participant is at a minimal marginal cost.

For reasons outlined in the literature review (section 2.6), it is difficult to trace the direct earnings achieved as a result of a specific investment in blended learning. Hence, for the purposes of this research, and based on Horton's work (2000), ROI is defined as the savings produced by blended learning against that of only classroom instruction divided by the additional investment required for blended learning.

1.2.10 Experiential and Hands-on Learning

Bersin (2004) commented under the heading of "Research supports the value of experiential learning" that:

> After participating in different events, individuals were assessed three months later to measure retention. Results clearly showed that experiential learning drove much higher retention rates…..
>
> Is it possible to create experience through web-based training? Yes. In e-learning, experiential learning is accomplished with simulations, scenarios, and interactivities…(Bersin, 2004, p. 39)

The term hands-on learning is used to refer to experiential learning where an interactive approach is used to the learning approach such as using real equipment and hands-on software exercises, as opposed to an instructor merely presenting the materials in a lecturing format without feedback and interaction from the participants.

1.2.11 Laboratories and Laboratory Work

Huntley, Mathieu, and Schell (2004) defined a laboratory (or lab, as it will be henceforth referred to, for brevity) "as a room or building containing specialised equipment" (p. 398). Lindsay (2005) noted that a typical lab class "comprised a small group of students, and a demonstrator (often a postgraduate student), grouped around a piece of hardware located in a lab. Students typically conduct a series of experimental procedures as outlined in the lab handout, they record the data from the hardware, and they write up a report based on this data and the underlying theory in the week or two subsequent to the session" (p. 44).

Gandole (2005) added to this by remarking that a lab "should aim to encourage students to gain:

- Manipulative skills
- Observational skills
- Ability to interpret experimental data
- Ability to plan experiments
- Interest in the subject
- Enjoyment of the subject
- A feeling of reality for the phenomena talked about in theory" (p. 49)

Lindsay (2005) added that labs were also useful in introducing students to the world of the engineer and scientist and provided a focus point for student-student and student-instructor interactions. He summarised the underlying principles for lab work being:

- "Illustrating and validating theoretical concepts
- Introducing students to professional practice, and to the uncertainties involved in non-ideal situations
- Developing skills with instrumentation
- Developing social and team skills in a technical environment" (pp. 45-46)

In the context of e-learning using a remote lab Huntley et al. (2004) noted that the additional requirements here are to enable students to share expensive computing resources with no restrictions as to location or time.

1.3 Myths about Distance Learning and E-learning

A number of researchers (A. J. Henderson, 2003; Mendenhall, 2007) have commented about some of the myths about distance learning (and e-learning) they have encountered. These have mainly arisen as a result of the increasing use of e-learning to improve the features of distance learning. These myths about distance learning as compared to the traditional classroom sessions using face-to-face instructing include:

Face-to-face learning is superior to distance learning

Mendenhall (2007) believed that there was a growing body of evidence showing that there is no significant difference between the two forms of instruction and quoted from the "No Significant Difference" (Russell, 1999) research. He suggested the challenge at present is to raise distance learning's quality dramatically by more judicious use of online learning as this gives the opportunity to individualise the learning to the course participants. On a negative note, Henderson (2003) noted that although e-learning providers have a dazzling collection of titles on offer; many of them are not much better than a book online and are passive and uninteresting.

There is minimal interaction between instructor and students

Mendenhall (2007) felt that a well designed program provided even more interaction than a traditional course due to the online study groups, discussion groups, instant messaging, email. The instructors have more methods of access to them (email and phone) and reported more time spent in interfacing to their students. Poor quality e-learning offerings have contributed to this perception of minimal interaction (Schank, 2002).

Distance Learning is appropriate for only a limited range of subjects

Mendenhall (2007) indicated that this was becoming less true as the technology becomes more supportive. However, lab work was still better done in the traditional setting. The purpose of this research was to investigate whether this lab work could be effected successfully over the internet.

Distance learning is only suitable for certain types of students

Mendenhall (2007) noted that distance learning does attract a significantly wide spectrum of learners as it makes education very flexible in terms of time and place. There is evidence though that distance learning is not necessarily appropriate for younger students (Neal & Miller, 2005).

Online degrees are not valued highly by the community

Mendenhall (2007) quoted research from Eduventures which showed that 62% of employers believed that online learning was equal to or better than classroom-based learning. This is supported by recent research from the Sloan Consortium (E. Allen & Seaman, 2006).

Measurement of distance learning is difficult due to limited contact

Mendenhall (2007) noted that traditional learning was based on keeping the student in a classroom for a certain length of time. This was not necessarily a good measure as the students are not always in the class. But online training does have rigorous methods of assessment due to the obvious risk of cheating and often uses an oral defence by the learner. Plagiarism was also checked meticulously due to the perceived higher risk. Online assessment technology has become a burgeoning industry as a result of the increased need to reduce risks in this area.

The quickest and easiest path to a degree is with distance education

A number of institutions have emerged providing very low quality education and these have damaged the reputation of distance learning. But Mendenhall (2007) felt that students spend more time on the actual learning process and do not have to waste any time sitting in a classroom.

The instructor becomes less important in distance learning

Mendenhall (2007) suggested that the teacher role is increased due to the additional interfacing required with the learner. It was possible now for the teachers to interact personally with the learners in answering questions, mentoring and giving specific remedial review work to do, as the technology can automate some of the presentation. The increasing work load for the teacher engaged in online education has produced some challenges for institutions in terms of providing adequate compensation.

Distance learning costs less to provide

The initial costs of instructors, course development and maintenance are significantly higher for distance learning. The concept was that once a certain volume of students has been achieved, the costs per incremental participant can be reduced. Mendenhall (2007) quoted from The National Centre for Academic Transformation (www.center.rpi.edu) who have demonstrated an average 37% decrease in costs with improvements in student learning and retention. The emphasis has to be on achieving a certain number of students for this to be true. If the number of students is below break even point, the costs are likely to be more than for the traditional classroom environment.

Distance learning will replace the traditional classroom

Mendenhall (2007) indicated that this was unlikely to happen as the traditional university provides the opportunity for students to socialize, perform research and provide other services such as medical support. Henderson (2003) indicated that no one can sit slumped in front of a computer screen for two days. Or can easily get hands-on practical experiences and talk to colleagues a few metres away in a classroom setting. Perhaps in the future but not at present. A blended approach which is a combination of both e-learning and classroom-based instructor-led instruction is probably an excellent method of addressing this perceived shortcoming of e-learning.

The onset of e-learning will make a dramatic improvement to the learning process

Some years ago, admittedly before the internet was as widely used, Russell (1999) reviewed the various technology platforms used over the past 75 years and came to the conclusion that there was really no difference in the learning impact from the different media used in training. Whether it was 16mm films, CD's, or the classical classroom. it would appear likely that this supposition would apply to e-learning as simply another method of harnessing technology for educational needs. Russell went on to say that what makes the difference is the way one instructs. There is no substitute for a good quality instructor and well designed and practical learning materials.

1.4 Background Research on Blended Learning

It is useful to briefly examine recent research (including doctoral) which examined blended learning, classroom and e-learning. This will be covered in more detail later.

Jackson (2000) compared the results of taking a Project Management course using e-learning technology (asynchronous) against the traditional instructor-based method and found that the web-based technique was at least as effective as the instructor led method. One hundred and thirty two participants from ten countries successfully completed the study and were randomly selected from a web-based promotion.

Esch (2003) investigated 4,000 office workers to survey the impact of e-learning versus classroom training for improving their proficiency in using a new building wide telephone system and concluded that the e-learners performed considerably better in terms of skill achievement, technology acceptance, satisfaction and cost avoidance behaviour such as saving the firm money as a result of the training. Perhaps, the problem with this methodology of gathering data was that the selection of subjects for either group could be biased as it was self selected.

Boyle, Kolosh, L'Allier, and Lambrecht (2003) compared five groups using a common asssessment: blended learning in three variations (text objects from a textbook, instructor-led or an instructor-led customised course), e-learning and a control group who received no training. The results indicated that there was a significant improvement of blended learning over e-learning; but not much difference between the blended groups. E-learning demonstrated a marked improvement over the control group.

Hentea, Shea and Pennington (2003) noted that distance learning programs are increasingly using hybrid or blended models to maximise the level of interaction between students and university staff. They quoted the Thomson learning test on adult learners (Kiser, 2002) which investigated three groups (blended learning, online learning, and no training) performing tasks using Excel (Kiser, 2002). The test results showed that the blended learning group performed tasks 30% more accurately and 41% faster than the online-only group.

Banks (2004) compared the effects on a group of working adults engaged in each of three different forms of learning (classroom, online and blended). He applied Kirkpatrick's levels of training analysis to determine knowledge acquisition. These levels were reaction of the participants (level 1) and learning achieved (level 2). The statistical analysis used indicated no differences between blended and classroom content forms of delivery. Surprisingly, asynchronous online delivery had an improved reaction from participants compared to that of blended learning and classroom instruction.

Bernard et al. (2004) performed a meta-analysis on distance learning (referred to as DE), including synchronous and asynchronous techniques versus classroom learning, and "found some evidence, in an overall sense, that classroom instruction and DE are comparable…" (p. 420). They were however perplexed at the wide variability in the data, which cast some doubt over even these findings, and they made some disparaging remarks about the poor state of distance education research.

Weinstein, Wiesner, Zappe, Yu, and Bandyopadhyay (2005) compared the online versus classroom (face-to-face) formats for a number of large enrolment general education university courses. Their findings were that there were no differences in the exam scores, pre- and post-tests. A large number of students found the electronic materials (powerpoints, images, online quizzes) useful in learning the materials. A large percentage of students felt isolated from the instructor in the online version. Both lecturers and students noted the flexibility of the online format.

The approach proposed in this research in only assessing at two levels of reaction and learning, should be contrasted with Lewis and Orton's work discussed in Bonk and Graham (2006) who have indeed assessed for all of Kirkpatrick's four levels, a large number of managers engaged in one of their blended learning programs over 10 months. However the program was intensive involving three phases of 48 hours (Phase I), five days in-class (Phase II), and 25 weeks online (Phase III). It is unclear how many were assessed in levels three and four but it appears that they were assessing approximately 6,600 participants.

Neumann and Carrington (2007) produced an international synchronous e-learning session for 450 learners situated on 41 university compuses in Australia and New Zealand in March 2006. They then drew each group of participants into local discussions, thus creating a blended approach. They felt that overall the training was successful.

Sitzmann (in press) used a literature review of 96 studies to compare web-based instruction to classroom instruction and found that classroom instruction to be more effective for teaching declarative (cognitive and structural) knowledge when learners were randomly assigned to courses and more instructional methods were used for the internet-based format, a more active format was used and additional practice was used. This is not really a fair comparison. Learners expressed equivalent reactions to both methods of instruction. Web-based learners also acquired greater levels of knowledge (compared to classroom instruction) when they had greater levels of control (pace, content or sequence) in their learning process. In line with R.E. Clark's (1983, 1994) research, they found that when the same instructional methods were used in the instruction that there were no differences. They found that blended learning was more effective than classroom instruction for both declarative and procedural knowledge. But learners reacted more favourably towards classroom learning than the blended form.

In conclusion, there has been a significant amount of work comparing the classroom, blended learning and e-learning but minimal research as applied to engineer and technician training. Leading on from this suggested research, the hypotheses will be discussed in the next section.

1.5 Research Hypotheses

1.5.1 Overall Thrust of the Research Hypotheses

The overall aim proposed is to determine whether blended learning with a hands-on interactive approach applied to synchronous e-learning will improve the reaction, learning achieved and ROI of industrial automation training compared to that of either classroom training or e-learning? It was argued that in many respects blended learning was better than only using classroom training or e-learning, measured in terms of reaction from the participants, learning improvements and ROI. The specific hypotheses developed to achieve this aim were based on previous research findings; the most significant being that of Banks (2004).

In the context of industrial automation training, the hypotheses developed for the study are listed in the following sections. The two terms, reaction and learning, used below have been defined operationally earlier but they will be restated for clarity. As per section 1.2, reaction (level 1) measures the participant's satisfaction with a course. According to Banks (2004, p. 48): "Kirkpatrick (1994) defined reaction as what the participants thought of the particular program, including materials, instructors, facilities, methodology, and content. Response to reaction questionnaires helps to ensure against instructional design decisions based on the comments of a few very satisfied or disgruntled participants."

As remarked earlier in section 1.2.1 (Definition of terms), Kirkpatrick (1998) stated that learning (level 2) measures the changes in knowledge, skills and attitudes. Banks (2004) also remarked that "Learning is concerned with measuring the knowledge principles, facts, techniques, and skills presented in a program. Learning is more difficult to measure than reaction (Kirkpatrick). Learning measures must be objective and quantifiable indicators of how the participants understood and absorbed the material" (p. 48).

The main reason why only levels 1 and 2 were examined in this research was that the investigation was focussed on a comparison between blended learning, e-learning and classroom training and was not intended to demonstrate that the knowledge acquired has an impact on the business or individual. It was presumed, *ceteris paribus*, that the training provided has been selected by the management of the company in the belief that it will have benefits for the company.

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1.5.2 Web-based Worldwide Survey

The hypotheses listed below were tested using the web-based worldwide survey which was used to get information on the actual use of blended and e-learning in the industrial automation business. Bonk (an e-learning specialist and widely published academic) who runs a professional survey company (http://www.surveyshare.com) provided the software for the construction of the instrument. Some of the survey questions in the instrument were derived from his work (as outlined in Chapter 3).
As e-learning was a relatively new approach to training in a traditionally conservative engineering environment, it was possible that most respondents in the industrial automation business had not used e-learning and the concept of blended learning was unknown; hence the need to minimise the possibility of respondents attempting to answer questions on issues they had no knowledge.

As noted in Banks (2004), most evaluation techniques use one of Kirkpatrick's four levels. The most basic measurement is based on "reaction" to the training. Hence the first hypothesis used this as a measure. Operational definitions of the terms used in the hypotheses are in section 1.2.

H_1 Synchronous e-learning produces an improved student reaction compared to that of classroom instruction alone.

H_2 Remote labs or simulation software are not used extensively as part of e-learning courses for engineers.

H_3 There is currently no extensive use of e-learning and blended learning for engineers and technicians.

H_4 There is significant growth in blended learning courses for engineers and technicians.

1.6 Brief Review of Methodology

The proposed methodology was based around performing a worldwide web survey (with 2,450 eventual respondents). A simple univariate analysis was performed on the survey data and the descriptive statistics assessed to see the penetration of e-learning and blended learning. Initially, it was planned to undertake some interviews of some of the respondents, but the wealth of qualitative responses (over 2,000 comments) made this unnecessary.

1.7 Contribution of the Research

Linquist, quoted in Bonk and Graham (2006), urged further research in the area of blended learning with the comment:

> Blended learning is highly resourceful in drawing on the best material from the older siblings. Additional research should be able to refine this process (Bonk & Graham, 2006, p. 234).

Following on from this comment by Bonk and Graham, it is hoped that this research will suggest the best combination of components of blended learning as applied to engineering (and industrial automation training).

Kirkley and Kirkley, quoted in Bonk and Graham (2006), remarked that:

> Authoring tools, instructional design guidelines, and instructor guidelines must be developed that will ensure effective learning occurs using these technologies in a blended learning environment (Bonk & Graham, 2006, p. 546).

Bernard et al. (2004) pondered whether it is worth comparing distance education with classroom learning by noting the assertions of Clark (2000) and Smith and Dillon (1999). Clark felt that it was not; his sentiments are explored in section 2.7.

Smith and Dillon on the other hand felt that as long all possible confounding variables were carefully isolated; then it would be worthwhile. Bernard et al. also pointed out in the context of the exploding variety and number of distance learning (DE) and indeed, e-learning courses being offered, that it is important for more research in this area "not only whether DE is a worthwhile alternative, but also in which content domains, with which learners, under what pedagogical circumstances and with which mix of media the transformation of courses and programs to DE is justified" (p. 384).

As van Dam (2004) indicated, new technologies (such as blended learning and e-learning) are going to have a tremendous impact on how engineers and other technical professionals are trained in the future. This research contributed to the existing body of knowledge by demonstrating that specific blended learning techniques (such as hands-on interactive techniques) can make a significant improvement to the reaction, learning, knowledge acquisition and ROI of blended learning for industrial automation training as compared to that of only classroom instruction and e-learning. Although Sitzmann et al. (in press) was specifically referring to e-learning, they were also considering blended learning when they supported this assertion with the comment: " …online instruction will have utility to organizations and institutions if it results in learning and retention, is well-received by users, and is cost-effective to the sponsoring organization or institution." Sitzmann et al. added that if these techniques were proven to be effective, organizations could justify applying them. On the other hand, if they were demonstrated as not being effective, traditional instructing approaches would be maintained or alternative methods sought.

From a more specialised point of view, this research contributed to theory in industrial automation training by showing that the quality and ROI of classroom training could be significantly improved by complementing it with an effective e-learning approach, forming a blended learning offering.

Admiraal, de Laat, Rubens, and Lally (2003) noted that small and medium enterprises, in Europe, are often drivers of innovation (e.g., industrial automation) and employment but are unable to pay for training. It is hoped that this work will enable the application of lower cost e-learning to these firms and thus enable an increase in training and thus, innovation and employment in these industries.

In conclusion, Oliver, quoted in Bonk and Graham (2006), remarked that:

> Our work suggests a strong need for researchers to continue to explore this form of learning design and investigate design strategies that will guide instructors and designers in the appropriate forms of blended learning they choose to employ (Bonk & Graham, 2006, p. 513).

It was clear from the research done to date that each of the three types of learning has both advantages and disadvantages and that the blended approach to learning was likely to bring substantial benefits both in an improved learning experience, achievement as well as the ROI.

The thesis structure is given below.

1.8 Thesis Outline

Perry (1995) suggested that the five chapter format was suitable for this type of work. The APA format (*Publication manual of the American Psychological Association*, 2005) as modified by Curtin University of Technology requirements was used throughout. The thesis was structured as follows:

Chapter 1 – Introduction and overview. This contained background to the topic; details of the research problem; definitions and methodology.

Chapter 2 – Literature Review. This examined parent and immediate disciplines insofar as analytical models and research questions.

Chapter 3 – Research Methodology. A justification of the paradigm and methodology. Some preliminary suggestions on research were contained in Bolker (1998).

Chapter 4 – Results. An analysis of the data and assessment of the patterns of data for each hypothesis and the research question.

Chapter 5 – Conclusions. Conclusions about the hypotheses; implications for theory; limitations and suggested future research. Two other authorities (Davis & Parker, 1997; E. M. Phillips & Pugh, 2000) suggested an additional chapter entitled "Discussion on the Results" between Chapters 4 and 5 above, but this was considered unnecessary as this would be thoroughly covered in the Chapter 5 entitled "Conclusions" without compromising the concluding remarks.

The resources required to undertake the research will be briefly listed in the following section.

1.9 Resources Required

These were based on the author's experience in direct marketing of engineering courses and products for the past 15 years. The different activities are listed below.

1.9.1 Web-based Worldwide Survey

An email campaign to approximately 120,000 individuals total were conducted using IDC Technologies' mailing list, engineering magazines / professional organisations and industrial automation web sites. The email contained an introductory note outlining the research and stating that it was conducted under the auspices of Curtin University. An automated web form was used for the survey. A special offer was arranged allowing the respondent to download a free book worth $40 and receive a discounted e-learning session if the survey was filled in, so as to improve the response rate. The final collated results were made available to everyone who filled in the survey instrument.

1.9.2 Public Relations

An estimated 300 hours were spent in raising the public awareness in the engineering community (and the various professional bodies such as the Institution of Engineers) and getting support for this research.

1.10 Ethical Considerations

It was important to maintain the confidentiality of all respondents and firms participating in the research. No individual responses were distributed to any organization, firm or society. Only aggregated results were distributed in such a way that the individuals could not be identified. Authorisation to proceed with the research was given by the Curtin University of Technology Human Ethics Committee with approval number HR 1/2007.

1.11 Limitations

The research was limited to e-learning, blended learning and classroom training as applied to mainly industrial automation training for tertiary qualified engineers, technologists and technicians in the corporate world and did not consider other areas of engineering (such as civil and aeronautical) to much extent. The personnel working in this area were limited to those with job titles such as electrical, instrumentation, control and mechanical engineers, technologists and technicians.

The research focussed on short course training which is typically two to four days in duration in the classroom instructor-led setting and excluded other courses such as those for longer durations as offered by universities.

Due to the preponderance of contacts in the English speaking world from the IDC Technologies' database used in the survey, it was likely that these results will not necessarily be relevant to the non-English speaking world, as the sample size was limited in these countries.

The environment was restricted to the corporate sector and did not include undergraduate and postgraduate learning conducted by universities and colleges.

Although no restrictions were placed on the size of the firm, provided it was a genuine corporate vehicle, it was the author's experience that small companies did not fund training of employees to the extent of the larger corporations so it was likely that this segment would be missing to some extent from the research results.

There was one final potential limitation of the research. The field of blended learning was moving very swiftly (in line with the rapid technological changes in the software and telecommunications industries) and there was a potential risk that over the five years that the research was conducted that the results would be outdated.

Finally, the use of the author's company's database of contacts may have introduced bias into the survey results due to management preferences, sourcing of staff, location of company headquarters and so forth. This was not believed to be a problem as the databases have been built in a reasonably random manner.

1.12 Background of Researcher

The author has had extensive experience (15 years) in industrial automation training mainly from the classroom perspective managing a company providing industrial automation and general engineering training and publishing services throughout the world with over 120,000 individuals trained. He has had extensive experience in blended learning over the past four years with preparation of web sites, e-learning and managing numerous profitable and effective courses using this genre of training. By no stretch of the imagination is this intended to imply that the author is an expert in these new technologies of learning; but he has been surrounded by very competent and knowledgeable experts in this endeavour.

Chapter 2

Literature Review

2.1 Overview of the Field

2.1.1 Introduction

Shortly before the stockmarket collapse in 2000, John Chambers, CEO of Cisco Systems, made the prediction:

> The biggest growth in the internet, and the area that will prove to be one of the biggest agents of change, will be in e-learning. (Rosenberg 2001, p. xi).

There has been a proliferation of remote or distance training using the internet (often referred to as e-learning) in the technology education areas. Blended learning (Bersin, 2004), being the area of interest in this research, has also grown in importance and is a combination of the different training media such as classroom instruction, on-the-job training and e-learning. Typical approaches for e-learning are web-based (asynchronous) and streaming of video (synchronous) over the internet (Rossett, 2001). The synchronous form of e-learning as a key component of blended learning will be examined in more detail in this section.

Higgins and Keightley (2007) asserted the following benefits in using e-learning: anytime, anywhere, any place training; reduction in time to learn; consistency in training; increased payback; no-risk environment; flexible access to training; ongoing reinforcement; improved motivation due to the computer technology used; community building; quicker time to market and finally improved monitoring of the learning process.

The rapid growth in the use of e-learning either on its own or through blended learning has been canvassed in Chapter 1. However it is worthwhile again emphasising this growth with the following points. Mallak (2000) quoted the following statistics to demonstrate the growth of e-learning. One million students were enrolled in distance education (including e-learning) in 1999 and the number was estimated to more than double to 2.2 million in 2002. Mortleman (2004) did a survey of more than 100 HR directors and training managers and found that interactive multimedia training has overtaken both books and video as the preferred way to gaining new skills.

In reflecting on the success of the UK's Open University, Davies (2006) noted a few issues which were essential to developing a successful university providing mainly distance and e-learning programs. These included:

- Political commitment from the highest levels of government
- High quality teaching materials
- Good student support
- Academic credibility (e.g., the value of a degree with e-learning)
- Research activity at the institution demonstrating to everyone that they are learning from a widely accepted university
- Adequate infrastructure to support e-learning and computer services

2.1.2 A Maturing Field

Bersin ("E-learning evolves into mature training tool," 2006) noted that a recent survey by Bersin and Associates of 526 companies in the USA and Canada indicated that e-learning comprised 33% of workplace training in 2005 (up from 24% in 2003). Approximately 80% of training and HR managers indicated that they felt that e-learning would increase in 2006. Bersin believed that there were four stages of e-learning evolution comprising:

Stage One	Getting started. Driven by cost savings using off-the-shelf courses and installing a LMS (Learning Management System).
Stage Two	Expansion. Application of blended learning, customised courses and expanding use of the LMS.
Stage Three	Integration and Alignment. Application of governance and performance management.

Stage Four — Learning on Demand. Use of a Learning Content Management System (LCMS) to make learning available on demand.

Bersin ("E-learning evolves into mature training tool," 2006) indicated that their research suggested that most organisations' e-learning and indeed, blended learning, programs were between stages two and three and were thus mature applications. This would appear to indicate that training using blended learning and e-learning has moved away from an experimental form to an accepted type of training which would be considered seriously by the more conservative corporate engineering sector.

In the following section, it is instructive to move from the general and global view to the Australian applications of e-learning and blended learning (especially with reference to hands-on training).

2.1.3 The Australian Experience

Turning to local users of e-learning, in a study where 140 Australian organisations were interviewed telephonically during 2006, M. Phillips (2006) noted that 72% of respondents used e-learning in structured training. The most common uses for e-learning were induction (27%), compliance such as occupational health and safety (25%) and technical training (23%). A significant 40% of the respondents indicated that e-learning would increase as a percentage of their training budget in the next 12 months. Insofar as e-learning tools were concerned, 34% of respondents were using web conferencing and 34% were using video conferencing. There was an estimated 11% increase over the next 12 months in the uptake of web conferencing. It was not clear from the survey whether the respondents clearly understood the differences between video conferencing and web conferencing. In barriers to entry of e-learning, 61% indicated: "too time consuming", "lack of computer literacy" and a preference for a "hands-on" approach (M. Phillips, 2006); issues which it was hoped that this research would address with the hands-on laboratories, as an example. Specific comments in this vein were:

"We often need a hands-on approach to our training requirements." (Paul Nesditt, Australia Post)

"E-learning is great in theory, but it doesn't always produce the same results as hands-on training in our business" (Peter Goodwin, BHP Billiton)

"The practical component of hands-on training is sometimes better than any other training" (Dave Nicholls, Alcoa World Alumina Australia)

These comments would suggest that hands-on training would be a useful approach especially if it could be encapsulated in e-learning. Another observation from the survey above was that there was an encouraging uptake of web conferencing in Australia (11% growth in the past year).

2.1.4 How Engineers and Technicians Learn

The previous section suggests the need for practical or hands-on work for students of engineering and industrial automation. This is reinforced by Table 2.1 produced by Trotter (2007) who suggested the different types of instruction in how students learn. This table has been modified following the criticism from Fadel and Lemke (2008) who felt that assigning percentages to each item in the table below is overly simplistic and indeed unproven, but that in using multiple modes in the learning process is more effective than traditional, unimodal learning.

Table 2.1

What Students Remember (Adapted from Machine Design p. 84 January 11, 2007)

Absorption Results	**Type of instruction**	**Level of instructional design**
High	Simulations and games Interactive live e-class or seminar	High
Medium	E-course with audio and video E-course with visual, online self-study guides, and online powerpoint presentations	Medium
Low	e-mail, e-documents, and e-white papers e-reading E-learning	Low

This suggested that blended learning using interactive synchronous e-learning was perhaps appropriate for achieving high absorption learning rates with a higher efficacy as opposed to only applying the asynchronous e-learning approach. It would also appear that a hands-on interactive approach with real equipment (using a lab, for example), could generate a very high absorption rate.

Coco ("Results-oriented learning," 2006), Microsoft's general manager for engineering excellence remarked that he believed that learning professionals only generate 10% of the knowledge in an organisation. He felt that most of the knowledge generated was through the employees of a business collaborating and working as a community. This again suggested the need for a synchronous method of e-learning creating communities of practice with employees of the company passing on knowledge to each other on a worldwide basis.

These comments suggested that synchronous e-learning with hands-on activities in a collaborative learning environment as a valuable component of blended learning could be successful.

A historical review of e-learning (and blended learning) is outlined next to provide the background to the contemporary developments in the field. Then the different forms of learning (e-learning, blended learning and classroom training) are discussed in more detail. This is followed by a discussion of the field to which blended learning was applied in this research, namely industrial automation. The important topics of Kirkpatrick's Evaluation levels and ROI are then expanded upon as this lends further support to the use of blended learning, if a reduction in costs can be demonstrated. The debate as to whether the medium of instruction has any impact is reviewed.

Cognitive load theory will then be reviewed to see how this can be applied to blended learning. Following on from this, constructivism plays an important part in e-learning and blended learning in modern learning and is examined. This will lead onto the clarification of the terms explicit and tacit knowledge which was applied in the industrial automation area, followed by a discussion of remote laboratories where tacit knowledge can be important in terms of experimentation. The challenges with e-learning and blended learning are then noted. Finally, gaps in the literature and possible research questions are listed.

2.2 Historical Review of E-learning and Blended Learning

In order to grasp the development of e-learning and blended learning, it is important to place it within the context of classical distance learning. Distance learning can be traced back to the mid-nineteenth century correspondence colleges mainly in the USA and Europe (Baab, 2004). As Baab (2004) then pointed out, media and communication technologies emerged in the eighties which enhanced simple text and audio tapes used in distance learning and led to the arrival of e-learning (and thence blended learning).

Rosenberg (2001) gave a summary of the evolution of e-learning over the past 80 years from the position of films. In 1922, Thomas Edison predicted that the new technology at the time, film, would replace textbooks in the classroom. As can be evidenced, this never happened. This theme of the possibility of technology replacing traditional classroom tools, has been repeated with each new wave of technology such as radio, film, video, DVD's, computer-based training and latterly e-learning.

Training films were used successfully throughout the American military to drive a consistent message home on war propaganda, especially during World War II. As Banks (2004) noted, military instructors needed to move "vast numbers of people through orientation, attitude, and technical instruction. To achieve their goals, they turned increasingly to training films, filmstrips, simulation, flip charts, flannel boards, and models..." In the 1950's and 1960's, film formed part of the public school's curricula especially in the social and physical sciences. Television was the next technology wave using video tapes (and latterly DVD's) and was still in common use in 2005. Banks referred to Alexander (1958) who noted that as early as 1957, the American Society for Training and Development (ASTD) experimented with closed circuit TV to teach 2000 Christmas postal employees. The main reason for the lack of success of television as an outright replacement for an instructor, was believed to be the lack of a high level of interactivity required by students.

The first attempt at interactivity in training was in using computer-based training (or CBT) and this developed rapidly with the arrival of the personal computer in the early 1980's. Unfortunately, most CBT programs were text-based and fairly rigid in terms of interactivity. According to Rosenberg (2001), they used the technique of "drill and practice" which required the student to read a few, generally text-based, computer screens and then perform a test using multiple choice questions. This was not well received and with the advent of internet-based training, CBT has declined in use. Perhaps as a result of CBT's poor performance, many researchers such as A. Mitra and Steffensmeier (2000), as cited in Chandra (2004), expressed doubts on the educational value of computers in teaching.

According to van Dam (2004), the first article on internet-based training appeared in Training Magazine in 1997, signalling rapid growth in this area. According to a succinct summary by van Dam (2004), quoting from IDC, the e-learning market rapidly grew from a few million dollars in 1995 to US$3.4 billion worldwide in 2000. However once the stockmarket crashed in 2000, many e-learning vendors went bankrupt or merged with other players in the industry and there was a significant decline in business in this area. In 2002 Smartforce and Skillsoft merged and created a relatively global giant in the e-learning industry, offering business and IT skills training with anticipated sales for 2006 of $200m (Skillsoft, 2005). There has been a series of other consolidations with some of the major players in the corporate e-learning market. In October 2005, Saba, a Learning Management System vendor acquired Centra, a web conferencing firm creating a $100m business ("Saba acquires Centra," 2005). Skillsoft paid approximately $270m to acquire NETg (part of Thomson learning). The resultant corporate entity will provide online courses, simulations, videos, and ebooks. Thomson Corporation recently (late 2006) put its $5bn Thomson learning division on the market as well; thus creating an even more dynamic market place in the e-learning area. Cisco (Baijia, 2006) announced in late 2006, that it had launched its video conferencing platform Telepresence with expected revenues of $US1bn within three years targeting distance education, medical care and security. It was estimated that it would bring savings of up to $US100m per annum to Cisco in travel expenses alone.

From 2003 onwards, a realization started taking place that a considerable amount of e-learning was not delivering satisfactory results due to the cost and time of developing courses and the inadequacies of the learning process (Bersin, 2004). The term blended learning was then coined to indicate that the optimum approach was to use a combination of media to achieve success with training. The approach especially from 2005 was also to align the blended learning with the business objectives in achieving better productivity and a safer workplace.

The training results for e-learning in the future look excellent. IDC indicated that the revenue from live e-learning (synchronous as opposed to asynchronous presentations) would exceed US$5billion by 2006. Ziegler (2002) indicated that the Australian and New Zealand markets were growing swiftly in terms of sales and quoted from an IDC report which stated that the e-learning in this region moved from a base of US$90 million to US$582 million for 2004. Most of the e-learning was focussed on IT subjects but there was also strong growth in business topics. He gave two examples of innovative applications of e-learning with the Star City Casino (Sydney) gaming staff being trained through e-learning rather than traditional classroom techniques and saving an estimated $US 1.6 million and the Australian Cricket Board training their coaches using simulation techniques to improve their cricketing skills. There has however not been much direct evidence of significant activity or growth in e-learning and blended learning in the engineering and industrial automation arena. This issue was investigated further in the research and a wealth of applications identified.

The different forms of learning such as e-learning, classroom learning and blended learning are now discussed in greater detail.

2.3 The Different Forms of Learning

2.3.1 E-learning

Overview

As noted earlier in section 1.2.5, e-learning lets one learn at a distance over the internet. This enables one to learn at any time at any location and is often referred to as online learning. The minimum requirements are an internet connection, a computer and access to an e-learning provider on the web. Typical types of e-learning listed by Rosenberg (2001) are video conferencing (synchronous) and web-based training (asynchronous). This means that employees at work can do a variety of training activities over the internet ranging from skills certification and live updates on company products. Although e-learning is a subset of distance learning, Watkins (2005) noted that it should not be an electronic analogue of a traditional correspondence course, "in which interactivity and engagement have often been lacking " but one "…that is exciting, interactive, purposeful, and beneficial for online learners" (p. 2).

Advantages of e-learning

Hall ("E-learning expert urges EHS managers to take risks," 2004) noted to a group of Safety Engineers that successful online learning programs " are very interactive, visual, and provide real-time, hands-on training" (p. 14). Hall felt that training provides an organisation with a competitive advantage and reduces costs, but needed to focus on key topics, train on-demand and provide immediate answers to users' questions. E-learning could do this.

The benefits, as pointed out by Henderson (2003) and supplemented by other authors, for e-learning compared to other approaches such as instructor-led training in a classroom are:

- Travelling to class is minimized for students meaning lower costs and reduced time loss and any time any place learning (Anido et al., 2004)
- One can learn at one's own convenience
- The material can be absorbed in smaller portions
- The costs of the actual training can be lower when compared to instructor-led training, especially useful for developing countries (Ahmad, Udin, & Yusoff, 2001)
- Speed of ramp-up in delivery and rollout of training is swift
- Business requirements can be responded to quickly and effectively.
- One is able to update multiple sites with new material quickly

- It is scalable up or down easily to handle more (or less) requirements such as instructors and time of delivery
- There is a consistent message to multiple sites and participants with knowledge consistency (Anido et al., 2004)
- Learning is available 24x7 hours per week or time independent (Anido et al., 2004)
- One is able to build a community within a business
- It easily fits into the e-business and existing IT infrastructure of an organisation
- Learning quality can be improved on existing classroom training using consistency and repeatable higher quality training materials and instruction.
- It is adaptable to different learning styles and pace (McVay-Lynch, 2002)
- One can achieve global reach with the learning materials (Anido et al., 2004)
- Arguably, it is claimed that it is more rapid than traditional learning techniques (Anido et al., 2004)
- It can "Provide a means of documenting a complete curriculum" (Armarego, Fowler, & Roy, 2001, p. 260) so that the departure of an instructor from designing and presenting a course does not mean it has to be rewritten.

Disadvantages of e-learning

The disadvantages of e-learning, as pointed out by Henderson (2003), are:

- Without interaction between people can be dull
- Computer pages on a screen (such as a book) are difficult to learn from
- Hands-on experiences are difficult to provide
- There is minimal or no interaction with other class members
- The presentation is fragmented and a holistic picture of the learning process is difficult to acquire
- There are low completion rates of e-learning courses – there is little motivation to complete.

There are two types of e-learning, as discussed below.

Asynchronous e-learning

Asynchronous e-learning occurs where learning does not occur simultaneously. Some examples from Hall (2002) of this would be taking a web course which was self-paced and does not require simultaneous interfacing between the instructor and learner. Asynchronous e-learning has been historically popular as it is arguably less demanding of immediate access to an instructor, it is closer to the web page structure and has lower bandwidth demands. Lau and Bates (2004) reviewed the literature for e-learning in undergraduate medical education and found that a small proportion of articles (4%) discussed the use of synchronous e-learning (video conferencing) whilst the remainder (96%) focussed on asynchronous technologies.

Synchronous E-learning

Synchronous e-learning occurs where communication occurs at the same time between individuals (e.g., between instructors and learners) and information is accessed instantaneously. Examples from Hall (2002) include real time video or audio conferencing or chatting in real time. According to Whalen and Wright (2000), video conferencing allows for simultaneous communication between student and instructor in real time with both voice and video.

In evaluating whether to use synchronous e-learning, Matthew (Hyder et al., 2007) suggested that one should first of all consider whether a learning need exists and then look at building a business case.

Some of the advantages for using synchronous (as opposed to asynchronous) e-learning included:

- Connecting dispersed learners.
- Real-time interaction and collaboration
- Sense of immediacy and co-presence
- Developing a learning community
- Balancing learning dynamics (such as different types of learners ranging from extroverts to female/male issues)

- Unique functionality such as whiteboards, mark up tools, application sharing, "web safaris"
- Easier group learning, discussions and dialogue
- Easier access to expensive and highly knowledgeable instructors
- Standardised learning experience for instructors at widely dispersed locations
- High quality collaborative informal learning between different individuals

Murray (Hyder et al., 2007) indicated that the main categories of synchronous e-learning technologies, are often confused by different users probably due to the rapid growth in the field, and comprised the following:

- Teleconferencing (comprising audio conferencing and video conferencing). Audio conferencing, often referred to as conference calling, is using the telephone only to implement synchronous training. It has mostly been superseded by more modern approaches such as video conferencing. Recently, it has undergone a revival due to the use of cell phones and the use of downloadable podcasts. Video conferencing comprises full screen video and audio using high speed dedicated telephone lines (such as ISDN) or over the internet using the TCP/IP suite of protocols (Wilcox, 2000). Murray felt that video conferencing was diverging into two areas: high definition "telepresence" (Lichtman, 2006) suited to training fields such as medicine where high quality video was critical on the one hand and affordable standard PC-based systems on the other hand.
- Webcasting. This was originally derived from the activity of broadcasting over the internet. This was taken to mean a combination of audio and video sent from a single source to multiple receivers with limited interactivity and based on high quality streaming audio and video. This technology is especially useful in reaching numerous individuals simultaneously, but where responses from learners will be limited.
- Web conferencing or e-conferencing (Shi & Morrow, 2006). This is generally what is referred to when discussing synchronous e-learning and comprises an interactive audio/video connection between instructor and learners with additional features such as whiteboards, application sharing, polling, quizzes, slides, web tours and use of other media. Barlow, Peter, and Barlow (2002)

indicated that web conferencing, as compared to video conferencing, only allows the camera feed in one direction, but voice and written communications in both directions.

Downs (2004) defined web conferencing as a technology that allowed a group to communicate and collaborate in an electronic conference format over the internet. She indicated that there are two main types of web conferencing approaches possible:

A webinar is an internet conference where slides are initially downloaded from the moderator's site and the learners then communicate with the presenter via telephone or a web-based chat option.

Webcasting on the other hand uses streaming video and perhaps, audio over the internet. This allows the data to be transferred in a continuous manner and the presentation commences before all the data is actually transferred. This disagrees somewhat with what Murray (2006) indicated above, in that she did not categorise webcasting as a subdivision of webconferencing.

This was highlighted by Keegan et al. (2005) who remarked on the confusion in the use of the appropriate terminology in the area of e-learning especially in simultaneous group-based teaching through the internet. He discussed some of the terms that can be used to refer to this group-based e-learning. Virtual classrooms indicate a grouping of students with instructor-led training. Virtual indicates that the meeting will be done virtually or electronically; not in a face-to-face situation.

Downs (2004) listed the typical methods of delivery required of a web conferencing solution:

- Slides presentations using the ubiquitous Microsoft Powerpoint
- Speaker chat between speakers and with moderator
- Questions and answers in text from the participants
- Polling of the participants by the speaker at appropriate areas of the presentation

- Use of an electronic whiteboard by the speaker for writing and drawing on the screen
- Screen sharing of the presenter's desktop with participants
- Application sharing where the presenter allows a participant to take control of the slide show and presentation
- Web touring where the presenter can take the participants on a tour of certain web sites
- File transfer for appropriate files to participants (such as presentation files)
- Use of emoticons (such as happy/sad/confused) to allow participants to communicate with speaker.
- Gaming and simulations. This area, whilst still in its infancy,was rapidly advancing and encompassed "online virtual environments that respond and dynamically adjust to learner input" (Hyder et al., 2007, p. 5). Of interest to this research was the opportunity to allow for online learning of psychomotor skills which had been previously associated with face-to-face demonstrations.

Details of synchronous e-learning

As synchronous e-learning technologies are of major interest in this research, it is worth examining this field in more detail especially as far as the mechanics are concerned.

Keegan et al. (2005) discussed the differences between instructor-led training (ILT) and video conferencing as follows. ILT referred to the traditional experience with training presented in a classroom by an instructor. Video conferencing occurs when there is a two way audio and video link between instructor and students. Generally, they were designed for meetings rather than education settings and lack some of the important teaching aids such as whiteboard and question and answer software components.

Keegan (2005) listed some of the major providers of synchronous e-learning systems. These included:

- Centra
- Webex

- Horizon Wimba
- Sumtotal
- LearnLinc
- Elluminate
- Interwise

As can be seen, there are a number of vendors.

In his doctoral investigation, Meulenberg (2005) noted that the use of video conferencing (using PC's) was rapidly growing worldwide to link classes and students over the internet. Some of his principal findings were as follows. Appropriate training in video conferencing was lacking in most of the participating organisations – most technical problems could be overcome with adequate training. The human element in setting up a successful video conferencing system was underestimated. A central co-ordinator was critical to managing the coordination between the different sites. IT support must be available from all organisations. Identical equipment (hardware and software) at the different sites was critical as a minimum. Additional training resources (such as whiteboard/videos/software) added value to the video conferencing experience. Eye-to-eye contact was critical, hence the cameras must be placed as close as possible to the incoming pictures. High data rates contributed significantly to the quality and success of the experience. Technical ease of use with the video conferencing package was vital and finally, the dispersed nature of the audience and resultant group dynamics needed careful attention to keep the geographically separated audience feeling united.

Grayson and Monk (2003) noted that modern video conferencing equipment did not support a natural mutual gaze between instructor and learner because the camera was mounted on top of the monitor with the result that other person's eyes were displaced vertically downwards (as they were looking at the computer monitor). They believed gaze awareness, where one knows where someone is looking is important as a conversational resource. They suggested that to optimise the possibility for mutual gaze awareness, the camera should be placed as close to the image of the remote participant as possible and any horizontal disparity here, should be avoided. Small video windows to a minimum size of 176 X 144 pixels, with a head and shoulders view, can be used without disrupting the mutual gaze awareness environment.

Bliesener (2006) noted that a major problem with synchronous e-learning was that sound and video of each participant was often significantly different in quality and timing between the transmitting and receiving sites due to imperfections in the transmission media and equipment. He suggested a number of techniques to improve the experience. The first was to ensure that more cues and inputs should be provided from the remote site. This included such items as verbally explicitly explaining everything a participant did from handing over control of a computer mouse to indicating they are finished with talking; ensuring that any actions (e.g., clicking a mouse) are indicated to the other participant graphically; allowing for varying of the audio and video by the participants to allow for a richer experience, by for example, panning the camera around the room; to adding an additional camera to the remote site to allow the participants to view not only the lab, but the first camera and the participants. A second suggestion was to provide feedback from the remote site in terms of the quality of video and audio by transferring this data back to the other (local) participant. Finally, he suggested adopting syntopical monitoring (Bliesener, 2006) where an identical workstation was placed next to the one being used by the participant. This then allowed the remote site to view what the local participant was actually experiencing by viewing this additional stream of audio and video.

Tscholl, McCarthy, and Scholl (2005) suggested the importance of non-verbal cues for “dialogue, discourse and information management”. They found that adding high- quality video (at least 25 frames/second), had an effect on the discussion, attitudes and behaviour of participants in that more general concepts would be produced in the discussion. The investigators felt the video may increase the intimacy between the students and it would act an “icebreaker”. (Tscholl et al., 2005). It should be noted that students tended to try and establish eye contact but because of the camera settings, this was never actually made.

Baecker (2003) noted that asynchronous tools “rarely succeed in establishing the sense of immediacy, interactivity, and shared purpose that results from face-to-face meetings”. He listed the design requirements for the ePresence webcasting package he developed, which were broken into five categories: Participants, Media, Interactivity, Archives and System. A more detailed description of some of his categories were as follows:

Participants

- Identify and support the needs of the various types of participants (such as remote and local participants, speaker and moderators, archived broadcasts)
- Design for scalability
- Support a variety of platforms (such as Windows/Apple/ Quicktime/Linux)
- Give priority to support of remote participants over local participants
- Design the classroom where the session is being presented for both speaker, audience and webcast
- Ensure the moderator provides significant support

Media

- Ensure that priority is given to providing quality sound over quality video
- Do not restrict speakers to only powerpoint but use other aids such as whiteboard/web surfing, software demonstrations
- Emphasise quality slides and screen capture over video
- Create a heightened sense of presence by using high quality video

Interactivity

- Emphasise interactivity with public chat and minimise transmission delays
- Remote viewers should be able to independently control slides and access web materials
- Provide archiving of all materials in a non-linear fashion which can be viewed interactively with annotations

System

- Archive all user experience materials and activities (such as chat) for later review

Thomas and Chasick (2007) in discussing the changes from classroom to distance learning (or synchronous e-learning), noted that as the instructor you have to be responsible for driving the session and maintaining a high level of energy to keep all the participants engaged. Chasick mentioned that what worked in a classroom was not necessarily going to work in a distance learning environment. He felt that the ideal class size was between 18 and 20 people with an absolute maximum of 25. He suggested that students have to actively participate at least 80% of the time with a maximum length of 60 minutes for a session. Finally, he indicated that a high quality headset (and amplifier) was essential for the instructor.

Kismihók (Keegan et al., 2005) made some suggestions on ensuring a successful synchronous e-learning session:

- Schedule and allocate the time carefully
- Keep the e-learning experience shorter than the equivalent physical classroom session
- Check out the equipment (such as audio/video) and software well before the class commences
- Make the presentation as interactive as possible and avoid monotony
- Add in videos, web cams and demos to illustrate the presentation
- Be careful about allocation of microphone usage for all participants
- Emphasise ongoing feedback from all participants during the presentation
- Keep an eye on the public chatroom for any pointers during the presentation
- Drive a good atmosphere during the course
- Record the presentation, if possible
- Let the participants assess the presentation at the conclusion

Heeler and Hardy (2005) noted that most online courses used text as the key method of communications with occasional use of phone conversations. They felt one of the main drawbacks in this form of communications was the lack of video in the instructional process as much of the learning process revolves around visual communications. They pointed out that face-to-face instruction had the advantage that both student and teacher could see what the other was doing and observe the non-verbal communications. They found that video technology can be used in the web conference format to increase the interaction which included both video, audio and text-based communications. They listed the additional activities available in web conferencing that should be investigated such as demonstrating software online, monitoring student progress whilst in a lab situation and new assessment methods of the student.

Matthew (2007) then listed some of the business opportunities in using synchronous e-learning (and as a possible component of blended learning):

- Productivity improvements due to reduced travel and associated costs (and stresses)
- All sessions are recordable and thus are usable at a later date by others
- Easily scalable to larger or smaller learning audiences
- Spread into new communities of learners due to its ease of access
- Allowing for rapid deployment of training to cope with high employee turnover and restructuring of the company
- Timely delivery and reusability on a just-in-time basis
- Tracking of learner performance and achievement.

Other variations on e-learning

Scholl, McCarth, Sasse and Parnes (2005) noted that chat and instant messaging systems have become increasingly popular. They suggested that despite the prevalence of video and audio conferencing, text-based chatting offered several advantages over audio such as providing a balance of synchronous and asynchronous communications for supporting unscheduled informal communications. They referred (Scholl et al., 2005) to a number of other papers which indicated that video provided a "richer sense of presence"(Short, Williams, & Christie, 1976), "helps coordination of communication" (Daly-Jones, Monk, & Watts, 1998) and "facilitates emotional expression" (Ehrlich, Schiano, & Sheridan, 2000; Herbsleb, Atkins, Boyer, Handel, & Finholt, 2002). They pointed out that due to the bandwidth limitations (and video's significant data requirements), that high quality video to large groups was challenging. As a result they developed what they referred to as "video chat" (Scholl et al., 2005) where participants communicated using a combination of video and text chat. They investigated video conferencing with video chat and found that a low bandwidth of 0.2 frames per second (fps) was considered unacceptably low quality as the transmission of basic emotional expressions was blocked at this rate. They did find however that with equal bandwidth sharing and a minimum frame rate of 2.5fps, the quality was considered acceptable. Users remarked though, that it was difficult to watch both the video and chat windows simultaneously.

Serfontein (2004) noted from Thomson (1999) who remarked that e-learning should not be regarded as a mere information transmission model where the instructor sends selected readings and lectures to the participants, who absorb these materials and then respond with assignments and write examinations.

Downes (2007) also cautioned against regarding the proliferation of digital content in a range of courses as actual learning. He indicated that he regarded the Open University where a fully online fully packaged course was provided, as being the gold standard, and providing a learning experience. The MIT's OpenCourseWare initiative, he stated, was only digital content with learning possible, but not in itself, an example of online learning.

2.3.2 Classroom Instruction

Overview

Hall (2002) made the point that traditional training is classroom-based and instructor-led. This is also referred to as face-to-face learning. Classroom training is still the dominant form of corporate training (Banks, 2004; Tai, 2005). Zenger and Uehlein (2001) believed that instructor-led training was strongly rooted in everyone's school experiences and would be difficult to change.

Advantages of Classroom Instruction

The main advantages of classroom training can be summarised as:

- People are suited to learning in social groups (Voci & Young, 2001; Weaver, 2002)
- It is easier to exchange ideas and interact with peers in a face-to-face setting (Tai, 2005)
- There is a lower possibility of misinterpreting messages (Piskurich, 2003)
- Familiarity based on generally extensive experience with classroom instruction (Voci & Young, 2001)
- Easy to set up interactive environment for learners, other learners and instructor (Voci & Young, 2001)

Disadvantages of Classroom Instruction

The disadvantages (compared to e-learning) are summed up in section 2.3.1, but the main issues according to Tai (2005) are:

- Lack of easy communication via electronic mechanisms
- Lack of easy repetition of parts of a program that are not clear to participants
- Longer time to train employees
- No ability to train at participants' own pace.

An alternative view of classroom instruction

Ullery (2002) stated that technology (presumably including e-learning) could be used to enhance classroom learning and gave a few suggestions:

- Focus on presenting media in a graphical way using animation, video and other multimedia techniques
- Use audio in addition to the other media
- Emphasise experiential learning ("learning by doing")
- Apply adaptive programming logic
- Let learners dictate the pace of the learning experience
- Encourage and assist in collaboration between students and instructors

- Optimise management of the learning process (e.g., good feedback for instructors on student's progress).

One could argue that adding audio and other media into the classroom setting creates a blended learning experience. Blended learning is generally considered a combination of classroom and e-learning and is assessed in the next section.

2.3.3 Blended Learning

Overview

Dziuban, Hartman and Moskal (2004) noted that the blending of face-to-face learning with other technology-based forms of learning has been around for over 40 years. What had spurred on recent developments of this model has been the advent of e-learning. Other terms used for blended learning include hybrid learning and mixed-mode instruction. They suggested that for the purposes of this discussion, blended learning encompassed all courses that combined face-to-face classroom learning with online learning, and a resultant reduction in classroom contact hours. They emphasised that blended learning should not be merely considered in terms of time allocations to each segment of the blend but rather with the following attributes: a shift to learner-based orientation as opposed to the current instructor driven approach; increased interaction between learners, instructor and learner and learner and content; and finally, a combined formative and summative method for assessment of both course participants and instructors.

Masie (2002) stated that blended learning is the combination of two or more distinct methods of training such as classroom instruction with on-line instruction or simulations with structured courses.

Singh (2003) listed a number of blending dimensions:

- Offline and online learning such as study materials and other resources over the internet and the remainder via classroom-based instruction
- Self-paced with live learning such as review of appropriate materials and then a moderated synchronous session with one's colleagues

- Unstructured and structured learning such as conversations, loose documents poured into knowledge storage areas; both available to workers when required
- Custom content aimed at the needs of the corporation and off-the-shelf content which approaches the training in a generic way
- Learning, practice and just-in-time performance support tools to support a new job-task at hand

Driscoll (2002) noted that there are four concepts to blended learning. She listed these as combinations of:

- Different modes of web-based learning (such as streaming video and live virtual classrooms).
- Different pedagogical approaches such as constructivism and behaviourism
- Different forms of instructional technology (DVD, face-to-face instruction)
- Mixing of instructional technology and appropriate on-the-job tasks

She felt that the greatest advance would be in integrating blended learning with work and that blended learning was an excellent way to gradually move from the traditional classroom to e-learning in an incremental way.

Teng et al. (2007) noted Graham's comments that there were three common definitions of blended learning of either a combination of instructional modalities or instructional methods or a combination of online and face-to-face instruction. Graham felt that the third definition is the more relevant as it "mirrors the historical timing of the emergence of blended learning ideas and approaches" (p. 2).

Blended learning according to Bersin (2004) is the combination of different training "media" (technologies, activities and types of events) to create an optimum training program for a specific audience. Table 1 lists various components.

Table 2.2

Blended Learning Components (Adapted from Bersin (2000, p. 173))

Blended Learning Component	**E-learning activity**
Instructor-led training (often referred to as classroom training)	No
Webinars (live e-learning and referred to as synchronous learning)	Yes
Courseware (Web-based)	Yes
Simulations (Applications, business, process)	Yes
CD-ROM-based courseware	Yes
Rapid E-learning courseware (using Microsoft powerpoint)	Yes
Internet delivered video (Bersin refers to this as replays)	Yes
EPSS (Electronic Performance Support Systems)	Yes
Offline Video (Video tapes)	No
Video Conferencing	Yes
Collaboration Systems (such as chatrooms)	Yes
Conference calls	No
Job Aids	No
Workbooks	No
On-the-job exercises	No

As indicated above, some of the blended learning components are e-learning activities.

Sanders (2003, p. 118) supplemented the table with her list of blended learning components which included:

- “Instructor-led training
- seminars*
- remote labs*
- online mentoring*
- virtual classrooms*
- virtual communities*
- simulations
- video on demand
- audio on demand*

- web books*
- CD-ROM's*
- books*
- assessment*"

The items above marked with a * symbol are additional to that from Bersin's Table 2.2.

For the purposes of this research and based on Banks' work (2004), blended learning was defined as two thirds synchronous e-learning and one third classroom-based instruction (in terms of time). Bersin (2004) listed a number of criteria such as culture of participants, degree of collaboration required and shelf life of programs in deciding on the optimum blend.

Dziuban et al. (2004) remarked that the benefits of blended learning included: increased face-to-face contact over that of exclusively online, higher student learning outcomes, convenience and flexibility for students, increased "information literacy", improved efficiency of classroom use and campus logistics, reduction in direct instructional costs by 25% to 50% and reduced attrition rates compared to pure online learning. They did note that one of the major challenges was adequate scheduling to take up the unused classroom hours released by blended learning. Following on from these observations, Henderson (2003) felt a blended approach represented a successful compromise.

In "Lessons from the e-learning experience" ("Lessons from the e-learning experience," 2002a) it was pointed out that there are a number of ways to improve the quality of information transferred to learners:

- Simply placing text put into an online learning form is inadequate and far more needs to be done to make it a learning experience
- Encouragement and support is critical to motivate learners to complete the learning
- E-learning on its own is part of a blend of training and should not be done on its own

- People have different learning requirements and the instructing has to be targeted to the individual

They suggested that blended learning may be the best training approach to deal with these issues.

Mitra (2003) in a detailed report on online education, concluded amongst other things, that an effective internet-based learning facility was yet to be developed and a hybrid or blended approach might be appropriate especially for developing countries (such as India).

Critique of blended learning

Whilst most of the comments above about blended learning have been supportive, M. Oliver and Trigwell (2005) were unenthusiastic about the use of the term “blended”. In a critique of blended learning they examined the various definitions used:

- Traditional learning combined with web-based online instruction. They suggested that all learning activities (including those of traditional learning) today involved some form of e-learning; so this definition is inappropriate.
- Mixing online learning with face-to-face instruction. They felt that there was something “particularly special about the Internet per se” (p. 19) and online was nothing more than learning from the internet which is simply “an extension of file sharing networks” (p. 19).
- A combination of media and tools employed in an e-learning environment. They felt that “pedagogy is a form of practice” (p. 19) and not “an inherent quality of media” (p. 19). Further to this, all learning uses blended media, so is blended learning.
- Mixed contexts in which learning takes place. They argued that all learning blended the contexts in which it occurred, so again, the term blended learning became redundant.

- Mixed theories of learning (such as constructivism, cognitivism, instructionism). However, they emphasised that each of these positions were irreconcilable; hence multiple positions could not be held simultaneously. So no mixing (or blending) was possible in this context.
- Mixed learning objectives (skill-driven, attitude-driven and competency-driven learning quoted by Driscoll (2002). They felt that this was appropriate only to design and not to the actual learning process where the student will probably gain skills, competencies and attitudes; hence blended did not add much to the discussion.
- A combination of different pedagogical approaches. Again, they felt that instruction of any duration would inevitably result in blending occurring, thus making this term meaningless.

In conclusion, M.Oliver and Trigwell (2005) believed the term blended learning was badly defined and inconsistently used. They commented further that "Blended learning, is arguably, a term introduced to redeem the millions of pounds invested unwisely in purely online training" (M. Oliver & Trigwell, 2005, p. 21). They suggested that blended learning could be redeemed by considering it as improving the variation that a learner experiences. Oliver and Trigwell referred to various references (Bowden & Marton, 1998; Marton & Tsui, 2004) in describing variation theory which indicated that for learning to occur, the learner should feel a variation in the learning experience. They noted that it is possible that blends of e-learning with other media "may make it easier to help students experience the variation in the critical aspects of the topic being learnt" (M. Oliver & Trigwell, 2005, p. 23).

Wilson (2005) rebutted M. Oliver and Trigwell's critique by indicating that it was unlikely that the millions of pounds spent on blended learning and e-learning were wasted. He did agree that blended learning was a poorly defined term and lacked some robustness. He felt that blended learning typically commenced as a mix of e-learning and non e-learning approaches but then became an issue of media selection. He added to this, saying that media decisions are frequently based on logistical issues, time to deliver, cost and scale and results in poor outcomes. He suggested adding to Oliver and Trigwell's (2005) blended learning list, referred to above, that of time and work; where time refers to extending the duration of blended learning by adding in more non-learning time and where the latter refers to blending learning and working (which Wilson felt to be the most important).

Examples of blended learning

Spiglanin and Gardner (2004) have successfully added e-learning on aerospace engineering to their firm's internal education program to create a blended learning approach. There was an improvement in productivity in that sessions were available on demand to students. The response from participants in terms of number attending and post presentation surveys were good. They also added in a blended learning approach where they took the traditional instructor-led classroom sessions and created recordings for later use by other employees.

Humbert and Vignare (2004), at the Rochester Institute of Technology, surveyed their students who were undertaking some of their courses through blended learning and found that over 75% liked the blended learning format, course completion was excellent (less than 5% left the program) and they felt that the interaction was greater and of a higher quality. It was unclear whether this survey compared these results with pure distance or classroom-based learning; presumably a mixture of both.

Optimising delivery of blended learning

Anderson (2000) noted that there are three factors to consider when determining the effective delivery options for blended learning. These included content; learner needs and technology availability.

He stated that there are four main types of content:

- Informational content which is simply a list of facts such as a sequence of prices for a product line.
- Procedural content which links together a series of action steps to form a process such as calculating the repayment schedule on a mortgage when the interest rate is known. This is learned through practice.
- Behavioural content is considered similar to procedural content but there are more correct actions and possible paths. An example here would be how to

perform an engineering design for a renewable energy solar panel system for a house.

- Conceptual content "offers a web of connections" and "permits the learner to extrapolate from the known to the unknown" (C. Anderson, 2000). An example here would be setting up a new office in a new country based on an existing country's activities.

The second delivery option, learner needs, referred to whether the learner is refreshing existing knowledge, needing to learn only part of the course and how they intend to apply the learning. The third delivery option, technology availability, refers to such issues as connection quality to the internet or corporate LAN.

Brodsky (n.d.) listed what he considered are four blended learning blunders which should be avoided to provide effective learning. Initially, it was important to consider what e-learning does well and to focus on these strengths when considering what to blend with it and thus to avoid the weaknesses later. The second issue was to define clear learning objectives with the appropriate training methodologies tied to these. One needs to be aware that often, on analysis of the situation, training is not going to solve the problem but some other intervention may be required. The third suggestion was to ensure that each training methodology must not stand alone but must be integrated into a holistic solution presented by real experts with no compromise on the quality on delivery of the end product. The final point was to ensure that it was important to action a true blended approach in the implementation process and not to only focus on e-learning.

Advantages and disadvantages of blended learning

The main advantages and disadvantages of blended learning can be seen under e-learning in section 2.3.1. Blended learning (Bersin, 2004) was designed to obviate the failures in e-learning due to high attrition rates by combining classroom and e-learning sessions and increasing the motivation of the participants to complete the learning programs. In addition, blended learning could reduce the criticality of poorly designed e-learning programs with high quality instructor-led sessions.

An excellent application of e-learning and blended learning is to the field of industrial automation where this is increasingly being used for training purposes as it has a strong computer focus. According to DeNardo (2007) technical training in the industrial automation area could be characterised by "content related to engineering sciences, applicable to a person's job function in terms of product support and knowledge with a range of complexities extending from step-by-step operation to repair and troubleshooting" (p. 2).

A brief review of what industrial automation comprises will be examined in the next section.

2.4 Industrial Automation

According to the online encyclopaedia Wikipedia (*Automation*, 2007), this is defined as the "use of computers to control industrial machinery and processes, replacing human operators." Devine (2003) noted from DuVall that automation was first used in the early twentieth century by the automotive industry to describe "the process of applying automatic control devices to production equipment" (DuVall, 1996, p. 539). DuVall noted that there are three building blocks to an automation system (or automated operation or process): a repeatable manufacturing operation or process, a control system and a material placement system.

The main advantages of industrial automation are lower costs in accomplishing the same tasks, repeatability, improved quality control and closer integration to the business systems of the enterprise. Typical components that form part of an industrial automation system are sensors, control valves, hardened industrial computers and human machine interfaces (HMI's).

There are various levels of industrial automation. At the lowest level on the factory floor, instruments are used to monitor and measure the industrial processes such as flow rates and temperature. Also at this level, valves are used to control the flow rates of materials. The next level up comprises industrial computers (often referred to as Programmable Logic Controllers) which take the signals of the instruments and issue control signals to the valves and other related devices to regulate the processes in an orderly and automated manner with an emphasis on efficiency and optimisation. The third level comprises computers on which software runs (often referred to as Supervisory Control and Data Acquisition or SCADA packages) and which issue instructions to the Programmable Logic Controllers and display all the industrial process information (such as flow rates/temperatures/pressures/levels) on a computer screen (Harjono, 2001). This information is used by the plant operator to make decisions on the management of the plant.

Examples of the particular requirements for industrial automation training will be examined in the following paragraphs.

An example of new technologies applied to an industrial automation training application for a dairy’s bottling line was described ("See it and do it," 2006) where animation, video and audio commentary demonstrated the processes and equipment operating functions to engineering personnel. This was on-demand training and removed the need for dedicated training staff.

Amos (2007) referred to Campbell who indicated that training of automation technicians, technologists and engineers should include mechanical engineering, electronics, process control and computer science. Amos also quoted Ryan who felt that these technical professionals should have a basic troubleshooting skill as well. Ryan continued by saying that he felt one of the greatest difficulties students have is the ability to conceptualise what is displayed on an operator display and to visualise the real process represented by this data (and in the process changing data into information). He believed that students have to have significant amounts of hands-on training in preparing them for a future career as an automation technician/technologist or engineer. In order to address this point, in the research, the hands-on nature of blended learning has been emphasised.

According to Iversen (2006), the increasingly sophisticated automation, instrumentation and process control equipment used in industry, coupled with a greater productivity imperative, less staff and the shortage of skilled employees is producing new challenges in training in this arena. The challenges include an increased demand for customisation of training materials, more courses on-site with less travel for employees and increased online training. There have been challenges with lack of interaction and hands-on learning with the online approach and a solution has been to use a blended approach. An example of blended learning was given of introductory training in a classroom followed by online training. Iversen (2006) concluded by observing that a good example of the benefits of successful automation training was with a major USA food manufacturer where response times from maintenance personnel were improved and downtime significantly reduced.

It was important to demonstrate that industrial automation training using e-learning and blended learning is equivalent or better than traditional classroom instruction using a generally accepted set of metrics. The ones from Kirkpatrick are widely accepted and were used in this work and will be discussed in the next section.

2.5 Kirkpatrick's Evaluation Levels

As discussed earlier, there are four levels based on Kirkpatrick's (1998; Kirkpatrick & Kirkpatrick, 2005) model, with an additional fifth level suggested by J.J. Phillips (2004):

Level 1 Reaction and planned action. This measures participant satisfaction with the course and captures planned actions.

Level 2 Learning. This measures changes in knowledge, skills and attitudes.

Level 3 Application. This measures changes in on-the-job behaviour

Level 4 Business Impact. This measures changes in business impact variables

Level 5 Return on Investment (ROI). This compares program benefits to the costs.

As Thalheimer (2007) warned, there is very little correlation between the level 1 (so called smile-sheets) and level 2 assessments. He quoted Alliger, Tannenbaum, Bennett, Traver, and Shotland (1997) who indicated a typical correlation level of less than 0.2. Learners are often overconfident about their perceived prowess in their level 2 assessment. Hence the best method is to actually measure the training results with real assessments.

A key driver in using e-learning and blended learning is reduced costs. This can be assessed by using the ROI to quantify the savings and this will be reviewed in the next section.

2.6 Return On Investment (ROI)

In a survey conducted by HR Focus publisher IOMA ("And the cost-savings winner is....e-learning," 2003) in 2002, e-learning was considered to be the top initiative in terms of cost savings for training initiatives implemented in the past year. The reasons for the cost savings are essentially minimisation of travel costs and reduction in time away from work.

The use of video conferencing in conjunction with online training for learners as well as for new staff orientation were particularly effective from a cost savings point of view. As Reynolds (2005) pointed out, it is increasingly important to demonstrate the return on investment in training, but a common criticism is that this is not done that frequently.

M2 Presswire ("Reports coverage on Futuremedia," 2006) reported on an innovative application for e-learning in training new recruits for Virgin Atlantic cabin crew which has reduced training time and costs, improved learning and included a database which allows tracking of each learner's progress. The original ROI was to be over a period of two years but due to the success of the program it was reduced to one year.

As Sitzmann (in press) pointed out; even if e-learning is proven to be equivalent to classroom instruction in terms of effectiveness, cost savings (and thus ROI improvements) on their own would support this medium of learning.

Kypreos (2003) felt that the real cost benefits from e-learning included:

- Reduction in training costs such as travel, accommodation, hotels and materials
- Quicker launch of products onto the market with faster implementation of training

- Reduction in staff turnover by providing more challenging and interesting training
- Minimising of downtime due to quicker access to pertinent information
- Improved productivity
- Improvement in customer satisfaction and thus more sales and greater retention
- Improved quality of products and services
- Employment and retention of better quality employees
- And perhaps, better knowledge management

From both a direct and indirect sense, these can all be considered to have a financial or ROI impact.

ROI is defined in accounting terms as earnings divided by the investment in achieving these earnings (Anthony & Reece, 1979). Most research (J. J. Phillips, 2004) concluded, that e-learning is considerably less expensive than classroom (or instructor-led) training, and thus has a considerably better ROI for each additional course participant. In e-learning there are minimal expenses incurred in travel and every additional participant is at a minimal marginal cost. The measurement of ROI is particularly difficult to do on a repeatable basis due to the depth of research required of a particular company's processes. The literature reveals that there are two interpretations of ROI. Whalen (2000) used it in the context of an improvement that e-learning yields against that of traditional classroom training mainly in terms of cost savings. J.J. Phillips (2003) went beyond this and directly related the training to cost savings or additional revenue in the company. In this research, it was proposed that ROI is used in the context of a comparison of blended and e-learning against that of classroom training. This was due to the difficulty in assessing each company's increased revenue or savings that directly originate as a result of the training expenditure, as J.J. Phillips (2003) espouses.

In a written communication (email communication dated 8 July 2005) with Brandon-Hall, a major research company in e-learning and blended learning, they indicated that "..only about 11% of organisations even try to measure impact at the levels of

….ROI. There are not simple models for assessing this, without really exploring the individual organisation's goals and creating a bridge between training and the bottom line". Hence it was felt that the savings resulting from the use of blended learning or e-learning against that of classroom learning would be used as the yardstick.

According to Whalen and Wright (2000), there are two methods of financial performance for e-learning (and by extension, blended learning) in terms of using the break even point and the ROI in comparing e-learning against classroom-based training. They felt that ROI demonstrated the economic gain (or indeed sometimes, loss) from having initiated a project. The break even point is where the costs for classroom-based training are equal to that of e-learning. The fixed costs (mainly for development) of e-learning are presumed to be higher than that for classroom training, but the incremental cost for e-learning is less than that for classroom learning as the courses can be presented over the internet, to an unlimited number of participants. Each additional student has minimal incremental cost against that of the higher classroom costs.

In calculating ROI for e-learning, it was presumed at worst case that there is no difference in the learning output (with knowledge and skills) from either e-learning or training in the classroom. This presumption is backed up by numerous studies such as Russell (1999) who indicated that there were no differences between typical classroom training and e-learning. So the thrust of ROI are the savings that e-learning can generate in comparison with that of classroom training (discussed below).

In terms of asynchronous versus synchronous (e.g., video conferencing) e-learning, Whalen and Wright (2000) felt that there was one main cost difference between video conferencing and web-based asynchronous training. This is the large cost in adapting the materials to the web server for asynchronous e-learning whilst for the synchronous version this is a considerably lower. So the initial cost of asynchronous web-based training is considerably higher than for synchronous video conferencing. The incremental costs for students in using the asynchronous form of e-learning were lower due to the fact that the e-learning material is continuously available on the web and no human intervention (and thus costs), using video conferencing for example, were required..

Horton (2000) indicated that the ROI can be calculated by dividing the savings produced by web-based training by the additional initial investment it required. This is in line with the definition of ROI used by Anthony and Reece (1979), discussed earlier. He stated the following ROI formula:

ROI =

<u>(Total costs for classroom training – Total costs for web-based training)</u>

(development costs for web-based training – total development costs for classroom training)

and quoted an example as follows:

ROI = ($513,000 - $338,500) x 100% / ($160,000 - $20,000) = 125%

Where: $513,000 was the cost of classroom training

$338,500 was the cost of web-based training

$160,000 was the development cost of web-based training

$20,000 was the development cost of classroom training

Another example ("Virtual classroom produces immediate ROI for T-Mobile," 2004) of calculating ROI is provided in the context of engineering training for T-Mobile where the ROI was calculated based on (Total savings – total cost)/total cost. It is difficult to reconcile this definition with that used by Anthony and Reece (1979); hence it will not be used. This was produced by the engineering and operations training manager and had a ROI that varied from 15% (a small group of 10) to 229% (a larger group of 125 staff). The Elluminate e-learning software package was used for synchronous training.

ROI must be the ultimate measure of evaluation from a business and corporate perspective and for any activity within a firm to be sustainable it must be measurable. A survey by J.J. Phillips (2004) indicated that the following statistics were relevant to ROI in a typical American organization in limiting the use of e-learning in a given organisation:

Table 2.3

Survey of Typical American Organisation on ROI and E-learning (adapted from J.J. Phillips (2004))

Responses to survey	**%**
Do not know about ROI and E-learning	6%
Market Confusion	15%
Efficacy of e-learning not proven	18%
Lack of high quality content	19%
ROI of e-learning has not been proven	24%
Employees lack internet access	25%
Lack of management buy-in	28%
Employees not motivated to learn online	30%
Cost	39%

The main payoff of the ROI methodology is that it enables one to justify and defend budgets for e-learning. There are five evaluation levels drawn up by J.J. Phillips (2004) building on the first four levels based on Kirkpatrick's (1998) model (discussed in an earlier section) :

Level 1	Reaction and planned action. This measures participant satisfaction with the course and captures planned actions.
Level 2	Learning. This measures changes in knowledge, skills and attitudes.
Level 3	Application. This measures changes in on-the-job behaviour
Level 4	Business impact. This measures changes in business impact variables
Level 5	This compares program benefits to the costs.

In a survey by Whalen and Wright (2000), cost benefits for Web-based courses in a Bell Canada pilot project had ROI's ranging from C$3 for every C$1 spent to C$33 for every C$1 spent. The synchronous training and the asynchronous training savings per student were C$1103 and C$702 respectively. The main savings claimed were from the ability to train numerous students without large incremental costs as well as the greater efficiency in the training with fewer hours (the so called compressor factor) to deliver a given course.

Woll (2007) described converting a 12-day instructor-led course in the semi-conductor industry, to a five-day classroom session, three hours e-learning and on-the-job training. He claimed that this resulted in a ROI of 157% (including a 60% reduction in time away from work). The reactions from the students and the learning effectiveness were equivalent for that of the classroom and blended solutions.

Anderson in the Training Magazine ("ROI gains some credibility," 2004) noted that when measuring the impact of learning that the effects of the learning gained must first be quarantined from other factors. He felt there were three ways to do this to perform a reliable return on investment (ROI) analysis:

- Interview learners on the impact of the training on any new behaviours or skills achieved.
- Review behaviours and skills achieved by doing a pre- and post-course assessment.
- Compare learners from a specific course to their peers in a control group who did not take part in the training.

Schreiber and Berge (1998) warned that in performing an ROI calculation to watch out for marginal costs which are often ignored. These are items such as “nondocumented overhead or embedded costs” (p. 396) and include items such as in-house technical maintenance and support.

Finally, M. Allen (2003) warned that a better ROI should not be the only driver in determining one’s training requirements, as one could be perpetuating less expensive but poorer training.

The ROI assessment can be applied to many different media in terms of classroom learning, blended learning and e-learning and the ongoing debate about the importance of media will be examined in the next section.

2.7 Delivery Media Debate

Over the years there has been considerable debate (T. Anderson & Elloumi, 2004) about whether newer delivery media (such as e-learning) are superior to existing approaches such as classroom learning. Sitzmann et al. (in press) referred to Clarke's research (R. E. Clark, 1983; 1994) where he stated that different delivery media have a minor impact on learning outcomes. The significant impacts come from instructional methods and differences, presumably in the class and instructor. He (R. E. Clark, 1983, 1994) felt that previous research had failed to eliminate other explanations for differences in media and also to quarantine instructional attributes (the so-called confounding variables) that were unique to a particular medium. Essentially, methods can be used to achieve changes to the learner's cognitive processes, whereas media exists only to bring the method to the learner. Similarly, Russell (1999) reviewed the various technology platforms used over the past 75 years and came to the conclusion that there was no difference in the learning impact from the different media. He felt that there is no substitute for a good quality instructor and well designed and practical learning materials. Simonson (2003) also felt that Clark's article (1983) was convincing about instructional media being outstanding in delivering and storing training materials but had no impact on learning. Simonson added that he felt what mattered was the method to promote the learning, the involvement of the student and the actual content. Joy and Garcia (2000) felt that Clark made a strong case in the sense that media are "primarily vehicles for instructional methods coincides with widely accepted learning theory" (p. 35). They concluded that most of the studies they have listed show "no significant differences in learning effectiveness between electronic and conventional classroom delivery" (p. 35).

On the other side of the fence, Sitzmann et al. (in press, p. 7) noted there are others (Dumont, 1996; Hiltz & Wellman, 1997; Sullivan, 2001) who believed that online training offered "greater flexibility and greater access to multiple learning modes such that it may be superior to media that are more grounded in single instructional methods" Kozma noted that whilst it may be difficult "to isolate individual instructional attributes to any single medium, it is possible to identify clusters of attributes (e.g., customisation and hyperlinking) that are more efficiently accomplished in one medium rather than others" (Sitzmann et al., in press, p. 6). Joy and Garcia (2000) put Kozma's argument another way by observing that essentially it is about "media and methods" being "inextricably interconnected" (p. 34).

In conclusion, Joy and Garcia (2000) felt that the outlook for research comparing media (e.g., e-learning against that of classroom instruction) was "bleak" (p. 38). They felt that if researchers did want to continue with a media comparison, they should pay special attention to the following independent variables: "prior knowledge, ability, learning style, instructor effects, learner familiarity with technology and method of instruction" (p. 36). Kirkwood (1998) added to this by urging researchers to ensure that in comparing the effectiveness of the different media, that they ensured that the teaching situations are as similar as possible. He however felt that a specific blend of media should be appropriately selected for a particular instructing requirement as no other will achieve the learning outcomes envisaged.

In this research, attention has been paid to observing the independent (or confounding) variables listed by Joy and Garcia (Joy & Garcia, 2000). However the research is not just about a simplistic comparison between different media but to understand more adequately the best blend applicable to industrial automation training.

A challenge is the difficulty many learners have in absorbing the materials and in completing their e-learning sessions, but if the knowledge transfer is poor and the training sessions were not completed, there would be a question about the efficacy of the training. This is examined in the next section in cognitive load theory and e-learning.

2.8 Cognitive Load Theory and E-learning

Van Merrienboer (2005) pointed out that cognitive load theory (CLT) has become important in e-learning. He drew on Sweller (2004) who pointed out that it is assumed that the working memory has limited capacity when processing new information, and the long term memory is unlimited as far as storing cognitive schemas. A schema can be considered to be a conceptual framework. Van Merrienboer referred to Miller (1956) who stated that the working memory capacity is about seven elements for storing information and two to four for processing information. Expertise comes from the knowledge stored cognitive schemas. It should be noted that a highly complex schemata (which has been constructed) can be brought into working memory from long term memory as one element, and this reduces the working memory load. There are three types of loads:

- Intrinsic cognitive load which is based on the "interaction between the nature of the materials being learned and the level of the expertise of the learner" (Van Merrienboer & Ayres, 2005).
- Extraneous cognitive load is based on the additional work imposed by poor learning skills and can be reduced by good instructional design.
- Germane cognitive load is "directly relevant to learning, such as schema construction and automation" (Van Merrienboer & Ayres, 2005).

The key principle of CLT is thus to minimize the extraneous cognitive load and to increase the germane cognitive load, but above all to avoid cognitive overload (R. C. Clark & Mayer, 2003).

According to Van Merrienboer (2005), some other observations that were relevant for for e-learning were:

A considerable amount of e-learning has a large number of interacting elements. It is important not to present all the information at once but to gradually build it up into a more complex application; thus reducing the intrinsic cognitive load. However care had to be taken in sequencing learning from simple to more complex, "if the combined task represents a low level of element interactivity for the target group" (Van Merrienboer & Ayres, 2005, p. 9).

Motivation is an important part of reducing drop outs and improving learning achievement for e-learning. This increases the germane cognitive load.

For optimum results, instructional methods should be devised to dynamically adapt the instruction to the learners' individual needs by continuously measuring the learners' level of expertise.

Thomas and Schoemaker (2007) suggested that the traditional course is dead and that informal (as opposed to formal) learning is an option to consider. They indicated that the purpose of a course is to bridge a knowledge gap that an individual or organization has. He paraphrased R.C. Clark and Mayer's (2003) book on "e-Learning and the Science of Instruction" where learning is "the process of assimilating and storing in long term memory new knowledge and skills such that they can be retrieved later from long term memory into working memory and applied to new unforeseen contexts and circumstances". He also distinguished between information access and learning. Information access is demonstrated with a search engine tool such as Google where some item is acquired but it is not transferred into long term memory. If this material that is accessed with Google is understood and remembered and then embedded in long term memory, this can be considered to be a learning event. He again quoted from Clark who felt that there are three long term goals in learning which are to inform (using Google, for example), perform a procedure (such as using a spreadsheet package to do a task) and finally, "perform principle" where you would need to apply knowledge to unexpected events. He emphasized however that the formal course is still very much in need when "foundational learning" is required in a formal setting. This is in learning a broad base of skills, especially acquired through experiential learning in a safe environment in an efficient manner, before the learners are exposed to the real world where they have to apply this know-how. It is believed that blended learning with its e-learning component is able to accommodate these requirements, as detailed by Thomas and Schoemaker above.

Finally, not necessarily directly related to cognitive load theory, but still associated, Clemons (2005) added some further suggestions on integrating brain-based learning into online courses as follows:

- Students will remember content more if it shifted from short-term memory to long-term memory though a technique called "elaborate rehearsal" with role plays, debates, video clips and so forth. An additional approach is to "chunk" (p. 29) materials into clusters of seven plus or minus two "chunks."

- Develop and present materials with different learning styles (e.g., voice/video) in mind.
- Enhance attentiveness with a maximum of 15-20 minutes of teaching before breaking. Opening and closing sessions are critical for maximum recall and emphasise interaction.
- Emotions are very useful for enhancing remembering; but minimise threats to the learner's well-being.
- Ensure learning is placed in context
- Learning is maximised with "rich, complex interactive experiences" (p. 31)
- Use patterns in learning (such as mnemonics) and finally,
- Good nutritional food enhances operation of the brain.

As mentioned earlier, blended learning enables a more learner centred (as opposed to a teacher oriented) approach and this is explored in more detail in the following section on constructivism.

2.9 Constructivism and Learning

Keegan (2005) felt that pedagogy could be broken down into two main thrusts:

Behaviourist/objectivist as per B.F.Skinner's approach requiring the transfer of knowledge from the teacher to the students where learning is evidenced by a changed behaviour in the learners. This is the traditional form of classroom teaching with the lecture format and is often referred to as positivist, realist, scientific or traditional (Fritze, 2003). The teacher is responsible for ensuring that learning has indeed taken place.

Constructivist on the other hand states that the students are active participants in the process constructing their own learning. The teacher becomes a facilitator of the learning environment. This is often referred to as interpretivist, naturalist, hermeneutic or alternative (Fritze, 2003).

Keegan (2005) quoted from Benbunan-Fich (2002) who remarked that if synchronous e-learning used the traditional classroom approach, it will be effectively employing the behaviourist/objectivist pedagogy. But he felt that it is important to go for more interaction so that the e-learning is aligned with a constructivist pedagogy.

Brandt (1997) remarked that constructivism is based on learners constructing knowledge by making sense of the experiences and interactions with it (Fritze, 2003), in terms of what they already know. They take an existing mental model and modify and expand it to fit the new experiences. Akpinar and Ergin (2007) added that "people learn by actively constructing their own knowledge, comparing new information with their previous understanding and using all of this to work through discrepancies to come to a new understanding" (p. 1). Mental models are "conceptual interactions of knowledge used to interpret the world, which are understood by users themselves through conceptualizations of those mental models" (Brandt, 1997). Brandt emphasised that experiential learning does more than merely strengthen mental models through repetition but confronts the learner with variety which then challenges their existing mental models of a given situation. The result is that the learner's existing mental model is then tested, modified and strengthened if new concepts are gained. Fritze (2003) felt that the constructivist worldview is relevant to computer facilitated learning systems (e-learning) due to its ease of handling the "real-life complexity and multiple perspectives" inherent in this work (p. 34). Armarego, Fowler and Roy (2001), cited Laurrilard (1993) and remarked that the constructivist approach applied to a university engineering program, meant that learners could construct personal meaning by engaging in dialogue with others and reflect on the multiple perspectives "to make sense of the experience gained" (p. 258).

Almala (2006) drew on the work by Piaget and Vygotsky in constructivism and noted that there are "two constructivist learning models: individual constructivism, where knowledge is constructed from personal experience by the individual and social constructivism, which declares that knowledge is acquired through collaboration with meaning negotiated from multiple perspectives". The emphasis in constructivism is that there is no single reality, but is constructed by the learner during the training process. He noted that during a synchronous e-learning session, learners build on their existing knowledge, and the knowledge from the other participants and the instructor to work iteratively to a solution to a joint problem by defining their ideas, concepts to the others and then defending and modifying their initial models in a collaborative way. This is done in accordance with the principles of social constructivism. Almala (2006) noted that Oliver (2000) pointed out that it is imperative that the instructor needs to provide adequate scaffolding. If the above is done, Almala, indicated that constructivism would provide theoretical support to create quality e-learning courses.

Vrasidas (2004) listed some constructivist approaches to optimising online learning for learners as follows: active learning; showing knowledge in different ways; real world real experiences when participating; online assessment using written essays and multiple choice quizzes; collaboration with their peers in working on real world problems; and finally, use of distributed tools such as video/remote labs by learners.

This research was concerned with practical hands-on lab work and it is instructive to examine how constructivism impinged on this.

Shiland (1999) pointed out new ways to make the learner in lab work take on more responsibility in the learning process. He believed the application of the theory of constructivism is a useful way of improving the learning process. He listed the following propositions as key to applying constructivism successfully in this area:

- First of all, knowledge is constructed in the mind of the learner
- Learning does require thinking and cognitive activity
- The new knowledge acquired must be meshed in with the existing knowledge the learner has already
- New learning originates from dissatisfaction with existing knowledge the learner has on a subject
- Knowledge is constructed by social interaction where concepts are clarified in conjunction with others
- The new knowledge acquired is cemented by applying it to some situation

As lab work is close to that of industrial automation, it is useful to examine how constructivism is applied here.

Henderson and Mirafzal (1999) described an approach to lab work where they used the principles of constructivism, collaborative working in groups and learning centred on the student. When the students had finished their experiments, they then presented their group results to the rest of the class thus developing their communication skills and clarifying their thoughts. They believe that students who are required to approach their lab work with this experiential approach (as compared to the traditional lecture approach) achieve 30% points higher on these type of assessment questions.

Another effective constructivist approach to learning is problem-based work. Chernobilsky, Nagarajan and Hmelo-Silver (2005) referred to problem-based learning, where learners work in groups with a facilitator to solve problems and reflect, as a great opportunity to construct knowledge collaboratively and to internalise what they have learnt. They suggested that moving problem-based learning online with appropriate tools to provide appropriate scaffolding can "further support collaborative knowledge construction" (p. 53). They remarked that the facilitator is extremely important in this type of online learning activity.

Boettcher (2007) listed ten principles in designing learning environments as derived from brain research and pedagogical theory such as constructivism. She hoped that these would be a useful guide in the design of instructing environments in both online and classroom classrooms. These are as follows:

- Every instructional experience has four elements: the learner, the mentor, knowledge to be transferred and a learning environment. The learner should always be at the centre.
- The learner interacts within the environment from mentor to student; student-to-student and student to resources.
- Learning only occurs through an interaction between a learner and the learning environment.

- The mentor must structure and direct the learning experience and take advantage of the new instructional options.
- Learners integrate new core concepts into their existing and unique knowledge structures.
- Every learner has a zone of proximal development (ZPD) which refers to "the space that a learner is ready to develop into useful knowledge" (Boettcher, Vygotsky 1978). This requires the instructor to be continuously aware of the learner's state of understanding by interacting at a high level with her.
- Concept formation is a series of intellectual operations, including the centering of attention, abstracting, synthesizing, and symbolizing (Vygotsky, 1962). It can be enhanced by making the thinking visible using discussion forums, blogs, visualization sessions and presentations – all suited to e-learning and blended learning.
- Learners should not have to learn all the content of a course; only the core concepts relevant to their application.
- Different types of instruction are required for different learning outcomes. The instructor should use a clearly defined outcome and ensure that the learning experience is designed to achieve these outcomes.
- More time spent on the given task means more learning. A good industrial automation training course could require a trainee to spend extensive time on-site programming an industrial computer and commissioning a system. And then repeating this experience again on another plant.
- The final point that Boettcher (2007) made is that each learner's brain is unique in the way learning occurs and its existing level of knowledge.

Vrasidas (2004) listed a few learning principles to achieve satisfactory e-learning and which impact on the associated Learning Management System (LMS). These included: being learner centred; a focus on active learning and problem solving; constructivist in nature; the inclusion of a real world context in the learning; collaborative and a high degree of interaction; provision for support of reflective learning and finally, an emphasis on the instructor providing immediate feedback to the learner.

As far as this research is concerned, it is believed that hands-on training using real equipment (e.g., a dough and a breadmaking machine) needed to be examined in more detail as this had the potential to contribute to the learning. Some of the work done in this area is discussed in the next section.

2.10 Explicit, Tacit Knowledge and Hands-on Training

There were few references to explicit and tacit knowledge transfer in using e-learning in the literature, perhaps, because easier transfer of tacit knowledge is considered to require a real object (as opposed to a computer) to work on. A good example of the differences between explicit and tacit knowledge is given by Nonaka (1998) where he noted that there are two different forms of knowledge in making bread. Explicit knowledge can be considered to be the product specification for a breadmaking machine as opposed to tacit knowledge which is a core part of the craft or profession and is built on learning via actual experience and action such as learning from a master over a passage of time on how to make good quality bread. Explicit knowledge is often referred to as information (Al-Hawamdeh, 2002). Hands-on training could thus be considered a method of transferring tacit knowledge. Nonaka (1998) stated further that tacit knowledge consists of technical skills built up over the years (such as breadmaking) through experience and "know-how". Nonaka went on to say that there are four basic patterns of creating knowledge in any organisation:

- to another apprentice, for example. This skill is gained by observation, practice and refinement to imitate the skills of the craftsman.
- From explicit to explicit. A good example of this would be collecting financial information about a company and then putting this into a report.
- Tacit to explicit. This could be in taking an engineer's approach to operating a refinery in an optimal manner and encapsulating this into a software program to take over this function.
- Explicit to tacit. This would happen when other employees of the company come to use this knowledge from tacit to tacit. This involves transferring the skills of a craftsman and to supplement and extend their tacit knowledge.

It is believed by the author that an excellent application of the transfer of tacit to tacit knowledge is being taught by an experienced engineer via hands-on work in a lab setting on a particular technique. Lab work with hands-on experimentation is an important part of engineering and scientific training and acquisition of tacit knowledge could be considered a key element of the learning experience here. From an industrial automation point of view, this could be the technique, often used in industrial automation, of tuning of a process control loop on different types of processes.

The different types of laboratories (especially online remote and virtual ones so critical for e-learning and blended learning) where hands-on experience (as opposed to a pure lecturing approach) can be gained, and thus tacit knowledge can be transferred, are discussed in the next section.

2.11 Classical, Remote and Virtual Laboratories

2.11.1 Practical Work and Labs

Colwell et al. (2002) noted that practical work and executing experiments helps students in learning science and engineering subjects. They quoted from Hewson and Hewson (1983) who stated that students need to engage in knowledge construction. This is difficult for students working in science and engineering as they "need to develop both conceptual and procedural understanding by appropriate actions" (Colwell et al., 2002). This requires practical hands-on activity. Colwell concluded with a contrasting view from Lave and Wegner (1991) where they observed that practical work is important to learners simply because this is what scientists and engineers do; hence students must embrace this world if they want to be scientists and engineers. Jochheim and Roehrig (1999) noted that doing experiments with live processes and equipment equips the engineering student with expertise in tackling engineering problems as well as improving their motivation. He added that many physical phenomena are difficult to understand and explain in words or textbooks but must be witnessed in action.

Ma and Nickerson (2006) noted that lab-based courses are a key to scientific education. They drew on other researchers such as Magin (1986), Amaratunga and Sudarshan (2002) who indicated that lab courses have an important impact on students' learning outcomes. They did a survey on the current research in traditional, remote and simulated labs and reviewed over a thousand articles.

Schaf and Pereira (2007) noted the reasons for labs for engineering students being the application of theory to practice, knowledge of real practical situations and provision of active, distributed learning and team learning skills and referred to a number of authors in support of this (Auer, Pester, Ursutiu, & Samoila, 2003; Faltin, Bohne, Tuttas, & Wagner, 2002; Watson, 1995).

Auer, Pester, Ursutiu, and Samoila (2003) noted that labs are an important part of engineering education as they allowed "the application and testing of theoretical knowledge in practical learning situations. Active working with experiments and problem solving does help learners to acquire applicable knowledge that can be used in practical situations" (p. 1208).

Auer, Pester, Ursutiu and Samoila (2003) listed a number of learning strategies in using labs:

- Application of the theory to the lab work for designing and comprehension of the experimental work
- Application of the theory to the practical lab work and examination of the discrepancies between theory and practice
- Working with real lab equipment and instruments
- Reflection on the results of the lab work
- Application of social and communication collaborative skills in a team environment
- Development of report-writing skills on the results of the lab work

Millar (2004) noted that finding out things for yourself rather than being told them, is generally better for the memory process. He went on to say that learning is not construction of something new or unknown, but "making what others already know your own" (Millar, 2004). Teaching of scientific knowledge is essentially an act of communication. He referred to lab work as practical work and believed the important question is how should this be used to supplement other forms of communication (such as verbal/written/graphical). He stated that the key role of practical work is to get the students to tie together the two domains of knowledge – ideas on the one hand and that of objects and observable objects on the other. He suggested that one way to make practical tasks very effective in making the student think is to apply the Predict /Observe and Explain (POE) approach when undertaking an experiment.

Some of his thoughts about practical work in teaching science were:

- Practical work is key to good science teaching
- There is a significant difference between a research lab operating on the frontiers of science and that of a teaching lab which is merely illustrating accepted knowledge
- Practical work to be effective needs:
- Clear learning objectives
- Task design is simple and tied into the main objectives

He suggested stimulating the students' thinking before the task commences with the POE approach.

All the above indicated the need for practical work for students of engineering and industrial automation.

2.11.2 Overview of Labs

Andria et al. (2006) listed the various teaching options with courses as being:

- Web-based lectures which could be interactive
- Web support to university courses (presumably this meant a form of blended learning)
- Simulation of actual experiments
- Remote labs

Lahoud and Tang (2006) pointed out that many distance learning students found that traditional lab experiments were not an option due to geographical separation. They suggested offering some form of virtual or remote lab environment for distance learning students. They described the two possible solutions:

- Virtual labs comprising the simulation software running on a host machine; but they believed that it is difficult for students to achieve the required skills and practice. Often very powerful and expensive servers are required to make the simulations as realistic as possible.
- Remote labs are equivalent to the traditional lab environment in using real equipment but situated at a significant distance from the learner.

Brown and Lahoud (2005) felt that there were actually three "innovative lab technologies" (p. 66) (as opposed to the two considered above). These were a software simulator (equivalent to a virtual lab above), a virtual learning environment (not considered above) and online laboratories (equivalent to remote labs above). A virtual learning environment occurs when the learner accesses a third party vendor's resources such as an online tutorial situated on a remote computer. The learner can then experiment with the instructions contained in the online tutorial with the appropriate software installed on her own machine.

Aldrich (2005) also noted in fact, that simulations (or virtual labs as mentioned earlier) could be subdivided into four different types, namely: branching stories where students make multiple-choice decisions; interactive spreadsheets; game-based models (such as computer-based solitaire) and virtual labs/virtual products, which are the focus of this discussion. Due to the preponderance of literature, discussed in the following sections, only considering two approaches, namely Virtual and Remote labs (Lahoud & Tang, 2006), the virtual learning environment will be considered a remote lab, because the experiments or simulations are performed on a remote PC.

Hence in the following discussion, two approaches will be examined: virtual and remote labs.

A useful table showing the difference between traditional, remote and virtual labs is adapted from Auer, Pester, Ursutiu and Samaoila (2003) below.

Table 2.4

Different Types of Labs and Their Characteristics

	Local experimenter	Remote experimenter
Real experiment	Traditional lab	Remote lab
Virtual experiment	Local simulation	Virtual lab

Ma and Nickerson (2006) referred to the impact that information technology has had on the creation of simulated labs and remote labs as useful alternatives to the traditional conventional labs. They pointed out that the effectiveness of these two new lab approaches as compared with the traditional hands-on labs was not examined in much detail in the research literature. They felt that the remote and simulated labs were an excellent way to share specialized skills and resources over a wide geographical area and thus reduce overall costs and improving the educational experience. Azimopoulos, Nathanail, and Mpatzakis (2007) concurred with this and emphasised the need for practical work as an important adjunct to the theoretical study.

Andria et al. (2006) indicated that it was important for students to achieve good practical training in a real working environment with instruments. They indicated that due to their high cost, labs are not as available as they should be and remote labs offered a good solution. They also noted that the typical architecture of the remote lab comprised a Learning Management System (LMS) which learners interfaced through the web server. The LMS connected through to a series of lab servers which allowed access and control of the actual lab equipment. Each lab server was connected to a few measurement servers which were physically connected to the lab equipment (presumably through either Ethernet, RS-232 or GPIB communication buses). The main services provided by the remote lab modules included: demonstration of the experiment from instructor to the student; visualization of the experiment by the student; control of an experiment by the student; and finally, construction of an experiment by the student.

Cooper (2003) noted that solutions in the past to distance learning students requiring lab work had been home experimenter kits and intensive residential sessions on the university campus. An example of this was the application discussed by Hong et al.

(2004). Hong et al. designed and implemented an online course for Digital Signal Processing where the hands-on experience was provided using a development kit at the student's site. The students indicated that they were satisfied with the lab exercises. This course used streaming video with synchronized slides. Some of the conclusions that were drawn from the course were that the audience needed to be carefully assessed to ensure the material is correctly targeted; a rich mixture of video/slide/self test questions/hands-on exercises and interaction made for an excellent experience; preparation of the lectures required considerable time and use of dedicated assistants to improve the course on a continuous basis was critical.

Remote labs are examined in some detail in the following discussion. In the research, it was proposed that they could be a key to providing hands-on practical interaction with real equipment and thus providing an opportunity for more interactivity, and as discussed in the previous section, the transfer of tacit knowledge. It should be noted that generally, remote labs were considered by their various proponents as an isolated or stand-alone activity rather than as a part of an interactive e-learning live lecture session, which was the objective of this research.

2.11.3 The Merits of Remote Versus Virtual and Classical Labs

Ma and Nickerson (2006) suggested a few reasons why there is so much debate about the merits of each of the lab technologies. The first reason is that different objectives are used in the measurement and comparison process. They broke the educational goals for lab learning into four: conceptual understanding, design skills, social skills and professional skills. They found that for hands-on labs, all four educational goals were well catered for. Simulated labs research tended to focus on conceptual understanding and professional skills and remote labs emphasised professional skills and conceptual understanding (to the detriment of design skills which are important in hands-on labs).

Ma and Nickerson (2006) made the second point that in the modern hands-on lab, equipment is becoming increasingly mediated by computers. This means that what has been a traditional lab is in fact a variation of the remote lab as all the work is done through a computer. The only difference is the proximity of the learner and the lab equipment. This leads to the concept that what might matter is not so much the individual technology but the peculiar amalgam of hands-on labs, simulation and remote labs in a specific context.

The third point that Ma and Nickerson (2006) stated is that the actual technology may not be as important as the student's belief in the effectiveness of the technology. They reported on Patrick's (1992) research which indicated that using simulation with a high degree of psychological fidelity but low physical fidelity can still lead to a high transfer of learning. They did point out that this belief should be supplemented by other factors such as motivation, peer collaboration, error-corrective feedback and richness of the media to provide an effective lab setting.

The final point made is that the degree to which students using remote labs collaborate and make sense ("sensemaking") of the data whilst working with each other will affect what they learnt from the lab.

Ma and Nickerson (2006) observed the following issues, drawing on the various researchers listed below:

- Most of the labs were in the engineering area as opposed to the natural sciences and other disciplines.
- There was no standard assessment procedure to evaluate the effectiveness of lab work with varied definitions of the various approaches. They observed that with the exception of Engum, Jeffries, and Fisher (2003), there was no major difference between hands-on, simulated and remote laboratories as predicated on the results of lab reports or testing (presumably after the lab work had been completed).
- There were promoters of each of the three lab types. The proponents of hands-on labs noted that these are vital to providing the learners with real data and unexpected mismatches between the theory and practical experiments (2000). Against this are the far greater costs, space requirements, instructor time and lab infrastructure.

The merits of the two lab types will be considered in the following sections, commencing with an appraisal of simulated labs followed by remote labs.

Ma and Nickerson (2006) noted that simulated labs were considered to be at least as effective as traditional hands-on labs. However, Magin and Kanapathipillai (2000) believed that simulation could result in some disconnection between the real and simulated or virtual worlds. An additional problem was the often significant costs of a simulation system (in some cases, more than the physical lab). Remote labs are becoming increasingly popular and provided flexibility in terms of place and time for a student and they can also be accessible to far more students. However, the educational effectiveness of remote labs was questioned by some, as students are likely be irritated by having a computer as an intermediary to the real world equipment (Keilson, King, & Sapnar, 1999).

Lunce (2004) felt that computer simulations were critical in distance education as they provided an opportunity for more interactivity. Typical advantages he noted, were easing the "interactive practice of real-world skills" (p. 1); communicating difficult scientific concepts, assisting the learner in predicting the course and results of actions taken, providing feedback and flexible learning, reducing the risk of possible hazards and expense. He also listed some of the disadvantages of simulations being: they can take longer than a normal experiment, coaching is an important additional requirement to make simulations effective, they can oversimplify the real situation and they may be very expensive and require extensive planning. In conclusion, Lunce (2004) believed that there was sufficient evidence to demonstrate that simulations could provide benefits to the student; however recommended further research in identifying the extent to which this technology can be applied to distance education. In another study, Akpinar and Ergin (2007) demonstrated with Grade 6 students in a study of static electricity that a well designed computer simulation improved the pupils' knowledge and their attitude to the subject. They quoted a number of other studies (Ardac & Akaygun, 2004; Ronen & Eliahu, 2000; Williamson & Abraham, 1995; Windsehitl & Andre, 1998) which supported this assertion.

De Capua, Liccardo and Morello (2005) expressed some doubts about simulations noting that they were simply the implementation of a mathematical model or "solving of equations" (p. 1692) and as they were always successfully completed they might impact on a student's assessment ability. Also due to the defined outputs which always occurred on a specific sequence of inputs, there was no room for practical experimental issues such as uncertainty and electrical noise. These sentiments were echoed by Jochheim and Roehrig (1999) in the preamble to their description of their omnidirectional vehicle remote lab.

The issues of remote labs will now be examined in more detail; initiated by a discussion on gathering of remote and realtime or live data through sensing technologies. Woodill (2007) pointed out the availability of remote sensing to gather information about objects and thus to study them. He suggested that the feeling of working in a real environment can motivate the learner. Typical examples of remote sensing devices are satellites, electron microscopes and telescopes. As these are normally very expensive pieces of equipment, sharing them with many researchers and learners makes the use economical.

Luntz (2005) noted that University of Melbourne scientists have been operating the electron microscope in Sydney remotely using the principle of telepresence. As Vangelova (1996) remarked, telepresence occurs when a user manipulates and observes a real and distant object. This enabled the scientists to work with samples that may be difficult or dangerous to transport and gave them easy access to an expensive piece of equipment and near realtime visual and audio feedback as well as the appropriate data.

Ianace (2005) also listed the requirements for successful video collaboration systems and referred to these as demonstrating telepresence. Applications included remote surgery and mining in inhospitable environments. These requirements included ease of use, complete portability of all equipment, control of remote objects, collection of large amounts of data from the remote site, and archiving of the interaction. He believed that future collaboration applications should demonstrate true interactivity between local and remote sites.

Fiore and Ratti (2006) noted the advantages of remote labs being practical assistance for distance learners in gaining appropriate skills and knowledge, improving safety due to avoidance of hazardous lab situations, distributing expensive equipment to many users and thus minimising on costs, and an improvement in quality and effectiveness due to concentration of resources in one location. A final attribute of a remote lab, they suggested, was to attract researchers who needed the specialised instrumentation and equipment. This would then transform the remote lab into a centre of excellence. They made some suggestions about future developments with remote labs. Firstly, participants need to have a strong theoretical background on the subject matter before commencing work in a remote lab. Secondly, the training phase must be planned carefully with the instructor being closely involved and collaborative efforts emphasized with other learners. Thirdly, the level of interactivity should be increased with more experimental control and monitoring of the experiments being possible. Finally, there should be a thorough assessment of the learners at the conclusion of the work.

Lahoud and Tang (2006) defined the requirements of the remote lab for their application as follows:

- Every PC in the lab must be able to monitor all network traffic and communicate with each other
- Students must be able to access all PC's and control all resources remotely
- The network configuration must be durable to be able to withstand a student's handling
- The instructor should be able to manage all lab resources easily and effectively
- Remote access must be simple and software resource requirements minimal for the students

Huntley, Mathieu, and Schell (2004) conducted research on remote labs in the IT area and indicated that the success of the remote labs was based on ensuring participation from both faculty and the IT department in the system design and installation. Five recommendations that they made to implement a successful remote lab included:

> "(1) Clearly defined lab objectives, (2) carefully designed lab architectures, (3) clearly defined administrative responsibilities, (4) tested and validated lab exercises, and (5) plans for continued faculty and IT staff development" (Huntley et al., 2004, p. 405).

According to Bertocco et al., industry requires continuous education and e-learning is an ideal way to provide this (2004). However where e-learning is generally deficient is the lack of provision of adequate practical or hands-on activities. They indicated that there are five items that are required to ensure that practical activities performed remotely from the lab are of adequate quality. These are:

- Responsiveness of the test equipment to the commands issued and data returned to the participant in the remote site.
- Flexibility in terms of altering the configuration of the instrumentation set up.
- Portability of the remote system so that the different hardware and software systems used by the instrumentation can be seamlessly supported
- Availability of the test equipment to the remote participants.
- Extensibility to the practical exercises should be easily implemented.

Bertocco (2004), concluded that e-learning would never replace the traditional hands-on lab approach, but could speed up the learning process.

Cooper (2003) noted three main reasons for remote labs:

- When the students are studying at a significant distance from the institution. In the past experimenter’s kits have been provided or residential schools are undertaken as part of the course. But these have not been satisfactory alternatives.
- When the lab equipment is very expensive. There has been an increasing need to provide state-of-the-art lab equipment; and a remote lab makes for a possible solution here. Ewald and Page (2000) supported this assertion.
- When the number of students makes for a difficult allocation of lab time. Here it is possible to open up the lab facilities on a 24/7 basis.

Another often not considered benefit with remote labs, is ease of use for students who are disabled.

Cooper (2003) felt that clear learning objectives were a critical part of introducing remote experiments to the learner and the original objectives used in a traditional lab may have to be modified significantly as they may not be achievable in a remote lab situation. The other issue he listed as being important is that the learner does not get sidetracked into focusing on user interface software (to the remote lab). It was imperative that they focussed on the learning activity and that the user interface conveys a sense of presence to the remote lab with clear evidence to the learner that they are indeed using real equipment, as opposed to a simulation. He indicated that this can be done by using extensive real time video of the experiment, progress bars to indicate that a command from the learner had been executed (with auditory feedback) and a status bar at the bottom of the display.

Callaghan, Harkin, McColgan, McGinnity, and Maguire (2006) noted the importance of remote laboratories in teaching engineering related subjects and suggested an architecture which could be generalised across different users.

Alves, Alves, Ferreira, and Ferreira (2006) remarked that remote experimentation is a learning resource which allows instructors to strengthen the practical experience for engineering courses. However, the construction of a suitable graphical interface to the remote experiment is not an easy task for the average teacher as this required a combination of the following components: instrumentation, experimental equipment, audio/visual feedback from the lab, collaborative communication channels for both the group and the instructor. They proposed a software solution that enabled teachers to create their own remote experiments and interface, without having to resort to programming.

Esche (2005) listed the benefits of the remote labs for students as follows:

- A more comprehensive experimental experience
- A more accurate representation of a hands-on experience
- Optimises their imagination and enthusiasm
- An asynchronous approach allows for more flexibility with instructors and students not being required at the same time
- Promotes self learning on the part of the student
- It allows for a more integrated self assessment approach

Insofar as the instructors (and their institution) are concerned, the benefits can be:

- They can easily add lab demonstrations into their instruction
- They can monitor the lab performance of students more rigorously
- Less scheduling problems due to excessive student numbers
- Fewer lab personnel required
- More flexible financial planning for expensive equipment is now possible
- Greater levels of safety can be achieved

Distance education can be enhanced with a hands-on lab component

2.11.4 Applications and Lessons Learnt from Virtual Labs

Virtual labs have not been discussed in much detail, as they are considered generally too expensive and there are some concerns about their efficacy for students (Ma & Nickerson, 2006; Magin & Kanapathipillai, 2000) mainly due to the difficulty in replicating the lab situation realistically and the students' perception that this is merely a simulation.

Alexiou, Bouras, Ginannaka, Kapoulas, Nani, and Tsiatsos (2004) described a virtual radio pharmacy lab they had constructed where the learners were represented by avatars. The learners could experiment with the radio-pharmacy equipment and carry out specific scenarios in a three-dimensional simulation of the lab environment. This allowed learners to collaborate with each other and with the equipment in the replica of a real lab.

Kluj (2005) described a four-stroke medium diesel engine fault simulator which is used to demonstrate the relationship "between the diesel engine technical state and its operating parameters, functions and features" (p. 149). The value in this simulator was the low cost and ease of installing it on board a ship, for example, where it would be particularly useful for the training of ship engineers.

Illyefalvi et al. (1999) proposed a virtual lab to support training of technical professionals in the microelectronics packaging business. He suggested that this would provide an opportunity for lifelong learning. He proposed three phases in setting up these virtual laboratories. The first phase would be in placing the existing paper-based materials for lectures and lab experiments on the web. The second phase would be including hypertext links to other related materials and the final phase would be creating interactive graphics, audio and video multimedia tools.

Kamlaskar (2007) produced a simulated electronics lab (for a Wien bridge oscillator) and surveyed students and faculty afterwards. She found that it demonstrated self-efficacy and self-reliance as a result of the lab activity and both learners and faculty indicated they felt it could be usefully used in conjunction with a physical hardware lab especially in providing repetition and thus enhancing the learning process.

2.11.5 Applications and Lessons Learnt from Remote Labs

A few examples of remote lab applications and the lessons learnt are listed in the following sections.

Cennamo et al. (2004) gave an example of a wind tunnel where the instructor and students connected from a remote site and executed various tests without any operators being present on site. This is useful for those organisations that do not have these types of experimental facilities. Although they did not give any indication of the pedagogical significance of the learning experience, they claimed that the site was robust and could be significantly expanded.

Lahoud and Tang (2006) designed a lab for experimenting with intrusion detection (IDS) and intrusion prevention (IPS) technologies with a maximum of 24 students; hence with only 16 lab hosts they broke the students into two groups who had different lab schedules (Sunday to Wednesday and Thursday to Saturday). They found due to the bandwidth requirements that at minimum a broadband-based service was required. Some other challenges were that students needed to reset (or clean) their machines after use.

Zhuang and Morgera (2004) created an undergraduate course entitled “Internet-based Instrumentation and Control” offered to senior undergraduate engineering students which integrated classroom lecturing with hands-on work. The concept was to make more efficient use of laboratories 24 hours throughout the day. The responses from surveys were that students however still wanted the hands-on experience to reinforce the learning process.

Fujii and Koike (2005) described the construction of a lab for an electronic hardware design course where the students used their own computers to interface to the expensive lab equipment and software in "a remote multi-user and time-sharing" (p. F3J-11) mode.

In the construction of a remote vehicle lab (incorrectly referred to as a virtual lab), Jochheim and Roehrig (1999) pointed out that additional safeguards had to be built into the system (in the software) to protect the lab hardware from any damage.

Finkelstein (2006) described an application of using a live online telescope with a student's (Paul Stacey) comments about the experience with his astronomy lecturer: "…Ron used application sharing to show me how to use the Web interface that controls the telescope….I set the shutter speed and snapped pictures ! The live nature of the session allowed us to examine each picture right on the spot" (pp. 27-28). Finkelstein remarked that immediate support and feedback from the instructor to the learner with hands-on interesting activities made for an outstanding online learning experience.

Nabielec (2004) designed a data logger which gathered various items of meteorological data (air temperature, humidity and wind speed) and could be accessed by students situated remotely using the Modbus protocol. They expressed some concerns about verification of the student's resultant knowledge and practical skills.

Pastor, Martin, Sanchez, and Dormido (2005) described a remote lab application with control of a servo motor. They indicated their reservations with using simulation software to train saying that real world experimentation with a real plant is essential for good training. They suggested that "Practical education needs to be based on errors and irregularities, as occurs in mechanical, electrical or chemical systems, as opposed to the ideal icons and environments represented on a computer display" (p. 173). This provided the student with the real world situation. They indicated that most universities created their own virtual and remote labs without reusing the software or hardware developed by others. They stated that three words summarised their hands-on open lab: "reusability, simplicity, and flexibility" (p. 181).

Lee and Kuo (2005) converted an engineering design and product development course for medical mechatronics students and allowed students to design and conduct experiments in the remote lab. Students could also control equipment in real time. Students could collaborate with each other and share results.

A novel application of hands-on learning was reported by Fukuda (2004) with Japanese and USA universities collaborating on various mechanical design projects. Fukuda felt that modern engineering design is being driven by quicker changes and a shorter life cycle of products. He stated that remote learning techniques are becoming more important here as they emphasise a hands-on approach which facilitates knowledge acquisition.

Cooper (2003) described four successful remote labs that were conducted as part of the PEARL project. These included setting up and running a spectrometer, a digital electronics lab, a computer vision system and a transmission electron microscope (TEM). Some additional comments from the learners using the digital electronic lab were that remote experimentation should not be considered a substitute for real experimentation and that real practical tasks were the most enjoyable (as opposed to developing code). Colwell et al. (2002) described the five main components underpinning these labs:

- The student's PC with a user interface and the remote lab client software
- A collaboration sever (video conferencing, application sharing, whiteboarding)
- A web server
- A lab server (control of the lab equipment and interfacing to the client)
- The remote lab software and hardware

Cooper et al. (2003) noted the lessons learnt were the importance of usability testing of the system before releasing it to a wider audience, the necessity for administrative software for multiple users (registration and booking of lab resources), collaborative communications software for multiple students at different locations working on a lab, and real time access to a lab as opposed to an off-line queued approach.

Esche (2005) discussed the establishment of a remotely accessible lab setup proposed for the undergraduate engineering program at Stevens Institute of Technology. The traditional lab had a procedure that involved the student undertaking some preparation for the lab work, a brief performance assessment of the student's ability to work in the lab from a safety and competence stand point, the hands-on experimental work and finally the data analysis and report. He felt one of the disadvantages with the traditional lab was the inability of the student to return later to the lab to do further tests. Often there is an excessive amount of unnecessary time spent in setting up the equipment for the experiments which often are recipe-type investigations; and often a lab session is simply impractical due to cost or logistics issues or safety concerns for the students. Hence, the Stevens Institute of Technology had set up a remote access lab which could be "accessed anywhere and at any time". The procedure followed can be similar to that of a traditional lab described above, but with much of the inefficiencies such as setting up equipment minimised. The students have been enthusiastic about the remote labs and requested that the program be extended to other courses.

Peretto et al. (2006) described the construction of a remote lab for electric and electronic measurement. The learner could access the lab through a standard web browser. The access to the lab was granted through the LMS (Learning Management System) server and thence the control of the experiment is conducted through a Lab Server (LS) that manages the data flow to and from the PC's that are connected to the experiment. Peretto et al. (2006) pointed out that the application is novel due to the minimal plug-in software that has to be downloaded; the high level of security of the learner's personal information; no source code needs to be rewritten due to the direct importation of the LabView VI software and any language can be used for the instrument control application. The main services provided by the LS software to the learner (on his PC) were as follows:

- Display of the virtual lab
- Display of the actual experiment
- Control of the experiment
- Creation of the experiment using a new LabView VI, for example
- Remote set up of the experiment using the learner's instrumentation bench at home

In conclusion, Peretto et al. (2006) noted that the advantages with this approach were that the learner could set up a remote test bench, verify that the physical circuit connections and layout were correct, before initiating the experiment. Importantly, the learner has actual physical contact with part of the equipment for the experiment.

In conclusion, Peretto, Rapuano, Riccio, and Bonatti (2006) remarked that there are considerable cost savings to be effected in training in instrumentation (industrial automation) by the sharing of remote laboratories and their expensive resources. Distance learners can achieve the appropriate level of practical experience by having access to these remote laboratories. They suggested that the current methods of teaching instrumentation courses area by web-based lectures, e-learning support for classical university courses, simulation of the experiments on the learner's computer at home and remote laboratories. They noted that e-learning technology has evolved with the following sequence of activities available: Online self study, online course with static visuals, audio/video conferencing in the presentation of courses, interactive synchronous e-learning classes, simulation of experiments and finally the highest level being practical experiments (presumably using remote laboratories and real equipment) (Peretto et al., 2006).

2.11.6 Difficulties with Remote Labs

There are numerous challenges in implementing hands-on laboratories as pointed out by Striegel (2001). He believed that the delivery of lectures, and homework materials through streaming videos, virtual classrooms and interactive web pages was effective but suggested that the challenge of providing hands-on lab training has not been examined in sufficient detail. He noted that an in-depth understanding of lectures is really only achieved once the student undertakes hands-on lab work.

He created a useful table summarizing the challenge of distance education-based lab training.

Table 2.5

Summary of Distance Education Lab Difficulties (adapted from Striegel (2001))

Issue	**Duplicated Setup**	**Simulation-Based**
Cost of equipment	High upfront	Low cost
Licencing	One per student	Shared licences
Remote Access	Always available	Possibly not available
Manpower Development	None	Possibly substantial
Setup	On-site support	Participants may require tech support
Maintenance	Fixing of faulty equipment	Remote access availability, tech support
Student Interaction	May work at Centre	Isolated from other students

In reference to Table 2.5, and as remarked earlier (Magin & Kanapathipillai, 2000), there is some conjecture as to whether simulation software is cheaper than real lab equipment. A duplicated setup is a lab local to the distance learning students and which is situated at a considerable distance away from the main campus. Simulation-based training is performed through the internet but uses simulation software and hardware. The author believes that the comments for the simulation-based lab could be extended to that of remote labs.

Colwell et al.(2002) reported that Cooper (2000) felt that in some respects the PEARL system was not able to “reproduce the gestalt of working on real experiments in the laboratory”. He did feel however that it should be able to achieve many of the learning objectives for lab work.

Albu, Holbert, Heydt, Grigorescu, and Trusca (2004) pointed out remote labs were not as effective for training engineering students for the following reasons: minimal experience is provided in handling real equipment; there are less real world problems such as loose wiring and electrical contacts and the student is shielded from connecting equipment up incorrectly. They thus suggested considering using these remote labs as a prelude to real laboratories.

Cooper et al. (2003) reported that in comparing the remote and local labs that the students still felt that a real electronics lab was preferable to the limited remote lab arrangement, mainly due to the delays in communications and the lack of immediate access to a tutor.

Auer et al. (2003) noted that one drawback with online remote labs is that the experiments are pre-determined and the variation limited. They suggested, as a result, that the learners' metacognition skills are not as well developed by remote labs as their knowledge and skills, for example.

Agelidis and Armarego (2005) indicated that an increasing number of engineering teaching institutions were using e-learning and remote lab technologies for providing practical training, but they felt this was a compromise approach. Agelidis and Armarego felt that the use of remote virtual lab environments may not be the best way for training engineers as it distances the student from the field environment and introduces another software layer between reality and the student. They indicated that problem and project-based learning approaches have been successful in providing a good engineering education in many countries and a hybrid approach of the above, referred to as an engineering studio approach, has been adopted at the School of Engineering and Science at Murdoch University, Australia and had shown particular promise.

Bonatti, Peretto, and Tinarelli (2005) described a remote lab that they had constructed comprising a student's PC and server. They asserted that engineering subjects such as instrumentation and measurement require lab activities. They questioned whether a student using only a web browser (and no physical equipment), as proposed by various researchers (Arpaia, Baccigalupi, Cennamo, & Daponte, 1997; Gustavsson, Olsson, Akesson, Zakrisson, & Hakansson, 2005; Taylor, Honchell, & DeWitt, 1996) could really achieve proper pedagogical results. As an alternative to remote labs, Bonatti, Peretto, and Tinarelli (2005) suggested using a low cost set of hardware devices that could replicate the more expensive instrumentation. They created a remote lab with a client unit comprising PC, appropriate software and web pages, an intelligent breadboard, associated microprocessor-based control circuitry and individual electrical and electronic components which the student would have to configure. This connects through the internet to a web server which also controls the lab instruments. This approach allowed the students to experiment with physical cables, electronic components and instrumentation as if they were in the real lab with the instruments.

2.11.7 Conclusions

Almgren and Cahow (2005) believed that the factors that were improving computer-based engineering education were a desire to increase active and discovery learning, to make lab facilities available to the wider community and to provide students with more meaningful practical experiences. They believed that the appeal for online labs is due "to the increasing demand for active learning and flexible education, and for the appeal of implementing techniques of learning via discovery" (Almgren & Cahow, 2005, p. 3). They noted the use of a single development environment such as LabVIEW, could enable the instructor to "quickly publish the front panel of any LabVIEW program for use in a standard Web browser" (Almgren & Cahow, 2005, p. 3).

Brown and Lahoud (2005, p. 69) noted the online remote labs offered the most "practical and real world experience." They continued: "…they seem to value the functionality and real world experience gained from using online labs. These labs offer both the look and feel of a real world environment, but do so at a cost that is reasonable to the online learner" (p. 69).

Zare (2000) remarked that one can get a useful education from an online university but he believed that it devalued the instructor in the learning process. He believed that it was imperative for the teacher to inspire the students by motivating them to learn and to place the materials into a larger context. He also doubted whether online learning would be able to totally replace the hands-on exercises conducted in laboratories. He concluded with the following comment: "Which is better: face-to-face learning or computer aided instruction? is the wrong question. The right question is, How do you best combine both approaches?" (p. 1106). Naef (2006) echoed these conclusions by remarking on an analytical chemistry experiment he did with students using a gas chromatograph. He felt that a judicious combination of real, virtual and remote laboratories was the optimum approach.

Finally, in considering the nexus with the associated lectures to the labs, Zimmer, Billaud, and Geoffroy (2006) noted that for success in this endeavour, it was important that there was a high quality tie up between the equipment or instruments, the PC-based servers and software and the pedagogical environment comprising courses and tutorials.

2.12 Challenges with E-learning and Blended Learning

Whilst there are undoubtedly significant advantages in using e-learning as a component of a blended learning solution, numerous challenges have been identified and these are listed below with suggestions made on how to address these.

Some specific limitations of e-learning and blended learning are listed below.

2.12.1 Administration of Distance Learning

Hentea, Shea, and Pennington (2003) listed administrative problems with distance learning which included ineffective organisation (e.g., poorly organised class schedule and resources).

2.12.2 Technology

In terms of technology, van Dam (2004) noted the following problems with e-learning programs:

- No universal standardisation
- Inadequate connection speeds for good quality transfer of the modules

Matthew (Hyder et al., 2007) observed that technology failures put some stresses on the e-learning experience.

Keegan (2005) noted technology challenges included low availability of internet connections for students and weak IT infrastructure for students in what he termed Virtual classroom Technology systems.

Hentea, Shea and Pennington (2003) listed problems with distance learning which included inflexible course and learning technologies (e.g., poor bandwidth constrains the operation of the video). They felt that more effective use should be made of software and hardware tools and techniques in distance learning for both faculty and for students.

2.12.3 Difficulty in Completing E-learning Programs

Admittedly, the difficulties in completing a course are probably more of a symptom rather than a cause, but due to the number of comments made about this in the literature, this has been listed as a separate item.

Research by O'Connor et al. (2003) with 375 respondents in the USA for a quantitative research project revealed the attrition rate for e-learning is estimated to be about 26% for corporate training (against a reported rate of 3% for classroom learning). Factors that contributed to e-learning completion were:

- Personal motivation (73%)
- Interesting learning interactions (40%)
- Mandatory company completion policies (29%)
- Online instructors/facilitators' follow up (16%)

The conclusion was that the attrition rate is not as high as previously thought, but that organisations must still work out ways to motivate e-learners and provide them time to learn. In addition, poor instructional design increases the probability of a higher attrition rate of participants. Encouragement and support is critical to keep the learners motivated to complete the work ("Lessons from the e-learning experience," 2002b).

Gilroy (2001) felt that learning is undertaken both through a social and experiential perspective. She noted further that the lack of recognition of this issue has been one of the major causes of the low enrolments and high attrition rates in e-learning. She went on to say that the emphasis of most e-learning programs to date has been on delivering content to the detriment of the other issues in training and the informal collaborative approach between learners is what makes the content far more powerful and presumably improves the completion rate.

Based on Gilroy’s comments, learning networks may be a way of improving the completion rate of e-learning programs. The conclusion from Allen et al. (2003) indicated that virtual communities of practice do serve as excellent learning networks. The main reasons being that they situate the learning in the workplace, provide just-in-time learning and content-specific solutions to problems. They also achieve excellent results due to employee interaction. Desanctis et al. (2003) indicated that video conferencing and electronic forums (such as online communities) can provide different levels of support for learning networks. The degree of benefit for the participants depends on how the environments are structured.

Sanders (2003) noted that from a pilot blended learning program which she set up for Cisco Certified Network Associated certification that the learners found it was difficult to remain in the course due to work demands and distractions and the learning being too intensive and rapid. She felt that a more thorough analysis of the audience, its needs and setting up “learning centres” (p. 127) were useful lessons to minimize these issues.

Serwatka (2005) pointed out that lack of instructor training, inadequate course design, minimal learner interaction and personal commitments were reasons for poor retention of students in online courses. She felt that addressing learning styles is one of the most important issues in retaining students and learning materials need to be adjusted to fit in with the more computer-oriented contemporary students. Faculty need to demonstrate far more interaction in terms of quicker responses to student requests and discussions. A blended format of learning should be considered. Finally, discussion forums and debates should be used to engage students and appropriate “ice breaker” exercises included.

2.12.4 Lack of Interactivity

One of the greatest challenges with remote training using the internet is the lack of interaction with the instructor (Anaraki, 2004; Tapscott & Williams, 2006). The difficulty of using real tools to demonstrate and provide practical hands-on exercises (such as working with real equipment) for the participants (Rossett, 2001) has been challenging especially due to the differences between the classroom and e-learning (Thurmond & Wambach, 2004).

Wang, Gould, and Fulton (2007) referred to Vrasidas (1999) who defined interaction as “the process consisting of the reciprocal actions of two or more actors within a given context” (p. 25). Wang went on to refer to four types of interaction. These are, as outlined by Moore (1989), learner-content, learner-instructor, learner-learner interactions. Hillman, Willis, and Gunawardena (1994) added the fourth one pertinent to the e-learning environment being learner-interface interaction, with the interface being the interposing tool between the course and instructor and the learners. There is some conjecture about the differences between interaction and interactivity. Thurmond (2004), drew on Wagner (1994; Wagner, 1997) and noted that interactivity is oriented around the technology used, whilst interaction is between people and groups.

Thurmond (2003) defined interaction based on descriptions from a number of other sources (Hillman et al., 1994; Moore, 1989; Wagner, 1994) as:

> ….the learner’s engagement with the course content, other learners, the instructor, and the technological medium used in the course. True interactions with other learners, the instructor, and the technology results in a reciprocal exchange of information. The exchange of information is intended to enhance knowledge development in the learning

> environment. Depending on the nature of the course content, the reciprocal exchange may be absent – such as in the case of paper printed content. Ultimately, the goal of interaction is to increase understanding of the course content or master of the defined goals (p. 4).

It should be noted that this is also a problem with conventional classroom lectures as pointed out by Scheele, Wessels, Effelsberg, Hofer, and Fries (2005) who researched the use of mobile devices for the students to increase the level of interactivity. B. Muirhead (2004) added to this by remarking on the need to create a consistent level of interaction that enables real learning and enhances a community atmosphere. Smith and Taveras (2005) noted that student satisfaction is closely correlated with interaction from the instructor and referred to a number of other supporting sources (Shea, Swan, Fredericksen, & Pickett, 2001; Trippe, 2001).

Baab (2004) referred to Wagner (1997) who indicated that in the context of distance learning, "few topics have generated as much debate as the construct of interactivity". He went on to say that "interaction can be designed to increase participation, develop communication, receive feedback, enhance retention, increase motivation, negotiate understanding and support team building" (Baab, 2004, p. 35). Baab (2004) suggested that success in distance learning (which included online learning) is predicated by the degree of interactivity.

Keegan (2005) felt that one of the main challenges for e-learning is the lack of human contact (or face-to-face contact) or interacting between people. For example, body and eye language were no longer a part of the communication process as with the traditional classroom. With e-learning, an additional barrier is created between the teacher or facilitator and the learning participants. Matthew (Hyder et al., 2007) concurred by remarking that a significant drawback with online learning was the inability to observe the participants' body language and minimal eye contact and the inability to build rapport as with a face-to-face session.

Kenny (Keegan et al., 2005) felt that interactivity is critical to the success of the synchronous e-learning course. He made a few suggestions for improving the level of interactivity:

- Turn bulleted lists into a series of true and false questions to be answered by participants
- Replace keywords with blanks in the course manuals. Participants will have to fill these in during the presentation
- Perform evaluations online as the material is presented
- Request the participants to summarise the key points for each section of the presentation
- Require participants to diagram materials covered using the electronic whiteboard
- Interact with participants by presenting problems to them to solve and then picking a volunteer to explain to the group
- The e-learning session should be planned with explicit notes for the instructor
- Ensure all course materials are carefully numbered (e.g., slides/pages) so that participants know exactly where they are and can thus interact more freely with their peers
- Assign homework for the participants where possible

Keegan (2005) indicated that interactivity in terms of learning was understood to be communication between an instructor and students, as compared to the one-way instructor to students communication which is often seen in a physical classroom.

In commenting on an online software engineering course, Pankratius and Stucky (2005) recommended maximising the interaction between students and instructors especially "for diagrammatic techniques" (p. 640).

Downes (2004) made some suggestions on how to achieve interactivity in a web conference. She felt that questions and answers are the most important for interactivity. These should be built into the presentation and also at the end of the conference. A few pre-scripted questions may be useful to get thing moving with the participants. She indicated that text questions should be submitted through the web conference as these are non-intrusive. Preferably someone other than the presenter should answer these on the fly. Audio questions are also very powerful but the presenter must be able to handle the questions and a possible overload from individual questioners.

Hentea, Shea, and Pennington (2003) listed problems with distance learning which included inadequate interaction (e.g., instructor to students and between students). They felt that the level of interactivity, customisation for specific students and creation of learning communities should be increased.

Muirhead (2004) made a few suggestions on improving interactivity and these included:

- Promote critical thinking
- Provide relevant and engaging lectures
- Place online one's biography
- Praise students quality work
- Weave in stories into the class discussions
- Make the online interaction flexible

Loch and McDonald (2007) noted the comments from others (Guimaraes, Barbastefano, & Belfort, 2002) that distance learning e-learning environments do not always provide effective tools for interacting in mathematically oriented disciplines mainly from the point of view of typed communications. They successfully tested MSN Messenger together with an electronic ink function (both of which are free and easily available) and allowed for excellent interaction with diagrams, symbols and graphic charts that could be quickly created and easily modified.

Higgins and Keightley (2007) produced a useful table summarising the different types of e-learning based on interactivity required of each.

Table 2.6

Different Levels of Interactivity Based on Types of E-learning (Adapted from Higgins & Keightley (2007))

Tier 1 learning (low interactivity or graphic one-way communication)	**Tier 2 learning (moderate to high interactivity – has some degree of learner to computer interaction)**	**Tier 3 learning (high interactivity – includes learner to learner and learner to trainer interaction)**
Powerpoint presentation, learning on a personal digital assistant, e-books, podcasting, videotape, audio tape.	Interactive resources, quizzes, tests, reflective learning, games, simulations, demonstrations.	Virtual classrooms, streaming media, group games, video conferences, chat groups, emails, discussion lists, blogging, wikis, moblogging.

One area where learners can obtain greater interaction with e-learning is in working on hands-on training experiments on real life equipment in remote labs. This has the potential to transfer greater depths of knowledge than possible in simple collaborative discussions and is discussed in the earlier section 2.11.

2.12.5 Poor Quality E-learning Resources

There have been a number of comments about poor instructional materials in e-learning courses (van Dam, 2004). Henderson (2003) felt that the quality of e-learning was degraded by the use of poor learning materials and instruction compared to that of the classroom environment. Anaraki (2004) indicated that only using text-based materials, very little “rich content for good understanding” (p. 59) and “unstructured and isolated” (p. 59) posting of content and instructions for learners by instructors on the learning management system also contribute to a low quality experience. This assertion was supported by others who remarked that “online information is merely text put into an e-learning package” ("Lessons from the e-learning experience," 2002b, p. 19). Allen (Boehle, 2006) complained about the emphasis “on content instead of the learning experience” (p. 30) which was surely what the objective of e-learning was hoping to achieve. The other issue Allen made was that e-learning should be focusing on skill transference and not simply knowledge retention.

Keegan et al. (2005) reported on an experiment conducted by Krogstie (2005); where it was felt that virtual classroom sessions can be perceived to be monotonous and boring. Presumably this is a reflection on the quality of the e-learning resources and materials; although it could probably be argued this is also an indictment on the lack of interaction for the learners.

There have been questions raised about the poor quality that many users of e-learning comment on, in the research as evidenced by Schank (2002). Schank added that whilst he believed that a considerable amount of e-learning is unacceptably poor, he felt that there are six attributes of measuring (and thus in knowing how to improve) the quality of a training course. These include "failure" (when the course delivers unexpected results to the participants); the requirement to use "reasoning" in proceeding through the course; "emotionality" (the need to provoke an emotional response by the participant); "exploration" by the participants; "practice by doing"; "observation" (the course allows the participant to view things for themselves) and "motivation" (how much does the course motivate participants to complete the course).

In conclusion, Teasdale (2007) remarked that whilst he understood that each learner in an audience has a different learning style, in a corporate environment it is not practical to customise training materials to cope with each one.

2.12.6 Instructor Absenteeism

Smith and Taveras (2005) discussed a little noted fact about many instructors being absent from a considerable amount of e-learning interaction with their students. They stated that there is probably more work for the instructor in online training than with the traditional classroom, and the lack of face-to-face contact with learners, makes instructor absenteeism harder to notice. As has been discussed earlier, student satisfaction with e-learning is tightly related to interaction with the instructor. Smith and Taveras suggested improved instructional design, new technical tools and perhaps more obviously, a more conscientious instructor, as being possible solutions.

2.12.7 Difficulty in Working in Teams in an Online Environment

Dool noted (2007) that the use of teams by organisations in the USA over the past few years has grown significantly. He quoted an estimate which held that one third of American companies with 50 or more employees would place half of them on self managed teams after 2000. He noted the main causes of conflict as revolving around "expected outcomes (grades), roles, style, values and resources (time), or basic personality conflicts". He believed that the miscommunication between online participants to be exacerbated by the asynchronous communications between participants. Real time intervention and holistic viewing of the conflict is far more difficult with different time zones and virtuality of presence. He made some suggestions on how to prevent team conflict by clearly setting expectations at the outset of the course, stating the objectives and requirements of the team assignment via the syllabus, setting up a team charter, and getting the instructor to assign the team members, actively monitoring the activities of the team and then quickly and appropriately dealing with conflicts.

2.12.8 Online Testing and Assessment

Eatchel (2007) pointed out that there is an increased risk with learners cheating in tests in e-learning compared to the traditional paper-based approach and this has to be reduced by expanding the online test bank as well as standardised test item development. Increased emphasis in this area will improve test validity, candidate fairness and protect against legal challenges to the validity of the results.

Hentea, Shea, and Pennington (2003) felt that poor assessment of student learning (e.g., inappropriate testing) could be addressed by ensuring classroom and online learning standards were equivalent.

Ó Suilleabháin and Goggin (Keegan et al., 2005) made the point there are two fundamental types of assessment for use with live e-learning. Formative assessment is used to modify the instructing or learning as it is conducted or to plan how it should be arranged. Summative assessment only gives feedback at the end of the whole instructing experience. Generally, assessment for e-learning is formative and this may go some way to addressing the problems with inappropriate conduct as it would be done over a number of sessions and the assessor, by interacting directly with all participants, could get to know them considerably better as far as their knowledge levels.

2.12.9 Miscellaneous Issues

Vrasidas (2004) listed some barriers to teaching online as lack of skills and knowledge in constructing and teaching online; minimal support and training for designing e-learning courses; the new approaches to online teaching appear to contradict the traditional face-to-face instruction; minimal tools to construct e-learning programs; e-learning infrastructure is still in its infancy; time allocated to online teaching is too short and finally, remuneration for faculty to move to e-learning is inadequate.

Van Dam (2004) noted the following miscellaneous problems with e-learning programs:

- A lack of investment in preparing these training programs
- Stated ROI's in using e-learning are not necessarily valid for many organizations

Other issues remarked upon by Matthew (Hyder et al., 2007) were that learners have a shorter attention span; there is minimal sharing of ideas and a reluctance to do homework; the difficulty for the instructor in managing the myriad of tasks such as software tools, timeliness and engaging the learners.

Keegan (2005) listed what he believed were typical disadvantages of what he terms as VCT (Virtual Classroom Technology) systems:

- Cultural difficulties in using e-learning
- Reduced control of course participants

Hentea, Shea, and Pennington (2003) listed inadequate student preparation (e.g., inappropriate student types and computer hardware/software) as a problem but this could be addressed by improved motivation of students to achieve successful outcomes to their distance learning studies. More effective use should be made of software and hardware tools and techniques in distance learning for both faculty and for students. Finally, they made the point that intelligent agents should be used to provide “more automated personalized feedback to cater for student’s individual needs.”

2.12.10 Simply Not Appropriate

Finally, it was pointed out ("Lessons from the e-learning experience," 2002b) that e-learning may not be the solution to a particular training requirement, but may need to be assessed with other solutions such as a blended approach.

According to van Dam (2004), specific areas where e-learning appeared not to work well using current technologies were:

- Exercises which require significant face-to-face contact such as negotiating and sales training
- Lab exercises which require access to real hardware which one can work with such as test rigs/instruments/valves/electronic test equipment. The proposed research examines this issue in the context of blended learning and remote labs.

In a discussion on Texas Instruments (TI) outsourcing training to another company, Collins remarked ("Case study: Outsourcing plays a vital role at Texas Instruments," 2004) that the supposedly “high tech people ” had minimal interest in e-learning. “TI engineers prefer to get information via technology, and prefer to learn with their peers in a classroom setting” (p. 40).

2.13 The Future of E-learning and Blended Learning

It is worthwhile examining future trends in e-learning and blended learning under the topics of disruptive technologies, mobile learning, telepresence, university-based education, top ten training trends and some of the overall trends in e-learning (and blended learning).

2.13.1 Disruptive Technologies

Hedberg (2006) emphasised the need for a revolutionary move away from simply reproducing the classroom approach if e-learning is ever to be successful. Hedberg referred to the need for Christensen's (1997) "disruptive innovation". This is technology, which takes over from the existing dominant technology despite being radically different and initially underperforming the current dominant technology. A good example here is digital photography taking over from the film-based approach. Hedberg believed that e-learning disruptive technologies could include digital repositories, learning objects, games, three dimensional virtual worlds and engagement (with learning). He referred to Metros (2003) who believed that "it is possible ….to create environments in which the learner is experiencing views of the world that are multimodal and require a range of literacies, not only to understand the different representative descriptions but also to employ tools with which the learner can construct and communicate their ideas with others" (Hedberg, 2006). He concluded by noting that it is vital to create a learning space for the learner which moves them from being a passive participant towards an active maker of their own experience.

2.13.2 Mobile Learning

Salz (2006) indicated that she felt there were considerable opportunities with mobile learning where the instruction is moved from the classroom into the learner's environment, wherever that may be. She listed a number of portable devices that are available for downloading audio products to, such as Apple iPods, MP3 players and PDA's such as Blackberries, and which can be used for presenting short courses. Higgins and Keightley (2007) noted the increased mobility with broadband access, wireless and use of PDA's.

2.13.3 Telepresence

Lichtman (2006) noted that telepresence will dominate video conferencing in the future and it is believed will have an enormous impact on synchronous e-learning. He defined telepresence as the "science and art of creating visual conferencing environments that address the human factors of the participants and duplicate, as closely as possible, an in-person experience" (p. 2). He listed a number of improvements over traditional video conferencing but in the context of this research the key ones are considered to be "the absence of visible technology" and "immersive and /or mirrored environments where participants feel as if they are in the same physical space" (p. 2).

2.13.4 The Future of University-based Education

MacDonald, Stodel, Farres, Breithaupt, and Gabriel (2001) suggested that due to the benefits of e-learning including such items as flexibility, cost effectiveness, a vast selection of subjects, an active and a dynamic educational environment and heightened interaction between learners, there is a need required for a new model for universities to harness these benefits, especially for working adults. They have called this the "Demand-Driven Learning model" and it comprised five components:

- Consumer demands ((1) high-quality content, (2)delivery and (3)service)
- Superior structure ((4) anticipation of the needs of the learner, understanding what motivates learners, a collaborative learning environment)
- Learner outcomes ((5) lower costs, minimal travel to venue, superior learning outcomes)

2.13.5 Top Ten (and more) Training Trends

Steed (1999) listed below what he believed would be the top ten training trends, presented in the context of the two significant forces impacting on the learning today, namely that of rapid globalisation and fast technological change:

- Increasing skill requirements will be driven by the fast moving technological change

- The workforce is becoming increasingly educated and more diverse (in terms of women and minorities)
- Restructuring in the corporate environment is changing the duration of jobs and smaller companies are providing more training opportunities
- Organisational training departments will continue to contract as companies increasingly outsource this type of work
- Technology will increasingly add value to the current mainly classroom-based training offerings
- Training departments are increasingly required to purchase training from outside the organisation (outsourcing) and to manage this in terms of acting as a broker
- The training department will increasingly focus on the outputs of training in terms of performance improvement rather than training for training's sake
- There will be an increasing emphasis on systems for measurement of using training to produce measurable results using "high-performance work systems" (p. 252)
- Companies will be increasingly knowledge-based and "learning organisations" (p. 253)
- There will be an increasing emphasis on people as a company's most important asset with improved systems to automate recording of an employee's skills and knowledge.

In the context of this research, it is important to see how these training trends translate into blended learning and a review of how this is examined by Bonk, Kim and Zeng is presented in the next section.

2.13.6 Blended Learning Trends and Predictions

In a recent survey, Bonk, Kim, and Zeng (Bonk & Graham, 2006) felt that there were ten key trends with blended learning. First, there would be more use of Personal Data Assistants in driving more mobile learning. Second, there would be more use of visualization and hands-on activities (as espoused in this thesis). Third, the learning would be more learner driven and oriented. Fourth, there will be considerably more collaboration and learning with one's peers. This was also mentioned many times in the results as an important method of learning. Fifth, there would be more enthusiasm for real world experiences. Again, this was mentioned many times in the commentary of respondents to the survey. Sixth, work and learning would be interlinked. The importance of on-the-job training was mentioned as a key learning approach for engineers and technicians by many respondents and linking e-learning and blended learning to the training process would be most effective. Seven, time scheduling of training would be less important. This was perhaps too abstract for more respondents to follow as this was not mentioned. Eight, blended learning would be the main designation for all learning. Again, not much was known about blended learning; hence this was only mentioned occasionally. Nine, the instructor would move from a sage on the stage to a guide on the side (as the cliché goes). This was emphasized by many respondents, in driving their own learning and discovery. Finally, the suggestion was that there would emerge blended learning specialists, resources and sites. There was not much evidence of this in the research, as this concept is relatively foreign to most engineers and technicians.

2.13.7 Miscellaneous Trends

Higgins and Keightley (2007) made a few further suggestions on how e-learning will develop in the future. These included:

- Increase in numbers of learners and courses
- Decrease in costs to develop e-learning
- Greater synergies between business and traditional educational institutions in terms of provision of e-learning solutions
- Improved quality and personalisation of e-learning.

2.14 Gaps in the Literature and Research Questions

It is instructive to examine recent research (including doctoral) which compares e-learning, classroom and blended learning, to locate possible gaps in the literature. This expanded on the earlier discussion on background research on blended learning (in section 1.4).

Laurillard, quoted by Jones in Bonk and Graham (2006), encouraged further research into blended learning by saying:

> ….we as academics build a body of knowledge on how we could make best use of technology in learning. There is not enough research evidence on which to base conclusions on the efficacy of blended learning, but this case study goes some way to fill the evidence gaps. There is clear evidence presented in this case study that a blended solution works better than an entirely computer-mediated environment. (Bonk & Graham, 2006, p. 192)

As Linquist, quoted in Bonk and Graham (2006), remarked under the heading of research opportunities:

> The outcomes of learners in blended learning, as well as those who complete their program exclusively in the two component delivery systems, classroom and online, provide a research opportunity to assess the comparative learning among the three deliveries of learning (Bonk & Graham, 2006, p. 233).

Kirkley and Kirkley, quoted in Bonk and Graham (2006), supported this with the remark, commenting on a form of blended learning:

> In order for these systems to be effective at improving learning and strengthening performance, the stakeholders in the learning process must be educated about the possibilities and trade-offs for effectively implementing them. As part of this decade-long effort, several research and development activities must continue to advance (Bonk & Graham, 2006, p. 546).

In the context of ROI and measurement, they added that:

> Much of the research in the field is focused on how to make the technology work or be usable. Learning scientists must begin to push the technologists for features that matter to

> learning. The industry as a whole must begin to explore the return on investment of these technologies (Bonk & Graham, 2006, p. 546).

Jackson (2000) compared the results of taking a Project Management course using e-learning technology (asynchronous) or the traditional instructor-based method and found that the web-based technique was at least as effective as the instructor led method. 132 participants from ten countries successfully completed the study and were randomly selected from a web-based promotion. She used a Kruskal-Wallis test to analyse the results. Jackson (2000) suggested further research needed to be conducted on long term retention of learned skills (presumably from these programs). She also suggested that team training sessions should be conducted rather than on an individual basis and the work performance related to the training programs.

P.M.P. Muirhead (2002) investigated whether global maritime education and training can improve traditional practices by using new technology (such as e-learning). A total of 90 responses were received to his survey. Descriptive statistics were used to analyse the results. He indicated further research was required into the use of computer simulators in assessing maritime personnel's competence.

Boyle, Kolosh, L'Allier, and Lambrecht (2003) compared five groups using a common asssessment: blended learning in three variations (text objects from a textbook, instructor-led or an instructor-led custom course), e-learning and a control group who received no training. The results indicated that there was a significant improvement of blended learning over e-learning; but not much difference between the blended groups. E-learning demonstrated a significant improvement over the control group. They suggested further research in using practical scenario-based exercises which focussed on the real working situation "in technology training settings to match a wider variety of software features and related business content topics" (p. 159).

Dodero, Fernandez, and Sanz (2003) compared blended learning to e-learning in a computer science subject and found that participation improved with blended learning (due to the classroom sessions) but did not improve the overall academic results. The e-learning used appeared to be mainly asynchronous web-based with electronic documents and study guides posted on the web for download (including an online chat forum for discussions). The question is whether synchronous (as opposed to asynchronous) e-learning would have made any difference to the results.

Esch (2003) investigated 4000 office workers to survey the impact of e-learning versus classroom training for improving their proficiency in using a new building wide telephone system and concluded that the e-learners performed considerably better in terms of skill achievement, technology acceptance and satisfaction and cost avoidance behaviour (such as saving the firm money as a result of the training). The problem the author believes with this methodology of gathering data is that the selection of subjects for either group would be biased (as it was "self selected"). Esch (2003) recommended further research for the application of e-learning in training end-users in new technology systems.

B. Muirhead (2004) noted that further research is required in interactivity so that teachers could better prepare their online courses. This is especially in the area of individual differences in the facilitator skills that can impact on the quality of interactivity.

Jones' (2004) research indicated that executives do not perceive e-learning as favourably as classroom training. She performed a quantitative quasi-experimental study with 117 executives using an asynchronous e-learning model against that of 97 executives using classroom style training. She used thematic analysis, Chi square and t-test analyses on the data. She recommended further research on demographic profiles of learners, culture and technology (such as sychronous e-learning) used.

Banks (2004) compared a group of working adults engaged in classroom, online (asynchronous) and blended forms of learning. He applied Kirkpatrick's levels of training analysis to determine knowledge acquisition. The statistical analysis used indicated no differences between blended and classroom content forms of delivery. Surprisingly, asynchronous online delivery had an improved reaction from participants compared to that of blended learning and classroom instruction. He suggested further research in the demographics of and learning styles of e-learning, instructors' reactions and effective assessment techniques for blended learning.

Tai (2005) used a case study approach and examined how e-learning is applied at three multinational companies (GE, IBM and Verizon). He concluded that e-learning had made a significant difference to each company in terms of effectiveness and method of learning compared to the more expensive face-to-face approach. A few of the key attributes he listed for successful implementation of e-learning included: strategic vision, corporate support, quality of content, accountability of learners and instructors and a well defined measurement system. Tai did not make any specific recommendations for further research.

Mascuilli (2004) compared an online and classroom version of a university mathematics course using a simple statistical t-test of differences of means of grade point averages (GPA's) using a two-sided hypothesis test. He found no statistical difference in the grades between the online and the classroom version. It would appear that a practical limitation of this research is that the participants of both courses would have self-selected and this thus would not be a random selection.

Bernard et al. (2004) performed a meta analysis on distance learning (referred to as DE), including synchronous and asynchronous techniques versus classroom learning, and "found some evidence, in an overall sense, that classroom instruction and DE are comparable…" (p. 42/65). They were however perplexed at the wide variability in the data, which cast some doubt over even these findings, and they made some disparaging remarks about the poor state of distance education research. They suggested further research in comparing distance learning with classroom-based instruction but in varying only "one of a host of instructional features being varied across the treatments" (p. 41/65), to avoid the errors in earlier research.

Thurmond (Thurmond & Wambach, 2004) in a study of interaction in online education noted the need for more study in the area of interaction and e-learning especially in the types of module designs. Complex and simple module designs should be compared.

Junaidu and Al-Ghamdi (2004) compared face-to-face and online teaching of a series of computer science courses and found that online courses provided better results, in terms of the final grades. However, it was unclear whether this was simply due to the student's innate ability or the additional lab work, quizzes and homework provided in the online courses. The two authors expressed doubt as to whether it was to do with online versus face-to-face courses. More research is thus required to determine what made the online courses more effective.

Neumann and Carrington (2007) produced an international synchronous e-learning session for 450 learners situated on 41 university compuses in Australia and New Zealand in March 2006. They then drew each group of participants into local discussions, thus creating a blended approach. They felt that overall the training was successful but suggested that more research should be done in understanding the impact of multi-modal characteristics on the learning process.

Sitzmann (in press) used a literature review of 96 studies to compare web-based instruction to classroom instruction and found that classroom instruction to be more effective for teaching declarative (cognitive and structural) knowledge when learners were randomly assigned to courses and more instructional methods were used for the internet-based format, a more active format was used and additional practice was used. This is not really a fair comparison. Learners expressed equivalent reactions to both methods of instruction. Web-based learners also acquired greater levels of knowledge (compared to classroom instruction) when they had greater levels of control (pace, content or sequence) in their learning process. In line with Clark's (1983; R. E. Clark, 1994) research, they found that when the same instructional methods were used in the instruction that there were no differences. They found that blended learning was more effective than classroom instruction for both declarative and procedural knowledge. But learners reacted more favourably towards classroom learning than the blended form. They recommended further research into comparing the different methods with far more detailed descriptions and also a greater depth into "which specific learner control options online learners prefer and which facilitate learning" (p. 33).

The gaps in the research reveal a few possible research questions summarised briefly below:

- Are there differences in the retention of learned skills through the different programs such as e-learning, blended learning and classroom training?
- What is the efficacy of computer simulation against that of classroom training in competence assessment of maritime personnel?
- As part of blended learning, is synchronous e-learning able to provide an equal or improved reaction, learning experience and ROI from the participants as against classroom training?
- How do the demographics of participants impact on the results achieved with e-learning and blended learning?
- How effective are assessment techniques for blended learning against that of the classroom?

2.15 Conclusion

Prendergast (2004, p. 3) indicated that it was vital to understand that "the educator is the trigger to foster or stimulate online learning, not the technology. If used appropriately, technology is just a tool that permits facilitating educators to encourage learning in a flexible imaginative way." Overall, current research identified in this review has indicated that blended learning, with synchronous delivery of e-learning, is capable of delivering equivalent results to that in the classroom. The need for a good instructor and the application of outstanding pedagogy no matter what media is being used, is again emphasized. However, the unanswered question is whether blended learning in an industrial automation environment using a hands-on learning approach can improve the reaction, learning and ROI over that of purely classroom instruction or of synchronous e-learning alone. And more importantly, what particular mix of components in the blended learning solution, will achieve these results. This is examined in the following chapters, with the proposed methodology outlined in the next chapter.

Chapter 3
Research Methodology

3.1 Introduction

When defining the methodology to use, it is important to base this on proven techniques and instruments used in past research. A combined quantitative and qualitative approach was employed in the research methodology.

The research question which the methodology had to test was whether blended learning will improve the reaction, achievement and return on investment (ROI) of industrial automation training compared to that of only through the classroom or e-learning. Blended learning comprised both classroom instruction together with synchronous video conferencing with an emphasis on a hands-on experience or "learning by doing" in the industrial automation environment.

Based on the research discussed in previous chapters, this proposed work was structured around a worldwide web-based survey with a resultant 2,425 respondents. It should be mentioned that it was originally planned to extend the web-based survey with a qualitative survey of 60 respondents and to conduct separate e-learning, blended and classroom sessions; but the large volume of responses to the original survey made this impractical as there was an enormous amount of unexpected additional data made available for assessment.

The technique of triangulation was applied in arriving at the conclusions due to having both qualitative and quantitative sources of data.

In the following sections, the hypotheses tested, previous methodologies and instruments, proposed instrument, sample used, measures and quantitative and qualitative data analysis are examined.

3.2 Hypotheses

There were four hypotheses that were tested:

H_1 Synchronous e-learning produces an improved student reaction compared to that of classroom instruction alone.

H_2 Remote labs or simulation software are not used extensively as part of e-learning courses for engineers.

H_3 There is currently no extensive use of e-learning and blended learning for engineers and technicians.

H_4 There is significant growth in blended learning courses for engineers and technicians.

Whilst the hypotheses above had to be tested, the survey had also to be designed to extract as much information about the state of e-learning and blended learning in the engineering and industrial automation area, as the degree of use (of the e-learning) technologies in this particular arena was unknown due to the paucity of literature considering this issue.

It should be emphasised that there was some uncertainty as to what degree the respondents in the industrial automation area would be familiar with e-learning (and indeed blended learning) and some caution had to be exercised in drawing up the survey in not assuming that the respondents have too much prior knowledge on e-learning (and blended learning). It was however presumed that the survey respondents would be familiar with classroom instruction and their general training needs.

The intention of the survey was to maximise the number of actual learners in e-learning and blended learning activities (as opposed to the human resource or training departments, for example). It was felt that individuals from a training department or training vendors who organized or sold training solutions, would perhaps give biased opinions based on what they believed the recipients should feel about the training. Most of the survey instruments identified were designed for those participants who had completed a specific e-learning or blended learning course shortly before filling in the survey (e.g., Appendices B and C). It was also important to ensure that only those participants who knew what e-learning or blended learning meant, completed the entire survey; and after general questions of general training requirements a graceful exit point was designed for the others.

A survey was done using the web on a worldwide basis (as opposed to any one individual country) to attract as many respondents as possible, as it would appear that the number of technical professionals using both automation equipment and applying e-learning or blended learning was limited. This provided information on the degree of use of blended learning and e-learning in the industrial automation business sphere.

It was anticipated that most of the respondents (80%) would be from the USA / Canada / UK / Ireland / South Africa / Singapore /Malaysia / Australia and New Zealand due to the focus of the database used, with the remaining 20% sourced from the rest of the world.

3.3 Previous Methodologies and Instruments Used

A number of instruments were examined such as that from P.M.P. Muirhead (2002) who investigated "A study of the impact of new technology and teaching methodologies on global maritime education and training into the 21st Century" (p. 310). Whilst his instrument examined computing and teaching resources in some detail, it did not explicitly compare e-learning, classroom learning and blended learning and being a few years old it has lost some relevance to the new e-learning technologies appearing. For example, it referred to CBT (Computer-based training), which is a term not used as extensively as e-learning or online learning and perhaps has connotations of mainly computer-based training using CD's and DVD's, which as pointed out in section 2.2 are not as popular today. Fresen (2005) provided an instrument which measured the students experience in terms of Kirkpatrick's reaction with WebCT at a major campus in South Africa. However this was aimed at the overall experience of a learning management system (LMS) and was not particularly suited to corporate education.

There were however a number of survey instruments that were partially appropriate to this research. These included:

- Automation training and certification metrics from Arcweb derived from an email communication with Wilkins (2007)
- Balance Learning Training Survey 2006 Blended Learning Options
- The Future of e-learning in corporate and other training settings by Bonk (Kim et al., 2006)
- IDC Technologies (the author's company)

The Arcweb survey was focussed on the industrial automation area, as this is where this firm works in terms of research on manufacturing. The Bonk survey was suitable from a learning (especially e-learning and blended learning) point of view, as this was the focus of this research.

It was considered imperative from an accuracy point of view in completing the survey and maximising the response rate to keep the process of answering the questionnaire to about five to seven minutes in duration and to advertise this fact vigorously (so as to maximise the response rate).

The instruments are discussed below and the most appropriate questions from each one identified and placed into a final suggested form, as presented in Appendix B. A comment for each survey question precedes the actual question. For brevity, the source of each of the questions is identified in parentheses in the comment preceding the survey item. If there is no note indicating the origin of a particular item in the instrument, it has been developed by the author.

3.4 Proposed Survey Instrument

Preamble to the survey

Comment

Part of the preamble below was taken from a survey prepared by Wilkins (2007).

Preamble

The highly skilled engineering and technical workforce in most production environments is getting older and in many cases retiring and leaving for good. High quality training is essential to maintain production and availability and most importantly, to improve your salary aspirations and job satisfaction. New techniques such as online training (or e-learning) and blended learning (a mix of online learning and classroom instruction) are making a significantly impact on training in business and we believe soon, the engineering and industrial automation environment and this research investigates ways of applying this to improve your skills and know-how quickly, effectively, enjoyably and at a lower cost than traditional classroom training.

A. Background Information on You and Your Organisation

Items 1 and 2 - Comment (IDC Technologies)

This was considered a useful engineering job level and function description and was used in preference to the other more human resources oriented categorisation in the other instruments. This categorisation has been used successfully in an earlier paper-based survey. There is some confusion between the technician and engineer job titles; so these two items were combined. As will be seen later in the survey results, there was some confusion between the level and function of the job.

1. **What best describes your position? (Please select the appropriate level)**

Level (select One)

○ Management

○ Supervisor

○ Engineer/technician

○ Trades

○ Operator

○ Other

2. **What best describes your job function (please select the appropriate function)?**

○ Corporate/Administration

○ Engineering

○ Human resources

○ Maintenance

○ Operations

○ Purchasing

○ Quality Control

○ Research and Dev.

○ Training

○ Other

Item 3 - Comment (Bonk)

This was useful to identify any variations between male and female use of e-learning and blended learning. Due to the preponderance of males in the engineering field, it was likely that the responses would be predominantly male oriented.

3. **Please indicate your gender.**

○ Male

○ Female

Item 4 - Comment

It was useful to gauge the use of new technologies against age of respondent. It was anticipated that there might be some relationship between youth and use of the newer learning technologies.

4. Select the age group that you fall into:

○ Below 30 years

○ 30 years to 50 years

○ Over 50 years

Item 5 – Comment (Bonk and some items from Arcweb)

Bonk's list was supplemented with a few items from Arcweb. This is a fairly standard breakdown presumably generated mainly from the international SIC coding scheme.

5. What is the primary focus of your organisation? (Please select the best fit)

○ Agriculture, Forestry or fishing

○ Communications (advertising, publishing, entertainment, media)

○ Construction or building

○ Consulting or contracting

○ Education

○ Financial Services, banking, legal, insurance or real estate

○ Government/Public administration

○ Health or medical services

○ Food, hospitality, travel, tourism, or recreation

○ Industrial or manufacturing

○ Information technology or technology services

○ Military

○ Mining

○ Non-profit organisation, foundation, or association

○ Oil and Gas

○ Pharmaceuticals

○ Public utilities (e.g. power, telecommunications, water,waste)

○ Pulp and Paper

○ Processing (e.g. minerals, beer, chemicals or food)

○ Refining

○ Semiconductor

○ Transportation (railway, shipping etc)

○ Wholesale/distribution/retail trade

Other:__________

Item 6 – Comment

This was useful to see whether there is any correlation between the size of an organisation and undertaking advanced learning initiatives. The research confirmed some interesting relationships.

6. How many people are employed in your organisation ?

○ Select here 1-100 ○ 101-500 ○ 501-1,000 ○ 1,001 – 5,000

○ 5,001 – 10,000 ○ more than 10,000

Item 7 - Comment (IDC Technologies)

This item gives an excellent breakdown on education level and it is thought that there may possibly be a relationship between this and the use of e-learning and blended learning. Some respondents may regard it as slightly offensive but the overall tenor of the survey should hopefully still any fears in this regard. There were some concerns raised about those who had almost (but not) completed their qualifications; and who would as a result be incorrectly categorised.

7. What is the highest level of education you have completed?

○ Some high school (or less)

○ High school graduate

○ Vocational/technical college/TAFE

○ University graduate

○ Advanced degree (Masters or above)

Item 8 - Comment

This provided a breakdown of locations of respondents and was useful in identifying whether there were differences in the take up of these modern learning technologies on a country-wide basis. It is arguable how useful this regional classification is; for example, there is a vast difference between Australia and Malaysia in survey characteristics. However doing it by country would have added complexity and additional time in completing the survey and it was elected to keep the simple classifications as above.

8. In which region of the world are you located in your job today ?

○ North America

○ Europe

○ Asia Pacific

○ Latin America

○ Middle East

○ Africa

B. Your current training status

Item 9 - Comment

It is presumed that most of the respondents would be learner/attendees in the training. This would be a useful check to ensure that this is indeed the case.

9. Please indicate how you participate in training;

○ As a presenter/trainer

○ As a learner/attendee

○ As both

Item 10 - Comment (IDC Technologies)

There was possibly some correlation between a department's training budget increasing and thus having more money for newer technologies such as e-learning. Or perhaps, a constriction in budget meaning training which is perceived to have lower costs (such as e-learning) would be more actively sought out.

10. Over the next few years, do you anticipate an increase or decrease in your department's overall technical training budget ?

○ Increase

○ Decrease

○ Will remain about the same

○ Uncertain

Items 11 and 12 - Comment (IDC Technologies)

This was modified slightly to focus on only the respondent's education as opposed to those who worked under them, as he/she may not be fully *au faux* with the details here and there would be errors arising as a result.

11. Please rate the overall quality of the formal education that you have received from the following sources:

	Poor		Average			Outstanding	
	1	2	3	4	5	6	7
Trade/technical schools	○	○	○	○	○	○	○
Universities	○	○	○	○	○	○	○
Vendor's training	○	○	○	○	○	○	○
On-the-job training	○	○	○	○	○	○	○
Distance learning	○	○	○	○	○	○	○
Other	○	○	○	○	○	○	○

12. If you selected OTHER from the previous question, please indicate briefly what it is.

Define: Other ___________

Items 13 and 14 - Comment (IDC Technologies)

This was considered useful in indicating the degree of interest of a specific firm in training and thus there may be some linkage to the use of e-learning and blended learning. The open ended nature of the question (no selection possible) may contribute to a degree of error due to the uncertainty of the respondent.

13 and 14. Please indicate the number of average yearly hours of technical training that you personally receive __________ and that a typical employee under your supervision receives ________ (Put N/A if no one is working for you)

D. Your current situation with online learning (e-learning) and blended Learning, where blended learning means a mix of online AND classroom or on-the-job training).

Item 15 - Comment

Whilst a no response to this question and the resultant further lack of responses, may be construed as a possible loss of information in the survey, it ensured that those who were not familiar with e-learning and blended learning did not provide possibly incorrect data in later questions. This is because they were excluded from filling in subsequent questions as a result of answering this query in the negative.

15. Do you know what e-learning or blended learning is?

- ○ Yes
- ○ No

If NO, then go to Question 36.

If YES go to question 16 below.

Item 16 - Comment

This was an essential question, to gauge whether the respondents are using any e-learning at all. It may well be that it is not being used at all.

16. Have you attended an online learning (e-learning) or blended learning training course in the past 36 months?

○ Yes

○ No

If NO (i.e. you have not attended an online learning or blended learning training course); then go to the Question 20.

Item 17 - Comment

This gives an indication of the area of interest in e-learning and blended learning. It is possible that the respondents are undertaking e-learning but only in the usual IT disciplines with nothing in the engineering areas. As subsequently turned out later, probably safety, compliance and management/business topics should have been added to the list.

17. What of the following courses have you taken with the online learning courses?

○ None
○ Computer application/software
○ New Hire Orientation
○ Personal development skills (e.g., time management)
○ Mechanical Engineering
○ Electrical Engineering
○ Instrumentation, Automation and control engineering
○ Data Communications and Networking
○ Civil Engineering
○ Other

State what Other is:___________

Item 18 - Comment

Whilst it is anticipated that many respondents are undertaking e-learning, it is not clear how many actually complete their studies. It is suspected that there is a high correlation between attending e-learning and non-completion of the courses.

18. What percentage of online courses did you complete ?

○ None
○ 20% or less
○ 21 to 40%
○ 41% to 60%
○ 61% to 80%
○ 81% to 100%

Item 19 - Comment

There is a considerable amount of e-learning available on a non-paid basis (on the internet). The proportion of e-learning that is paid for would give some indication of its perceived value and credibility.

19. Did you or your company pay for the most recent online session you attended?

○ Yes

○ No

Item 20 - Comment (Bonk)

This provides information on the reaction and perceptions towards e-learning.

20. What best depicts your attitude or viewpoint towards online learning?

Select here

○ I am extremely critical or pessimistic

○ I am somewhat critical or pessimistic

○ I have no opinion one way or another

○ I am somewhat supportive or optimistic

○ I am extremely supportive or optimistic

Item 21 - Comment (Bonk)

This might be difficult for someone to answer if they are on the periphery of e-learning and blended learning in the organisation.

21. How much knowledge do you have related to online learning in your organisation?

Select here:

○ None/No knowledge

○ Low/Minimal knowledge

○ Medium/Some knowledge

○ High/Significant knowledge

○ Extremely high/extensive knowledge

Item 22 - Comment

There is evidence from the work the author has done with over 400 students so far (and perhaps, common sense) that a session longer than 60 minutes would be difficult to maintain full concentration on. But it would be interesting to know the overall duration of an e-learning course.

22. What is the average total duration of a typical online learning course you have attended (i.e. possibly with multiple sessions)?

Select here:

○ Not applicable

○ Fewer than 30 minutes

○ 30 minutes to 60 minutes

○ 1 to 2 hours

○ 2 to 3 hours

○ 3+ hours

Item 23 - Comment (Bonk)

This was considered useful to gauge the application of blended learning (as opposed to e-learning). There might however be some misinterpretation of the term blended learning and the responses will have to be carefully interpreted as a result.

23. How long has your organisation been using blended learning (i.e. combining online experiences and face-to-face classroom sessions) as part of its employee training?

Select here:

○ No experience

○ 1-2 years

○ 3-5 years

○ 6-10 years

○ More than 10 years

Item 24 - Comment (Bonk)

This would provide a useful profile of the use of online training.

24. How long has your organisation been using fully online courses or programs as part of its employee training?

Select here:

○ No experience

○ 1-2 years

○ 3-5 years

○ 6-10 years

○ More than 10 years

Item 25 - Comment (Bonk)

This would gauge the perceptions of the target audience to online learning.

25. In general, are online courses more engaging or motivating than face-to-face courses and classroom designs?

○ Yes

○ No

○ Don't know

Item 26 - Comment (Bonk)

It is believed from anecdotal evidence, that the quality of online learning is not considered particularly highly. This would confirm this suspicion.

26. What is the overall quality of online courses used in your organisation?

○ Extremely boring/non-interactive

○ Somewhat boring/non-interactive

○ Somewhat engaging/interactive

○ Extremely engaging/interactive

○ Do not know

Item 27 - Comment

This would give some understanding of the mix of training used by the respondents.

27. Estimate the overall mix of training by format that you have personally engaged in over the past year. Total should add up to 100%. Please leave blank if you do not use.

___Face-to-face, instructor-led training

___Synchronous e-learning (instructor-led, online, real time, "video conferencing")

___Self-paced, online learning (e-learning modules)

___Technology-based offline (i.e. CDROM, DVD, computer lab)

___Mentoring, coaching, on-the-job

___Print-based learning (self-study of books)

___Audio/Video

___Other

___Total

Item 28 - Comment

Anecdotal evidence indicated that there is not much activity here in using these as supplementary support for e-learning and data here would confirm (or deny) this.

28. Have you ever undertaken hands-on training using remote labs or simulation software as part of your e-learning course? Please select which ones you have undertaken as part of your e-learning course

○ No/or I don't know what you are talking about

○ Hands-on remote labs on a computer remote to me

○ Simulation software to demonstrate concepts

○ Other

Item 29 - Comment

It is unlikely that most respondents would be familiar with this concept as this is not even applied much to traditional training. But feedback on this issue, would be helpful to gauge the overall acceptance of this.

29. **Does your organization calculate return on investment (ROI) for online learning courses, or initiatives?**

○ Yes

○ No

○ Don't know

E. **Future Projections of online learning (please make your best guesses regarding the future of online learning)**

Item 30 - Comment (Bonk)

Whilst it is likely that much of this information is probably unavailable to respondents, it would be relatively easy to find out and answer; so it has been retained.

30. **How will your organisation's spending in online learning change during the next few years?**

Select here:

○ Will decrease significantly

○ Will decrease a bit

○ Will be the same

○ Will increase a bit

○ Will increase significantly

○ Don't know

○ Other

Item 31 - Comment (Bonk)

This would add useful support to the other questions and has thus been retained.

31. **How will online learning be used in your organization in the next few years? (Check all that apply)**

○ Alternative to instructor-led (classroom-based) courses

○ Follow-up to instructor-led (classroom-based) courses

○ Sole source of learning

○ Supplement to instructor-led (traditional classroom-based) courses

○ None of the above: We will not utilize e-learning

○ Not applicable: Something else will emerge to replace e-learning in the next few years

Other:__________

Item 32 - Comment (Bonk)

This question would impact on everyone – whether they are from the training and human resources function or are actual participants in e-learning.

32. From the perspective of your organization, what is the most significant online learning issue or problem that must be addressed during the next few years?

○ Boring and low quality content

○ Cultural resistance

○ Fast changing technology

○ High costs

○ Insufficient management support and commitment

○ Lack of standards

○ Limited bandwidth

○ Limited organizational vision and planning

○ More hype than fact

○ Unethical vendors

Other:___________

Item 33 - Comment (Bonk)

This question could probably only be answered accurately by the training function, but it was considered useful.

33. **What percentage of employee training in your organization is blended (i.e. courses that have online as well as face-to-face or conventional classroom components) today and how might this change in 5 years?**

Percentage blended training today (2007)

Select

○ 0%

○ 20% or less of employee training

○ 21 to 40% of employee training

○ 41% to 60% of employee training

○ 61% to 80% of employee training

○ 81% to 100% of employee training

Percentage blended training in 5 years (2012)

Select

○ 0%

○ 20% or less of employee training

○ 21% to 40% of employee training

○ 41% to 60% of employee training

○ 61% to 80% of employee training

○ 81% to 100% of employee training

Item 34 - Comment (Bonk)

This question could be considered a reworked question of an earlier one; but it does have useful information and has been retained in the final survey instrument.

34. **What percentage of employee training in your organisation is fully online today and how might this change in 5 years?**

Percent fully online this year (2007)

Select

○ 0%

○ 20% or less of employee training

○ 21 to 40% of employee training

○ 41% to 60% of employee training

○ 61% to 80% of employee training

○ 81% to 100% of employee training

Percent fully online in 5 years (2012)

Select

○ 0%

○ 20% or less of employee training

○ 21 to 40% of employee training

○ 41% to 60% of employee training

○ 61% to 80% of employee training

○ 81% to 100% of employee training

Item 35 - Comment (Bonk)

This question may be best aimed at a training respondent who is skilled in the new learning technologies, but the information gained here would be useful and it has thus been retained.

35. In your organisation, which online learning technology will most dramatically increase in use during the next few years?

Select here

○ Asynchronous or delayed discussion forums (e.g., webboard, webcrossing)

○ Electronic whiteboards

○ Instant messaging and synchronous chat tools

○ Learning Content Management systems and learning object libraries

○ Learning Management systems and courseware

○ Online testing and examination tools

○ Synchronous or live presentation tools (e.g., Centra, NetMeeting, Placeware)

○ Video Streaming (e.g., lectures, content, experts, etc)

○ Web-based video conferencing

○ I don't know

Item 36 - Comment (Bonk)

Some of these terms may be misunderstood, but this gives a useful gauge of the different forms of training used in the enterprise.

36. In your organization, which of the following methods will be used to deliver training in the next few years? (Check all that apply)

○ Asynchronous tools (e.g., discussion boards, forums, surveys)
○ Blended (combining online and classroom)
○ Instructor-led classroom-based learning
○ Instructor-led online learning
○ Multimedia (CDROM, CBT, DVD)
○ Paper-based correspondence
○ Peer-to-peer online learning networks
○ Satellite broadcast
○ Self-paced online learning
○ Streaming video
○ Synchronous tools (e.g., chats, instant messaging, virtual classrooms, webinars)
○ Videotape
○ Virtual Reality
○ Wireless technology
Other:__________

Item 37 - Comment

The large number of qualitative comments received in the survey made it unnecessary to follow up with a further set of interviews.

37. Final comments and requests for final report

Feel free to list additional comments relating to any of the items in this survey, especially regarding the future of e-learning and blended learning. Actual e-learning stories and future e-learning predictions are also welcome.

____
____
____
____
____

Thank you so much for taking the survey.

Once it is completed, we will send you the results. Please be sure to double check the email address you provided, since this is the one we will use to send you the results and give you the complimentary e-learning course offers.

Please enter your email address:____________

Click at the bottom of this form to download the Industrial Automation book offer worth $40.

As part of this survey, we plan to interview some of the participants to better understand your training application if you have attended training in the area of blended learning and e-learning in the past 24 months. Please let us know if you would like to participate in this 20 minute telephone interview. Again, all results will be given confidentiality. In return for participating, we will ship you an engineering book of your choice selected from our bookstore (worth $110).

Do you want to participate in a follow up telephone interview?
○ Yes, you may contact me for a 20 minute (maximum) interview
○ No, please do not contact me any further. This survey was enough!

Comment
The gift of the book was considered one of the reasons for the high level of response

○ **Please click here to go to the site to download your free industrial automation book worth $40.**

The proposed instrument was summarised in Appendix A.

In the actual survey, two similar instruments were used. The first instrument captured about 100 responses but was slightly modified to allow for more "Don't know" or "Not applicable" responses to question 17 (What of the following courses have you taken as online (or e-learning) courses ?), and question 22 (What is the average total duration of a typical online learning course you have attended (including possibly with multiple sessions) ?). The responses for both were compared and there was very little difference. The importance of adding in more "Don't knows" made the survey easier to complete and reduced the frustration of not knowing an answer to a particular item. The first instrument was initiated on 7th August 2007 and closed on the 26th September 2007. By 24th August, there were minimal responses coming through. The second modified instrument was initiated on the 7th August 2007 and had a cut off date of the 30th September 2007 (actually, the survey software presumably had a bug and it was slated to finish on the "31st" September 2007). The rapid growth in respondents slowed down by the 30th August 2007 (at 1900) with a still substantial 10 responses per day coming through after this date. A total of 2425 responses were received in total for both surveys.

3.5 Sample used

It was estimated that with a global mailing list of about 60,000 from IDC Technologies supplemented by two USA-based industrial automation magazines , www.Automation.com with R. Zabel, editor, and Control magazine (www.controlglobal.com) with W. Boyes, editor, each with at least 20,000 circulation that approximately 1,200 respondents should be achievable as a sample for the preliminary investigation, with a 1% response rate. A smaller newsletter (www.iceweb.com) with a mailing list of approximately 1,500 generated by J. Russell, editor, also gave a further estimated 20 respondents.

An indication of the appropriate sample size can be gauged by applying the popular formula: margin of error in sample = (1 / square root of number of people in the sample) (Niles, 2007). Based on this formula and a sample size of about 2400, this would give a sample error of approximately 2%, which was considered acceptable.

3.6 Measures

The scales used in this survey were based on existing scales. Some basic wording was changed to fit the specific thrust of the survey.

3.7 Data Analysis

Specific issues in analyzing the data have been discussed earlier; but a few general comments are appropriate on the statistical protocols that were to be followed. A quantitative methodology was the primary basis; but was supplemented with a qualitative set of comments.

3.7.1 Preliminary Analysis

Strangely enough, before the univariate and more detailed statistical analyses were commenced there were a number of problems downloading from the web survey site with apparent corruption of some of the data. According to the surveyshare.com site, this was not corruption but differing formats used in the conversion from the web form to that suitable for an Excel spreadsheet. This required care and diligence in converting certain fields from the web site to a form suitable for analysis in the SPSS data format. As an example, for question 36, a "15" replaced a "1"; with obvious catastrophic results for the data. The surveyshare site noted that Excel has an erratic import wizard which sometimes translates numeric data. Once the data had been imported into the SPSS data file, it was cross checked against the source data (both in raw format and converted into numeric format) to ensure there was no risk of misinterpretation here.

The first item was to examine the data from a univariate point of view and to look at appropriate graphs and descriptive statistics and confirm whether the data are normally distributed or not. Also a look at the descriptive statistics (such as the mean) for the data, gives some valuable feedback on what the real issues were that were indicated by the data. A large proportion of the variables were categorical and in keeping with Coakes and Steed (2005) who remarked that: "The appropriate chart for a categorical variable (rank) is a bar chart and the mode is the appropriate measure of central tendency" (p. 62), was taken into consideration in the analysis.

3.7.2 Multivariate Analysis

Before the data could be subjected to multivariate analysis, a few required underlying assumptions had to be tested and transformations used to correct for the problems identified (Soutar, 2005). Normality is a key requirement for a valid multivariate analysis. The data should be tested by performing a normal probability plot where the line of the data distribution should follow the diagonal. As an additional check for normality, the modified Kolmogorov-Smirnov test was applied (Hair, Anderson, Tatham, & Black, 1998), as graphical plots can be misinterpreted. A check was also made for homoscedasticity and non-linearity.

A choice of multivariate analysis method comes down to a dependence or an interdependence analysis. In a dependence analysis (multiple regression, discriminant analysis, conjoint analysis and MANOVA), a set of variables is used to predict one or more variables; as opposed to an interdependence analysis (multidimensional scaling, factor and cluster analysis) which is used where there is some grouping of the variables. The primary multivariate technique that could be used was MANOVA to identify any relationships between the various independent variables and the mode of learning (whether this be classroom, e-learning or blended learning).

Exploratory factor analysis was used on all the data to assess whether there were any underlying dimensions and whether it was possible to collapse a number of variables into a smaller number of factors with minimal loss of information. This can be successful when there are statistically strong interrelationships between numbers of variables; which can then be explained in terms of their underlying factors. It was found that a univariate statistical analysis was adequate for the investigation.

3.8 Qualitative Data

The qualitative information was used to gain more information and to apply the principle of triangulation to the quantitative results to achieve more confidence in the final results.

Qualitative research (Jennings, 2005, p. 86) "focuses on the experiences, interpretations, impressions or motivations of an individual or individuals and seeks to describe how people view things and why. It relates to beliefs, attitudes and changing behaviour…the methods for data analysis include identifying patterns, themes, coding, grouping into coded categories and relating to theory." Jennings (2005) went on to note that one of the problems with qualitative research is that of validity and reliability as there are no numerical statistics to directly support the conclusions arrived at. It is hoped that the theory of triangulation, where a combination of techniques of research methodologies are employed to study the same phenomenon, will overcome the weaknesses or problems that come from a single study and thus the qualitative study will add credibility and depth to the quantitative analysis.

3.9 Conclusion

A worldwide web survey was presented in this chapter with two sources of data – quantitative and qualitative. The survey instrument was mainly based on that from Kyong-Jee, Bonk, and Zeng (2006) with an essential quantitative thrust. Although the survey instrument was fairly detailed, a simple opt-out question has been placed near the beginning to ensure that those who had no knowledge of the topic of e-learning and blended learning would not have to answer questions for which they were not qualified. As the qualitative sources were voluntary, it was initially uncertain about the level of response. The results discussed in the next chapter were from a large number of over 2,400 respondents and comprised a wealth of over 2,500 qualitative comments.

Chapter 4

Results

4.1 Introduction

The results are presented in two main themes: the quantitative and qualitative surveys. The respondents were from five main sources:

- IDC Technologies mailing list comprising about 60,000 emails of engineers, technicians and other technical professionals
- IDC Technologies web site with typically 1,000 visitors per day
- Control magazine (estimated effective 15,000 mailing list)
- Automation.com web site (20,000 effective mailing list)
- Iceweb newsletter (estimated 1,500 mailing list)

There were 2,425 respondents to the quantitative survey. There was an unexpectedly high degree of qualitative comments in the quantitative survey following and these are also discussed in section 4.2.5.

In reading the results and drawing conclusions, there are two sometimes confusing issues at play in reviewing the percentages. In order to avoid having respondents comment on areas where they would perhaps have no knowledge, and perhaps only give the wrong perceptions, a question was asked in Question 15: "Do you know what e-learning or blended learning is"? Approximately 27% indicated that they did not know and were excluded from the rest of the survey, apart from question 36 near the end, which asked what methods of training would be used in the future. Hence there will be a large number of respondents who would have skipped most of the survey; but who still must be mentioned for completion in assessing the results. Hence, in some of the tables following there is a mention of percent (of the total number of respondents, including those who would skip questions 16 to 35) and valid percentage (of those who filled in the specific question).

Many of the survey comments following had a few grammatical deficiencies which were hopefully improved with some minor editing in an accurate and non-patronising manner.

4.2 Survey Results

The survey results are broken down with the same numbering convention as the questions in the survey (in Appendix A). The qualitative comments are discussed as an adjunct to the related quantitative one.

4.2.1 Background Information

A. Background information on you and your organisation

1.0 What best describes the level of your position? (Please select the appropriate level)

As expected and shown in Table 4.1 from the target databases, the majority of respondents were engineers and technicians (56%). The second most highly represented group were managers (28%). There is likely to be some ambiguity between engineer and manager, with the respondents more likely to select manager if they have one or more people reporting to them (e.g., engineering manager or even chief engineer). There was negligible response from the levels of trades and operators (3% in total).

Table 4.1
Breakdown of Level of Position

		Frequency	Percent
Valid	Management	675	27.8
	Supervisor	209	8.6
	Engineer/technician	1358	56.0
	Trades	55	2.3
	Operator	5	.2
	Other	123	5.1

n = 2425

The 5% response for the Other category listed a variety of roles, but mainly academics and instructors (e.g., lecturer, instructor, researcher) and probably a separate category should have been created to include this category. The large number of academics and instructors presumably arose from IDC Technologies' database comprising a significant number of training and learning institutions.

Typical job titles listed in the Other category included:

- Academics/researcher
- Training instructor or manager
- IT manager
- Sales Engineer
- Consultant
- Administration manager
- Engineers (e.g., automation specialist) or technician (e.g., draughtsman)

Most of these however could be categorised within the original level structure in Question 1. And arguably, an engineer who works in academia is an engineer, not an academic.

In reviewing the responses above, it would appear that there is some confusion between level of the position (e.g., engineer or manager), as asked in Question 1, and function of one's job (what type of job function do you perform in your daily work), which is requested in Question 2.

A cross tabulation was done between level of position within industry and educational level with a Pearson Chi-square significance result (0.0, or $p < 0.001$, as henceforth will be referred to). It can be seen in Table 4.2 that for vocational or technical college graduates, university graduates and advanced degrees that there is not a major difference in the employment. With respondents who are high school graduates (or have some high school), there is stronger proportion who are in the trades positions, but strongly represented as engineers and technicians and under represented in management (as would be expected). The large proportion of advanced degrees who are represented by "Other" for the level are essentially academics as can be gleaned from an inspection of the respondents who explicitly described their positions here.

Table 4.2

Cross Tabulation of Level of Position against Educational Level

			Highest Level of Education					Total
			Some high school	High school graduate	Vocational/tech. college(TAFE)	University Graduate	Advanced degree (eg Masters)	
Level of your position	Management	N	4	13	168	325	165	675
		within Highest Level of education	36.4%	24.1%	22.2%	27.4%	39.8%	27.8%
	Supervisor	N	2	11	95	75	26	209
		within Highest Level of education	18.2%	20.4%	12.5%	6.3%	6.3%	8.6%
	Engineer/ technician	N	4	22	414	734	184	1358
		within Highest Level of education	36.4%	40.7%	54.6%	61.8%	44.3%	56.0%
	Trades	N	1	3	45	4	2	55
		within Highest Level of education	9.1%	5.6%	5.9%	.3%	.5%	2.3%
	Operator	N	0	0	3	2	0	5
		within Highest Level of education	.0%	.0%	.4%	.2%	.0%	.2%
	Other	N	0	5	33	47	38	123
		within Highest Level of education	.0%	9.3%	4.4%	4.0%	9.2%	5.1%
Total		N	11	54	758	1187	415	2425
		within Highest Level of education	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

($p < 0.001$)

With a cross tabulation ($p < 0.001$) of job level against age, it was noted that predictably, the older employees are in management (42% of the over 50 years, against 2% for that below 30 years old). For engineers, there are over 83% over 30 years of age with a small 17% below 30 years of age. This would mean a considerable amount of leadership will be leaving engineering in the next decade and there are insufficient people to take over. This would suggest a looming skills shortage in these areas.

2.0 What best describes your job function (please select the appropriate function)?

The dominant response was maintenance (59%), followed by research and development (14%).

Table 4.3

Breakdown by Job Function

		Frequency	Percent
Valid	Operations	78	3.2
	Maintenance	1433	59.1
	Engineering	12	.5
	Research and Development	344	14.2
	Quality Control	135	5.6
	Purchasing	5	.2
	Training	17	.7
	Corporate/Administration	119	4.9
	Human Resources	139	5.7
	Other	143	5.9

(n = 2425)

Approximately 6% categorised their job function as other. Many of the functions were incorrectly categorised in the Other category, such as Electrical CAD Designer and Systems and technology (automation) which should be engineering, and manufacturing as engineering or maintenance as the case may be. Other titles such as sales or sales engineer could be included under corporate/administration.

3.0 Please indicate your gender.

The number of respondents were overwhelmingly male (96%) with a tiny percentage female. This accords with the current state of engineering which is a male dominated field but the significant under representation of females is surprising.

Besides the lack of female respondents in the Middle East and South America; no other significant distributions by gender could be located on a geographic basis.

In view of the low overall representation of females, there is a comforting observation in the age to gender cross tabulation (Table 4.4), where the younger (below 30 years) age group is increasingly represented by females joining engineering (12%) compared to the over 50 years age group which only has 1.5% .

Table 4.4

Cross Tabulation of Age to Gender

			Gender	
			Male	Female
Age group	Below 30 yrs	n	240	32
		within Age group	88.2%	11.8%
	30 yrs to 50 yrs	N	1383	53
		within Age group	96.3%	3.7%
	Over 50 yrs	N	706	11
		within Age group	98.5%	1.5%
Total		N	2329	96
		within Age group	96.0%	4.0%

($p < 0.001$)

4.0 Select the age group that you fall into

The bulk of the respondents are in the over 30 years age group (90%). If it is assumed that the average engineer or technician commences work after qualification when she is 22, the percentage of younger individuals is quite low (10%) against that of the 30 to 50 group which is 59%. Hence there is evidence of the bulk of engineers being older, as the introduction to the survey suggests: "The highly skilled engineering and technical workforce in most production environments is getting older and in many cases retiring and leaving for good."

Table 4.5

Breakdown of Ages of Respondents

		Frequency	Percent
Valid	Below 30 yrs	272	11.2
	30 yrs to 50 yrs	1436	59.2
	Over 50 yrs	717	29.6
	Total	2425	100.0

There is some credibility to the comment about North America experiencing an aging in the workforce if Table 4.6, which is a cross tabulation ($p < 0.001$) of age versus region is examined. It can be seen that for North America there is a small percentage of below 30 years age group (4%) and a preponderance of the greater than 50 years compared to the other regions. Latin America exhibits a similar situation, although it has the majority of the respondents in the 30 to 50 year age group. The Middle East can be seen with a strong number (25%) of respondents younger than 30 years of age. Interestingly enough but expected, when the Asia Pacific region excluded Australia and New Zealand from the sample, it showed the strongest number below 30 years of age. This could be seen when the initial data gathered only included the SE Asian region.

Table 4.6

Cross Tabulation of Age to Region

			Region of the world						Total
			North America	Europe	Asia Pacific	Latin America	Middle East	Africa	
Age group	Below 30 yrs	N	19	34	165	2	14	38	272
		within Region of the world	4.2%	11.0%	13.1%	8.3%	24.6%	11.6%	11.2%
	30 yrs to 50 yrs	N	278	170	728	15	30	215	1436
		within Region of the world	61.8%	55.2%	57.9%	62.5%	52.6%	65.3%	59.2%
	Over 50 yrs	N	153	104	364	7	13	76	717
		within Region of the world	34.0%	33.8%	29.0%	29.2%	22.8%	23.1%	29.6%
Total		N	450	308	1257	24	57	329	2425
		within Region of the world	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

($p < 0.001$)

The cross tabulation of age versus organisational focus ($p < 0.001$) revealed some interesting trends. The areas which are growing significantly with under 30 year old entrants were oil and gas and mining, presumably due to the well publicised resource boom. The semi-conductor, construction and pharmaceutical industries showed some mild growth in the younger entrants; but still very small in absolute numbers. On the other hand, industrial/manufacturing, education and military showed significant declines in the younger workforce. With the notable exception of pharmaceuticals, across most organisations, it can be seen in terms of absolute numbers that the younger entrants are too few to replace those leaving. The picture is particularly bleak for industrial/manufacturing.

Table 4.7

Cross Tabulation of Organisational Focus versus Age

			Age group			Total
			Below 30 yrs	30 yrs to 50 yrs	Over 50 yrs	
Organisational Focus	Agriculture, Forestry, Fishing	N	1	8	6	15
		in Age group	.4%	.6%	.8%	.6%
	Communications	N	1	5	6	12
		In Age group	.4%	.3%	.8%	.5%
	Construction/building	N	9	20	12	41
		in Age group	3.3%	1.4%	1.7%	1.7%
	Consulting/contracting	N	36	179	115	330
		In Age group	13.2%	12.5%	16.0%	13.6%
	Education	N	9	63	50	122
		in Age group	3.3%	4.4%	7.0%	5.0%
	Financial services	n	0	2	2	4
		in Age group	.0%	.1%	.3%	.2%
	Government	n	4	35	19	58
		in Age group	1.5%	2.4%	2.6%	2.4%
	Health/medical	n	0	13	5	18
		In Age group	.0%	.9%	.7%	.7%
	Food/hospitality, travel	n	3	12	10	25
		In Age group	1.1%	.8%	1.4%	1.0%
	Industrial/manufacturing	n	39	345	145	529
		In Age group	14.3%	24.0%	20.2%	21.8%
	IT	n	7	36	19	62
		In Age group	2.6%	2.5%	2.6%	2.6%
	Military	n	1	23	14	38
		In Age group	.4%	1.6%	2.0%	1.6%
	Mining	n	27	90	31	148
		In Age group	9.9%	6.3%	4.3%	6.1%
	Non-profits	n	0	1	2	3
		In Age group	.0%	.1%	.3%	.1%

	Oil&Gas	n	44	126	51	221
		In Age group	16.2%	8.8%	7.1%	9.1%
	Pharmaceuticals	n	6	6	8	20
		In Age group	2.2%	.4%	1.1%	.8%
	Utilities	n	37	187	93	317
		In Age group	13.6%	13.0%	13.0%	13.1%
	Processing	n	15	95	37	147
		In Age group	5.5%	6.6%	5.2%	6.1%
	Refining	n	6	22	16	44
		In Age group	2.2%	1.5%	2.2%	1.8%
	Semiconductor	n	5	8	3	16
		In Age group	1.8%	.6%	.4%	.7%
	Transportation	n	2	26	6	34
		In Age group	.7%	1.8%	.8%	1.4%
	Wholesale	n	4	18	5	27
		In Age group	1.5%	1.3%	.7%	1.1%
	Other	n	16	116	62	194
		In Age group	5.9%	8.1%	8.6%	8.0%
Total		n	272	1436	717	2425
		In Age group	100.0%	100.0%	100.0%	100.0%

(p <0.001)

5. What is the primary focus of your organisation? (Please select the best fit)

The highest response for focus areas of the organisations were industrial or manufacturing (22%), consulting and contracting (14%), oil and gas (10%), public utilities (13%). The lowest number of respondents were derived from non-profit organisations (0.1%). This breakdown should not be taken as the typical structure of engineers and technicians worldwide but more a reflection of the databases used. The databases are however randomly constituted; so these figures could provide some indication.

Table 4.8
Breakdown of Respondents by Organizational Focus

		Frequency	Percent
Valid	Agriculture, Forestry, Fishing	15	.6
	Communications	12	.5
	Construction/building	41	1.7
	Consulting/contracting	330	13.6
	Education	122	5.0
	Financial services	4	.2
	Government	58	2.4
	Health/medical	18	.7
	Food/hospitality, travel	25	1.0
	Industrial/manufacturing	529	21.8
	IT	62	2.6
	Military	38	1.6
	Mining	148	6.1
	Non-profits	3	.1
	Oil&Gas	221	9.1
	Pharmaceuticals	20	.8
	Utilities	317	13.1
	Processing	147	6.1
	Refining	44	1.8
	Semiconductor	16	.7
	Transportation	34	1.4
	Wholesale	27	1.1
	Other	194	8.0
	Total	2425	100.0

A significant proportion of 8% were included under other. A brief examination of these entries revealed that most of them are already included in the other categories listed above. For example, engineering and manufacturing pumps is clearly a manufacturing activity; nuclear decommissioning is likely to be construction whilst pulp and paper would be processing.

6. How many people are employed in your organisation?

The bulk of the response came from individuals working for firms with less than 100 employees (26%) the next larger size being 101-500 (22%). There were still a sizeable number of firms with more than 10,000 employees (12%).

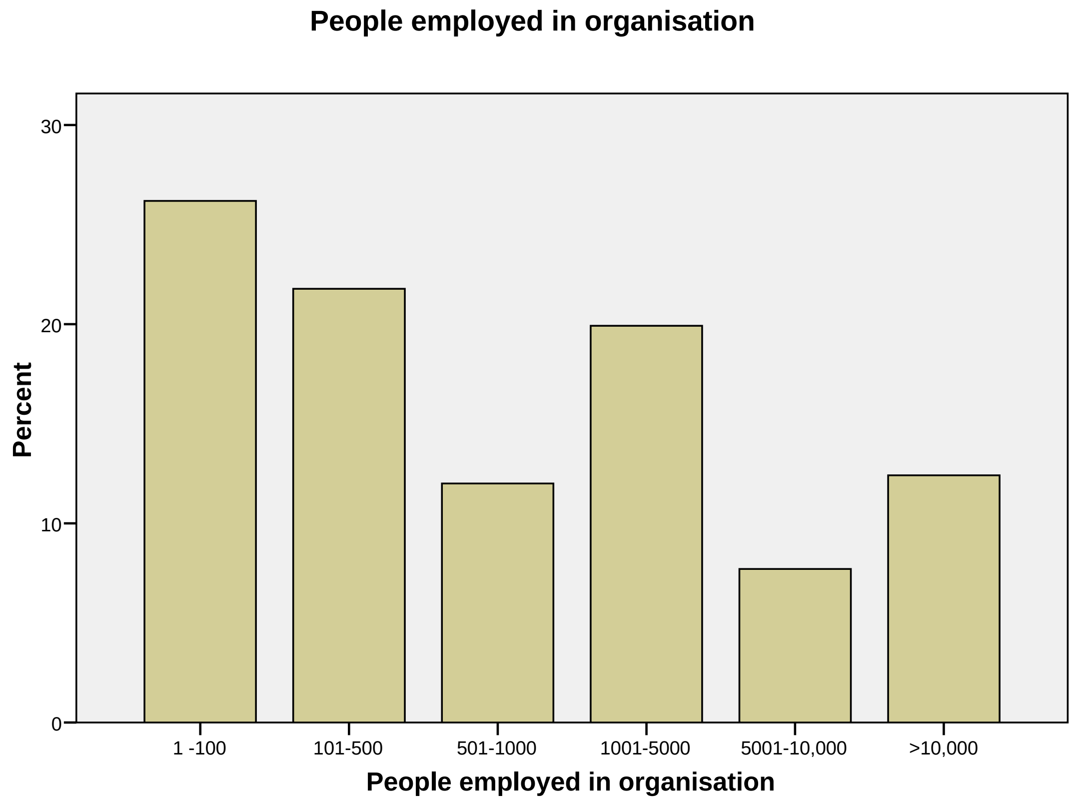

Figure 4.1. Breakdown of size of firms by number of employees.

7. What is the highest level of education you have completed?

Education levels are biased to the high side with a large proportion being university graduates or having an advanced degree with a total of more than 66% for both categories. It is arguable whether a university graduate in some of the countries is perhaps equivalent to that of an Australian TAFE college diploma. Hence the results may be incorrectly labelled due to the difficulty of categorising education consistently across the different regions.

Table 4.9

Breakdown by Highest Level of Education Completed

		Frequency	Percent
Valid	Some high school	11	.5
	High school graduate	54	2.2
	Vocational/tech.college(TAFE)	758	31.3
	University Graduate	1187	48.9
	Advanced degree (eg Masters)	415	17.1

(n = 2425)
(p < 0.001)

A cross tabulation of education level (row-wise) with region of the world (as derived from Question 8) is indicated in Table 4.10 below. It shows that in Latin America, there were virtually no non-university graduates that filled in the survey; with most categorising themselves as graduates or advanced degree holders. Technicians normally graduate from vocational or technical colleges and are normally critical to any industry acting under the instructions of the engineers who focus on higher level design activities. Similarly, in the Middle East, there is a proportionally higher number of graduates and advanced degree holders compared to elsewhere in the world. It may reflect the significantly higher revenues from oil, the consequent additional funds available for education in these countries for the local population and the use of expatriates for the lower level technician and trades tasks. In Africa, there are a significantly increased number of technical college graduates versus those of the other regions. And there is a comcomitant lower number of university graduates and advanced degree respondents. This may reflect the skills shortage due to the well publicised flight of graduates to the wealthier countries (such as the USA and UK). Although the results indicate that the USA has a similar profile to Africa, so perhaps nothing should be read into this.

Table 4.10

Cross Tabulation of Educational Level versus Region

			Region of the world						Total
			North America	Europe	Asia Pacific	Latin America	Middle East	Africa	North America
Highest Level of education	Some high school	n	0	1	10	0	0	0	11
		% within Region of the world	.0%	.3%	.8%	.0%	.0%	.0%	.5%
	High school graduate	n	14	7	27	1	0	5	54
		% within Region of the world	3.1%	2.3%	2.1%	4.2%	.0%	1.5%	2.2%
	Vocational/ tech college (TAFE)	n	162	90	376	0	5	125	758
		% within Region of the world	36.0%	29.2%	29.9%	.0%	8.8%	38.0%	31.3%
	University Graduate	n	192	146	658	14	37	140	1187
		% within Region of the world	42.7%	47.4%	52.3%	58.3%	64.9%	42.6%	48.9%
	Advanced degree (eg Masters)	n	82	64	186	9	15	59	415
		% within Region of the world	18.2%	20.8%	14.8%	37.5%	26.3%	17.9%	17.1%
Total		n	450	308	1257	24	57	329	2425
		% within Region of the world	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

($p < 0.001$)

8. In which region of the world are you located in your job today?

There was a fairly wide distribution across North America (19%), Europe (13%), Africa (14%) and Asia Pacific (52%). This would reflect the sourcing of the database which was biased towards certain countries, as alluded to earlier.

It is presumed that there is likely to be some smearing out of the results due to specific countries; by the grouping of South Africa within Africa and Australia and New Zealand within the Asian region. It is possible in subsequent analysis to minimise this effect by isolating a particular country by examining the domain used in the email name (e.g., .com.au).

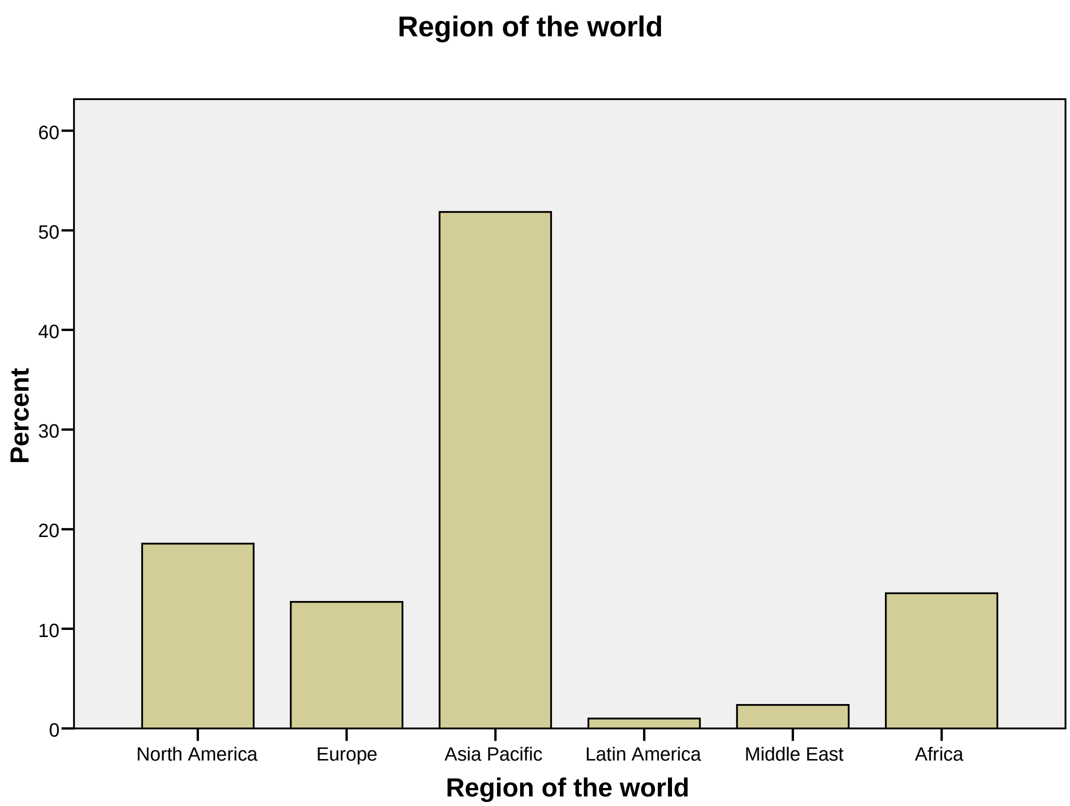

Figure 4.2. Classification of respondents by region of the world.

In a cross tabulation exercise between region and company size ($p < 0.001$), apart from Latin American companies (38%) being biased towards 1-100 employee size and Latin American, Middle East and African companies being biased towards >10,000 employee companies, most of the other results were equivalent.

4.2.2 Current training status

B. Your current training status

9. Please indicate how you participate in training.

There was a mix of instructors of 11% and learners of 45% with the remainder being both instructors and students (45%). It is unlikely that this latter group are full time instructors as Question 2 (Job Function) indicated only 1% of respondents were in a training department.

A cross tabulation ($p < 0.01$) revealed that those with advanced degrees were more likely to be instructors (or more appropriately called lecturers) than learners. This is probably influenced by the number of academics in the sample and is not an unexpected result.

10. Over the next few years, do you anticipate an increase or decrease in your department's overall technical training budget?

The majority of respondents indicated an increase in their training budget (46%) which is understandable due to the world economic (especially mining, oil gas resources and resultant engineering construction) boom in 2007. This would probably include an investment in e-learning initiatives. A small number of 4% indicated their training budgets were being reduced.

As can be seen in Table 4.11 cross tabulation ($p < 0.001$), the region with the greatest growth in training was Africa with 66% of its respondents indicating an increase in the training budget, closely followed by Latin America and the Middle East region. North America and Europe (41% and 36%, respectively) were more cautious about increases in their training budgets. As remarked earlier, it is speculated (based on analysis of initial results solely from Asia as opposed to Australia and New Zealand) that it likely that if Australia and New Zealand were removed from the Asia Pacific region respondents, that the results for this region would also show a strong growth in training budgets.

Table 4.11

Cross Tabulation of Region to Training Budget Change

			Region of the world						Total
			North America	Europe	Asia Pacific	Latin America	Middle East	Africa	
Overall technical training budget	Increase	N	172	104	519	11	21	207	1034
		% within Region of the world	40.9%	35.9%	44.1%	55.0%	45.7%	66.6%	45.7%
	Decrease	N	25	16	42	2	4	12	101
		% within Region of the world	5.9%	5.5%	3.6%	10.0%	8.7%	3.9%	4.5%
	Remain the same	N	176	131	471	5	9	73	865
		% within Region of the world	41.8%	45.2%	40.1%	25.0%	19.6%	23.5%	38.2%
	Uncertain	N	48	39	144	2	12	19	264
		% within Region of the world	11.4%	13.4%	12.2%	10.0%	26.1%	6.1%	11.7%
Total		N	421	290	1176	20	46	311	2264
		% within Region of the world	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

($p < 0.001$)

11. Please rate the overall quality of the formal education that you have received from the following sources:

If the modes of each of the forms of training are examined, it would appear that universities get the highest rating of very good, whilst trade/technical schools, vendors, on-the-job training received a good rating. Distance learning (of which e-learning is a component) did not receive a very flattering response – it is effectively the worse rated with an average rating, albeit with a significantly high degree of "Don't knows".

Some respondents have pointed out the weakness in this question of categorising of education is that people who have only partially completed a college degree, would probably be incorrectly placed, as engineers do not necessarily need to have a formal qualification to practise (as opposed to lawyers or doctors who have central licensing or registration boards before they can practise, for example).

12. If you selected Other from the previous question, please indicate briefly what it is?

A large number of the respondents (58%) commented on Other and some particularly useful and novel suggestions were listed; although a large number of them were incorrectly categorised as Other. Arguably, the respondents could have stated that the questions did not provide sufficient information or they did not have the depth of knowledge to categorise correctly. Examples of incorrect categorisation were "e-learning" which would be included under distance learning. And on-the-job training would have included items such as "hands-on with vendor's manual", "university of hard knocks", "people around me", "practices in the workplace" and "peer to peer training". "PLC and SCADA manufacturers" would be included under vendors training. And perhaps, training from such organisations as ISA and IDC Technologies could have been classified under Vendor's training; but this is perhaps ambiguous.

The positive result of this incorrect classification has been an enormously rich set of suggestions of alternative forms of training.

There were some useful additions to the categories and these included:

- Studying on one's own (e.g., technical papers, books self-training, e-books, self study, reading educational materials at my own pace, e-books, reading books/magazines, internet education using Wikipedia, online searching, vendor literature, help files on computer packages)
- Mentoring and learning from one's colleagues (peer-to-peer training, forums)
- Trade conferences and exhibitions
- Conferences
- Lectures at lunch time from professional societies

- Action learning in terms of a real company project
- Learning from committee participation and technical associations
- Working on engineering projects
- Government and military sponsored training
- Internal training put together by one's colleagues
- Management training

Other interesting ones were "learning from actual customer", "trial and error" and "in-house procedures".

There were two useful and thoughtful comments on alternative forms of training that were noted, and are reproduced below:

> Just like to comment on the job training - or experience-based training is the most important I have received. It is important to note it has only seldomly consisted of someone sitting down and explaining a topic to me most of the time it consists of having a go and learning-by-doing. The only way this can be done safely in engineering is by having a senior engineer or mentor providing a safety umbrella under which can one have a go the umbrella must catch all poorly concieved and thought-out designs and send them back for rework. This requires a senior engineer of considerable skill and intuition and confidence as he/she carries the risk of the work of their student but learning-by-doing is the only way to really learn engineering and is I think in-line with the nature of engineers anyway - spatial thinkers and doers (Second Survey, respondent 1224).

And

> Peer-to-Peer Training - is something that the industry has so far undervalued. This is training where a person of expertise passes on skills to the new entrant in an orgnisation. This is also need based training where the expert is delegating to free

> up his schedule and the candidate has attitude and willingness
> to learn (Second survey, respondent 1518).

13. Please indicate the number of average yearly hours of technical training that you personally receive.

There were varying interpretations in answering this question; presumably as a result of the different respondents with varying competencies in English with answers ranging from a few years to nil hours. The responses were converted to hours in the following way. Each working day was assumed to be 8 hours and when estimates such as 2 to 3 weeks were selected; the average was calculated (e.g., 2 to 3 weeks, would be (80 hours + 120 hours)/2 = 100 hours). A working year was assumed to be 11 months (with one month for the annual holiday; perhaps a little extravagant for the Asians and Americans). Large estimates of training hours were discarded and left open (e.g., 1000 hours or greater). The reason for this is that it is arguable whether there is a benefit accruing to an organisation when someone spends 1000 hours or more out of a possible 1760 hour work year, as to whether this is productive or indeed sustainable for a firm on an ongoing basis. It is believed to be more likely that either this is a short term training assignment or the question has been misunderstood. There is admittedly some confusion in answering the question where some indicated that they did self-directed reading and study (e.g., "informal" and "self-directed reading"). For consistency these numbers were discarded and only formal training was considered. This probably requires further investigation as self-directed study does knit in well with e-learning and certainly can be a very powerful and effective form of training and arguably can be better than prescribed formal training.

The mean would appear to be 64 hours. Although the histogram is not normal (hence variances are not really statistically appropriate), it should be noted that the deviation of 84 hours is rather large.

A cross tabulation ($p < 0.001$) was performed for hours of training against geographical location. An arbitrary categorisation of hours was done between 0 and 1000 hours as per Table 4.12 below. As suspected, the European and North

American hours of training were concentrated on the lower end of the scale with a maximum between 0 to 25 hours; whereas for Africa and the Middle East, the maximum number of respondents were concentrated from 26 to 50 hours. Admittedly, based on a rather thin sample (24 respondents), Latin America, had the hours concentrated around 76 to 100 hours.

Table 4.12

Cross Tabulation of Training Hours to Geographical Region

			Region of the world						Total
			North America	Europe	Asia Pacific	Latin America	Middle East	Africa	
Training hours category	0 to 25 hours	N	179	128	411	3	13	60	794
		% within Region of the world	40.0%	42.2%	33.0%	12.5%	24.5%	19.2%	33.3%
	26 to 50 hours	N	148	88	416	2	16	107	777
		% within Region of the world	33.1%	29.0%	33.4%	8.3%	30.2%	34.3%	32.6%
	51 to 75 hours	N	21	18	83	4	5	21	152
		% within Region of the world	4.7%	5.9%	6.7%	16.7%	9.4%	6.7%	6.4%
	76 to 100 hours	N	67	39	175	8	10	61	360
		% within Region of the world	15.0%	12.9%	14.1%	33.3%	18.9%	19.6%	15.1%
	101 to 200 hours	N	27	22	120	4	5	40	218
		% within Region of the world	6.0%	7.3%	9.6%	16.7%	9.4%	12.8%	9.1%
	201 to 1000 hours	N	5	8	39	3	4	23	82
		% within Region of the world	1.1%	2.6%	3.1%	12.5%	7.5%	7.4%	3.4%
Total		N	447	303	1244	24	53	312	2383
		% within Region of the world	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

($p < 0.001$)

As can be seen in Table 4.13, a cross tabulation (*p* < 0.001) of training hours categorised against overall technical budget revealed a direct relationship between hours of training and an increase in the overall technical training budget. This is not entirely unexpected, as a contracting training budget would be associated with a smaller number of training hours.

Table 4.13

Cross Tabulation of Training Hours to Overall Technical Training Budget

Training hours category * Overall technical training budget Crosstabulation

			Overall technical training budget				Total
			Increase	Decrease	Remain the same	Uncertain	Increase
Training hours category	0 to 25 hours	N	297	50	325	122	794
		% within Overall technical training budget	26.8%	48.5%	36.4%	43.4%	33.3%
	26 to 50 hours	N	361	25	304	87	777
		% within Overall technical training budget	32.6%	24.3%	34.1%	31.0%	32.6%
	51 to 75 hours	N	80	4	53	15	152
		% within Overall technical training budget	7.2%	3.9%	5.9%	5.3%	6.4%
	76 to 100 hours	N	186	11	134	29	360
		% within Overall technical training budget	16.8%	10.7%	15.0%	10.3%	15.1%
	101 to 200 hours	N	135	10	55	18	218
		% within Overall technical training budget	12.2%	9.7%	6.2%	6.4%	9.1%
	201 to 1000 hours	N	48	3	21	10	82
		% within Overall technical training budget	4.3%	2.9%	2.4%	3.6%	3.4%
Total		N	1107	103	892	281	2383
		% within Overall technical training budget	100.0%	100.0%	100.0%	100.0%	100.0%

(*p* < 0.001)

Anecdotal and qualitative comments noted that the smaller the organisation, the less likely there would be provision of training. Table 4.14, which is a cross tabulation of training hours against size of organisation (*p* < 0.01), shows this to be the generally the case in comparing an organisation with greater than 10,000 to one with 1-100. It can be seen that for all categories (apart from the lowest) that the percentage of training is consistently more for the greater than 10,000 employee organisations.

Table 4.14

Cross Tabulation of Training Hours against Size of Organisation

			People employed in organisation						Total
			1 -100	101-500	501-1000	1001-5000	5001-10,000	>10,000	1 -100
Training hours category	0 to 25 hours	N	245	168	83	165	62	71	794
		% within People employed in organisation	39.2%	32.4%	29.0%	34.8%	34.1%	23.9%	33.3%
	26 to 50 hours	N	192	180	107	148	58	92	777
		% within People employed in organisation	30.7%	34.7%	37.4%	31.2%	31.9%	31.0%	32.6%
	51 to 75 hours	N	34	36	16	27	20	19	152
		% within People employed in organisation	5.4%	6.9%	5.6%	5.7%	11.0%	6.4%	6.4%
	76 to 100 hours	N	74	74	46	76	23	67	360
		% within People employed in organization	11.8%	14.3%	16.1%	16.0%	12.6%	22.6%	15.1%
	101 to 200 hours	N	55	43	22	49	14	35	218
		% within People employed in organisation	8.8%	8.3%	7.7%	10.3%	7.7%	11.8%	9.1%
	201 to 1000 hours	N	25	18	12	9	5	13	82
		% within People employed in organisation	4.0%	3.5%	4.2%	1.9%	2.7%	4.4%	3.4%
Total		N	625	519	286	474	182	297	2383
		% within People employed in organisation	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

($p < 0.001$)

14. Please indicate the number of average yearly hours of technical training that a typical employee under your supervision receives (put N /A if no one is working for you)

The employee under the respondent's supervision receives approximately the same level of training (70 hours average) as those of respondent. The same adjustments were made as for the respondent's training hours, as discussed in the previous section. It is perhaps to be expected that the respondents would probably increase the estimate of the number of hours of their subordinates to be more than they receive to demonstrate more care.

4.2.3 Current situation with online and blended learning

D. Your current situation with online learning (e-learning) and blended Learning, where blended learning means a mix of online AND classroom or on-the-job training).

15. Do you know what e-learning or blended learning is?

Most knew what e-learning or blended learning was with 73% indicating knowledge of this area. In some respects, it is surprising that there are still a large number 27% who do not know what e-learning is. There were no significant trends on a regional basis. There is a not unexpected relationship between a higher level of education and (greater) knowledge of e-learning in a cross tabulation examination (admittedly with only a 0.07 significance from the Pearson Chi-square test). In addition, according to another cross tabulation, one is more likely to be knowledgeable about e-learning if one is a presenter/trainer ($p < 0.001$). Again, this is not an unexpected relationship as instructors would tend to be more knowledgeable about new training technologies.

16. Have you attended an online learning (e-learning) or blended learning training course in the past 36 months?

Approximately 36% had not attended an e-learning course against 37% who had in terms of the overall number (including those who skipped the question). It was roughly a 50% split (of the total respondents) when considering only those who had completed this specific question. This indicates that the engineering industry still has a long way to go to catch up to the computer and business communities in the take-up of this technology, especially considering that the e-learning sessions could be free and of a duration of a few minutes.

Table 4.15

Attendance at an Online Learning Course

		Frequency	Percent	Valid Percent
Valid	No	870	35.9	49.5
	Yes	889	36.7	50.5
	Total	1759	72.5	100.0
Missing	System	666	27.5	
Total		2425	100.0	

A cross tabulation ($p < 0.001$) as indicated in Table 4.16 of attendance at an e-learning course in the past 36 months to geographical region, revealed that North America had the second highest attendance of e-learning (62%) courses with Africa the lowest (41%). Surprisingly, Latin America (admittedly, with a small sample) had the highest level of 68%. Unfortunately Australia was not split separately out of Asia Pacific region, as this gives the third lowest and it is suspected that Australia on its own would be one of the highest.

Table 4.16

Cross Tabulation of Attendance at E-learning against Geographical Region

			Region of the world						Total
			North America	Europe	Asia Pacific	Latin America	Middle East	Africa	
Have you attended an online learning course	No	N	129	117	457	6	23	138	870
		% within Region of the world	37.8%	50.6%	51.3%	31.6%	56.1%	58.5%	49.5%
	Yes	N	212	114	434	13	18	98	889
		% within Region of the world	62.2%	49.4%	48.7%	68.4%	43.9%	41.5%	50.5%
Total		N	341	231	891	19	41	236	1759
		% within Region of the world	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

($p < 0.001$)

An issue suspected and noted in numerous qualitative comments, is the relationship between (e-learning) training and size of organization. It can be clearly seen from Table 4.17, of the direct relationship in the cross tabulation ($p <0.001$) between the size of an organization and the attendance at e-learning classes ranging from an organization size of 1-100, with 46% undertaking an e-learning class to 62% for an organization greater than 10,000 employees.

Table 4.17

Cross Tabulation of Attendance at an E-learning Course against Size of Organisation

			People employed in organization						Total
			1 -100	101-500	501-1000	1001-5000	5001-10,000	>10,000	
Have you attended an online learning course	No	N	241	202	118	166	58	85	870
		% within People employed in organisation	53.7%	54.2%	54.1%	47.6%	40.0%	37.8%	49.5%
	Yes	N	208	171	100	183	87	140	889
		% within People employed in organization	46.3%	45.8%	45.9%	52.4%	60.0%	62.2%	50.5%
Total		N	449	373	218	349	145	225	1759
		% within People employed in organisation	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

($p < 0.001$)

17. What of the following courses have you taken with the online learning courses?

As per the previous question, presumably there were about 37% of the respondents who attended one or many e-learning courses. There is possibly some uncertainty with this question, as there is a possibility of some mismatch between this question and the earlier one (Question 16) due to different time periods. The most popular courses were computer applications (19%), with personal development second at 14%. Instrumentation, Automation and Control Engineering courses were listed third at 11%. There was however an unusually large number of responses indicating Other (11%) with a wealth of online courses listed here.

Table 4.18

Popularity of Different E-learning Courses

		Responses		Percent of Cases
		n	Percent	
Online Courses taken(a)	None	674	27.8%	38.4%
	Computer Applications	460	19.0%	26.2%
	New Hire Orientation	88	3.6%	5.0%
	Personal Development	327	13.5%	18.6%
	Mech. Eng	62	2.6%	3.5%
	Elec. Eng	164	6.8%	9.3%
	Instrument/Automation	269	11.1%	15.3%
	Data Comms &Networking	133	5.5%	7.6%
	Civil Eng	11	.5%	.6%
	Other	238	9.8%	13.6%
Total		2426	100.0%	138.2%

a Group

The courses listed in the other category covered a wide range of topics ranging from the military, maths, economics to AIDS awareness. Based on the wide spectrum of topics which engineering professionals are taking, it would be fair to suggest that the market is vibrant and there is considerable activity going on in e-learning focussed on engineers. A number of the courses were listed in the Other category mistakenly (e.g., vibration analysis and tightening technology – torque which would have both been mechanical).

The ones which appeared popular on the list were:

- Safety (incl. occupational and food)
- Product specific training
- Management and business (e.g., part of a MBA or management postgraduate program)
- Ethics
- Property and loss protection
- Project management
- Physics and mathematics
- Vendor specific training (e.g., SAP)
- Financial
- Environmental

- Internal corporate type courses (such as administration and Standard Operation Procedures)
- Military (including standards and procedures)
- Bachelors degree program

In hindsight, the survey would have been better served if the list were supplemented with management and safety since additional topics to these were popular in the responses.

18. What percentage of online courses did you complete?

The initial reaction when viewing the Table 4.19 is that the majority of the e-learning courses were not completed by the respondents. It would appear that only 38% completed between 80% and 100% of a course (and presumably for 100% completion the percentage would be even lower than this). However, if those who did not undertake any e-learning course are removed, the completion percentage moves upwards to 64% (i.e. 38.5%/60%) - considerably improved; but obviously an issue that needs to be examined in more detail. This is as suggested in section 2.12.3 (Difficulty in completing e-learning programs) with somewhat better attrition rates than suggested in that discussion of 26%.

Table 4.19

Percentage of Online Courses Completed

		Frequency	Percent	Valid Percent
Valid	None	707	29.2	40.2
	20% or less	127	5.2	7.2
	21% to 40%	60	2.5	3.4
	41% to 60%	87	3.6	4.9
	61% to 80%	110	4.5	6.3
	81% to 100%	668	27.5	38.0
	Total	1759	72.5	100.0
Missing	System	666	27.5	
Total		2425	100.0	

A cross tabulation ($p < 0.001$) was performed between completion of online courses and attitude to online learning and as expected, it appeared that the highly supportive respondents (over 50%), were 81% to 100% likely to complete their courses.

Table 4.20

Cross Tabulation of Online Courses Completed to Attitude to Online Training

		Attitude to Online Training					Total
% of online courses completed		I am extremely critical/ pessimistic	I am somewhat critical/ pessimistic	No Opinion	Somewhat supportive/ optimistic	Extremely supportive/ optimistic	
None	N	11	78	187	342	89	707
	% within Attitude to online training	52.4%	34.5%	68.8%	36.5%	29.4%	40.2%
20% or less	N	1	21	19	67	19	127
	% within Attitude to online training	4.8%	9.3%	7.0%	7.2%	6.3%	7.2%
21% to 40%	N	1	9	6	39	5	60
	% within Attitude to online training	4.8%	4.0%	2.2%	4.2%	1.7%	3.4%
41% to 60%	N	2	16	2	52	15	87
	% within Attitude to online training	9.5%	7.1%	.7%	5.5%	5.0%	4.9%
61% to 80%	N	1	18	4	65	22	110
	% within Attitude to online training	4.8%	8.0%	1.5%	6.9%	7.3%	6.3%
81% to 100%	N	5	84	54	372	153	668
	% within Attitude to online training	23.8%	37.2%	19.9%	39.7%	50.5%	38.0%
Total	N	21	226	272	937	303	1759
	% within Attitude to online training	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

($p < 0.001$)

19. Did you or your company pay for the most recent online session you attended?

As can be seen from Table 4.21, a significant proportion (41%) of e-learning courses have been paid for. This gauge was used to assess how seriously possible users viewed the product in view of the fact that it is often assumed that much of what is available on the internet should be free (and this is supported by the qualitative comments reviewed later).

Table 4.21

Percentage Paying for E-learning

		Frequency	Percent	Valid Percent
Valid	No	1030	42.5	58.6
	Yes	729	30.1	41.4
	Total	1759	72.5	100.0
Missing	System	666	27.5	
Total		2425	100.0	

A cross tabulation ($p < 0.001$) was performed between paying and attitude towards online learning. It was noted that there was a significant number who did not pay for their e-learning and did not complete the course (93%) as per Table 4.22. As expected, paying for the courses gives a stronger possibility of completing the course. This can be seen from the cross tabs where the higher completion % is associated with paying patrons (e.g., 68% of those who completed 81% to 100% of a course, were paying respondents, against 32% who did not pay).

Table 4.22

Cross Tabulation between Paying for E-learning and Completion

Paid or not for online courses * Percentage of online courses completed Crosstabulation

			Percentage of online courses completed						Total
			None	20% or less	21% to 40%	41% to 60%	61% to 80%	81% to 100%	
Paid or not for online courses	No	N	658	61	24	37	39	211	1030
		% within Percentage of online courses completed	93.1%	48.0%	40.0%	42.5%	35.5%	31.6%	58.6%
	Yes	N	49	66	36	50	71	457	729
		% within Percentage of online courses completed	6.9%	52.0%	60.0%	57.5%	64.5%	68.4%	41.4%
Total		N	707	127	60	87	110	668	1759
		% within Percentage of online courses completed	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

($p < 0.001$)

20. What best depicts your attitude or viewpoint towards online learning?

A possible 70% (of those who knew what online training was) indicated that they were somewhat or extremely supportive or optimistic about online learning with a slender 10% indicating they were somewhat critical or pessimistic

Table 4.23

Attitude to Online Training

		Frequency	Percent	Valid Percent
Valid	I am extremely critical/pessimistic	21	.9	1.2
	I am somewhat critical/pessimistic	226	9.3	12.8
	No Opinion	272	11.2	15.5
	Somewhat supportive/optimistic	937	38.6	53.3
	Extremely supportive/optimistic	303	12.5	17.2
	Total	1759	72.5	100.0
Missing	System	666	27.5	
Total		2425	100.0	

21. How much knowledge do you have related to online learning in your organisation?

There is a wide distribution skewed towards a lower amount of knowledge on online learning. However bearing in mind, the total number who have taken the survey, the none/no knowledge percentage is effectively 38% (comprising 28% who knew nothing of e-learning (as indicated in Question 15) plus 10% who had no knowledge of it in their organisation), which is a significant amount. This shows that e-learning (and indeed blended learning) has a significant way to go to penetrate the engineering and industrial automation spheres.

Table 4.24

Knowledge of Online Training in your Firm

		Frequency	Percent	Valid Percent
Valid	None	253	10.4	14.4
	Low/minimal	515	21.2	29.3
	Medium/some	717	29.6	40.8
	High/significant	245	10.1	13.9
	Extremely high/significant	29	1.2	1.6
	Total	1759	72.5	100.0
Missing	System	666	27.5	
Total		2425	100.0	

22. What is the average total duration of a typical online learning course you have attended (i.e. possibly with multiple sessions)?

The average duration was for 30 to 60 minutes (19%), followed by a fairly lengthy 1 to 2 hour duration (15%). There is a significant proportion which had undertaken sessions greater than 2 hours (23%). The confounding variable is the number of sessions that were undertaken for a particular online course – it could be that the individual sessions were less than 60 minutes but were over a number of sessions.

A small percentage (1%) selected the Other category where it was indicated that some of the total durations were lengthy but spread over multiple sessions. Some of the individual e-learning sessions were extraordinarily long such as 3 hours long. Many of the respondents were undertaking a distance learning program over a few years (e.g., “2 years” and “year” were responses).

23. How long has your organisation been using blended learning (i.e. combining online experiences and face-to-face classroom sessions) as part of its employee training?

Most reported a fairly recent use of blended learning – over the past 1 to 2 years (22%) with a significant number indicating no experience with blended learning at all (52%). This question tends to agree with Question 24 (length of use of e-learning) with virtually the same percentages up to 6-10 years.

A cross tabulation ($p < 0.01$) between the duration of use of blended learning against job function revealed a significant relationship with training (and human resources to a lesser extent) indicating more than 10 years knowledge of blended learning. There were also fewer people who indicated no experience of blended learning from these two departments.

24. How long has your organisation been using fully online courses or programs as part of its employee training?

The majority of respondents to this question, indicated that they were not (see Figure 4.3) using online training at all (53%) with 21% indicating only over the past 1 to 2 years. The emphasis in the question has been on "fully" online courses; so presumably the respondents have answered the question correctly in interpreting this as completely online with no mix with classroom instruction (forming blended learning).

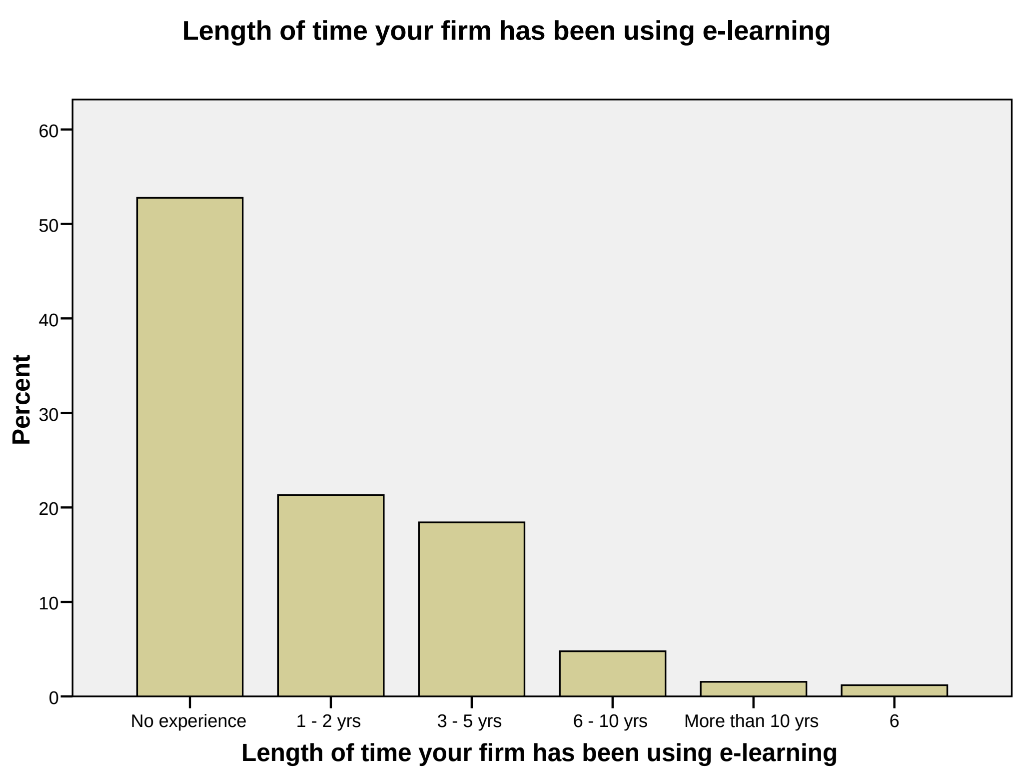

Figure 4.3. Length of time respondent has been using e-learning.

Under Other, there were no particularly useful suggestions apart from unsure. It is possible, as the one respondent indicated, that this is a “badly posed question”, that many respondents did not know the answer to this question.

25. In general, are online courses more engaging or motivating than face-to-face courses and classroom designs?

A significant number (56%) felt online courses were not more engaging. A proportion of this would include people who have not actually attended online training (50% from Question 16) and believe this to be the case without first hand experience. A very small percentage of 10% felt that online training is more engaging. A significant proportion (34%) of respondents absented themselves from answering this question directly, and presumably would mainly include those who had not attended an e-learning course.

Table 4.25

Online Courses more Engaging than Face-to-face Classroom

		Frequency	Percent	Valid Percent
Valid	Yes	177	7.3	10.1
	No	978	40.3	55.6
	Don't know	604	24.9	34.3
	Total	1759	72.5	100.0
Missing	System	666	27.5	
Total		2425	100.0	

26. What is the overall quality of online courses used in your organisation?

Although the majority indicated they did not know (42%); a cautious 38% thought they were “somewhat engaging/interactive” or “extremely engaging/interactive”. About 20% felt that they were either extremely boring/non-interactive or somewhat boring/non-interactive.

In retrospect, the previous two Questions 25 and 26, overlap to a certain extent but provide some interesting insight. E-learning in comparison with classroom-based activities is not considered as good (Question 25). However considered on its own as posed in this question, it was thought that the quality of e-learning is reasonably acceptable.

Table 4.26

Overall Quality of Online Courses in the Firm

		Frequency	Percent	Valid Percent
Valid	Extremely boring/non-interactive	41	1.7	2.3
	Somewhat boring/non-interactive	308	12.7	17.5
	Somewhat engaging/interactive	599	24.7	34.1
	Extremely engaging/interactive	64	2.6	3.6
	Do not know	747	30.8	42.5
	Total	1759	72.5	100.0
Missing	System	666	27.5	
Total		2425	100.0	

27. Estimate the overall mix of training by format that you have personally engaged in over the past year. Total should add up to 100%. Please leave blank if you do not use.

This was to give some understanding of the mix of training used by the respondents. All the distributions were non-normal and difficult to assign a mean to. However it was possible to summarise the modes for each of the distributions. Coakes and Steed (2005) remarked that "The appropriate chart for a categorical variable (rank) is a bar chart and the mode is the appropriate measure of central tendency" (p. 62).

A summary of modes is as follows:

Table 4.27

Summary of Modes from Various Forms of Training

		Overall mix of training - face-to-face	Overall mix of training - synchronous e-learning	Overall mix of training - self-paced online	Overall mix of training - Offline (eg CDROM)	Overall mix of training - mentoring, coaching etc	Overall mix of training – print-based learning	Overall mix of training - audio/video	Overall mix of training - other
n	Valid	1679	1095	1289	1223	1307	1390	1010	684
	Missing	746	1330	1136	1202	1118	1035	1415	1741
Mode		6	1	2	2	2	2	1	1

It can be seen that face-to-face training has a mode of 50% ("6") which is to be expected. In comparison, synchronous e-learning and audio/video have modes of 0 % ("1"). Self paced online, offline using CDROM, mentoring, print-based learning have modes of 10% ("2"). The observation is that self-paced online is thus slightly more than for synchronous e-learning. Note that the percentages were not normalised to 100%; but a spot check revealed that the totals for each respondent were approximately 100%.

28. Have you ever undertaken hands-on training using remote labs or simulation software as part of your e-learning course? Please select which ones you have undertaken as part of your e-learning course

Although in retrospect, it was noted that there was perhaps a defect in the way this question was posed where it should have allowed multiple responses (e.g., simulation software and hands-on remote labs could have both been selected), the responses are still useful.

As indicated in Table 4.29, a surprising 27% used simulation software as part of the e-learning course. A small percentage used remote labs (6%). A significant 65% indicated that they either did not know what this question was about or did not use remote labs or simulation software.

Table 4.28

Hands-on Training through E-learning or Not

		Frequency	Percent	Valid Percent
Valid	No; or don't know	1143	47.1	65.0
	Hands-on remote labs	113	4.7	6.4
	Simulation software	476	19.6	27.1
	Other	27	1.1	1.5
	Total	1759	72.5	100.0
Missing	System	666	27.5	
Total		2425	100.0	

In the comments field under the Other category (containing about 30 comments), there was a telling comment: "Tried to but found it difficult" and "software didn't run correctly on my computer"; indicating that the technology has been difficult to apply but perhaps the time is propitious to demonstrate in this research that it is possible and easy to apply. The other responses indicated that some respondents (only two) were using both hands-on remote labs and simulation labs. The question, did not allow this choice of both, hence the respondents used the Other field to indicate this. This oversight is not regarded as a significant problem because of the few that indicated in the Other category, that they had tried to select both categories.

A cross tabulation was performed with the other data gathered and there were some useful results. Firstly, for hands-on training against that of job function ($p < 0.001$), the training function was more likely to use remote labs, and human resources to use simulation software. However, the number of respondents in training was thin (13 total); so this result should be treated with caution. Secondly, for hands-on training against that of online courses being more engaging or motivating ($p < 0.001$) there was a significant direct relationship between engaging and using remote labs. However, for simulation software, there was no significant relationship. It is possible that the words simulation software mean different things to the respondents; hence the difference.

Table 4.29

Cross Tabulation for Hands-on Training using Remote Labs or Simulation against More Engaging than a Face-to-face Classroom

			Online more engaging than face-to-face classroom			Total
			Yes	No	Don't know	Yes
Hands-on training through e-learning or not	No; or don't know	n	88	586	469	1143
		% within Online more engaging than face-to-face classroom	49.7%	59.9%	77.6%	65.0%
	Hands-on remote labs	n	21	69	23	113
		% within Online more engaging than face-to-face classroom	11.9%	7.1%	3.8%	6.4%
	Simulation software	n	65	310	101	476
		% within Online more engaging than face-to-face classroom	36.7%	31.7%	16.7%	27.1%
	Other	n	3	13	11	27
		% within Online more engaging than face-to-face classroom	1.7%	1.3%	1.8%	1.5%
Total		n	177	978	604	1759
		% within Online more engaging than face-to-face classroom	100.0%	100.0%	100.0%	100.0%

($p < 0.001$)

29. Does your organization calculate return on investment (ROI) for online learning courses, or initiatives?

A significant (perhaps, optimistic) 9% indicated that ROI calculations on training were performed, against 43% who did not. There was some uncertainty in the quality of the responses to this question as the topic requires some knowledge of what ROI is (as can be seen with the large percentage of 48% who indicated no knowledge of ROI calculations).

There were about ten respondents who filled in the Other category but there was nothing particularly useful here apart from the comments of intentions of undertaking ROI calculations, the company does not provide training and calculations are done for "all issues".

4.2.4 Future Projections

E. Future Projections of online learning (please make your best guesses regarding the future of online learning)

30. How will your organisation's spending in online learning change during the next few years?

A convincing 50% indicated that online learning expenditure would either increase slightly or significantly with only 3% suggesting a decrease was going to happen.
Under the Other comment field, the remark was made by a few that they were uncertain or did not do any online training at all.

31. How will online learning be used in your organization in the next few years? (Check all that apply)

This question unfortunately indicated multiple responses were possible; but effectively only the single most important issue could be identified. The results may be suspect if the respondent was irritated by the duration of the survey and the fact that the question was inadequately posed.

It can be seen (Figure 4.4) that a strong proportion (56%) felt that they would use e-learning to enhance their classroom or instructor learning experience; thus creating a blended learning experience. This figure is achieved by adding together "Follow-up to instructor-led courses" and "supplement to instructor-led courses". Very few (4%) thought that e-learning would be the sole source of training in their organisation.

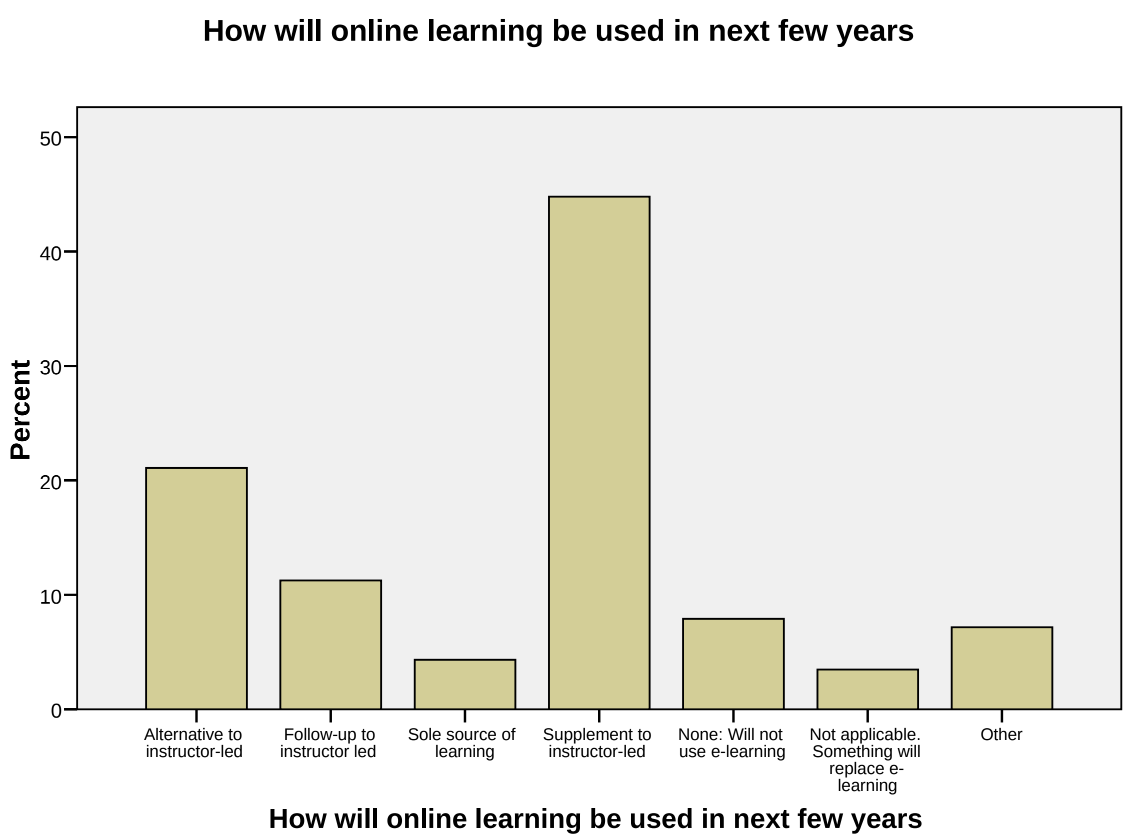

Figure 4.4. Usage of online training in the following few years

In the Other category, most responses indicated uncertainty ("I don't know"), they do not use any e-learning at all or they would consider using it as a blended course in conjunction with classroom instruction.

32. From the perspective of your organization, what is the most significant online learning issue or problem that must be addressed during the next few years?

The most significant problems were not directly related to e-learning production itself but were insufficient management support (16%), boring and low quality content (15%) fast changing technology (13%), and cultural resistance (13%). Of least importance, was regarded “More hype than fact” and “unethical vendors”. The theme of insufficient management support and boring and low quality content is canvassed extensively in the qualitative comments section later (Question 37).

Table 4.30

Most Significant Issue in Online Learning

		Frequency	Percent	Valid Percent
Valid	Boring & low quality content	253	10.4	14.4
	Cultural resistance	227	9.4	12.9
	Fast changing technology	234	9.6	13.3
	High costs	135	5.6	7.7
	Insufficient management support	277	11.4	15.7
	Lack of standards	82	3.4	4.7
	Limited bandwidth	143	5.9	8.1
	Limited organisational vision	150	6.2	8.5
	More hype than fact	68	2.8	3.9
	Unethical vendors	13	.5	.7
	Other	177	7.3	10.1
	Total	1759	72.5	100.0
Missing	System	666	27.5	
Total		2425	100.0	

The Other category for significant online learning issues, had some particularly useful comments covering a rather broad spectrum (with a large number who were unsure). These ranged from materials not in the local language, high costs, certification, lack of hands-on interaction, IT problems, bandwidth deficiencies, paucity of suitable materials, time issues, lack of experienced instructors and motivation to complete the materials. Some unusual comments related to non-standardised software and lack of experienced tutors to guide students with possible safety issues as a result. As indicated earlier, most of these comments were canvassed in the summary of points included in Question 37.

33. What percentage of employee training in your organization is blended (i.e. courses that have online as well as face-to-face or conventional classroom components) today and how might this change in 5 years time?

A definite 20% or less of employee training is blended today with most feeling that 20% to 40% would be blended in five years time.

Table 4.31

Percentage of Training that is Blended Today

		Frequency	Percent	Valid Percent
Valid	0%	608	25.1	34.7
	1 to 20%	714	29.4	40.7
	21 to 40%	248	10.2	14.1
	41 to 60%	114	4.7	6.5
	61 to 80%	48	2.0	2.7
	81 to 100%	22	.9	1.3
	Total	1754	72.3	100.0
Missing	System	671	27.7	
Total		2425	100.0	

Table 4.32

Percentage of Training that will be Blended in Five Years Time

		Frequency	Percent	Valid Percent
Valid	0%	144	5.9	8.6
	1 to 20%	424	17.5	25.2
	21 to 40%	471	19.4	28.0
	41 to 60%	387	16.0	23.0
	61 to 80%	202	8.3	12.0
	81 to 100%	56	2.3	3.3
	Total	1684	69.4	100.0
Missing	System	741	30.6	
Total		2425	100.0	

34. What percentage of employee training in your organisation is fully online today and how might this change in 5 years time?

Most felt that a nil % of employee training currently had an online component with a predicted 1 – 20% in five years time. This is less than the blended learning component as per the previous question.

Table 4.33

Percentage of Training that is Online Today

		Frequency	Percent	Valid Percent
Valid	0%	655	28.9	40.0
	1 to 20%	649	28.7	39.6
	21 to 40%	177	7.8	10.8
	41 to 60%	91	4.0	5.6
	61 to 80%	42	1.9	2.6
	81 to 100%	24	1.1	1.5
	Total	1638	72.3	100.0
Missing	System	626	27.7	
Total		2264	100.0	

Table 4.34

Percentage of Training that is Online in 5 years Time

		Frequency	Percent	Valid Percent
Valid	0%	174	7.2	10.5
	1 to 20%	510	21.0	30.6
	21 to 40%	399	16.5	24.0
	41 to 60%	338	13.9	20.3
	61 to 80%	180	7.4	10.8
	81 to 100%	64	2.6	3.8
	Total	1665	68.7	100.0
Missing	System	760	31.3	
Total		2425	100.0	

35. In your organisation, which online learning technology will most dramatically increase in use during the next few years?

The highest response (13%) indicated that learning management systems use would be increased followed by testing (13%). Web-based video conferencing was considered as third most in importance (11% of the responses). If the three forms of synchronous e-learning are grouped together (synchronous or live presentations tools, video streaming and web-based video), a total of 25% indicate this is the direction that will be followed in the future. Together with instant messaging (2%), asynchronous e-learning was not considered highly with only 3% indicating this would increase. A significant number (34%) indicated uncertainty with an "I don't know" answer.

Table 4.35

Online Technology which will Increase Dramatically

		Frequency	Percent	Valid Percent
Valid	Asynchronous or delayed discussion forums	43	1.8	2.4
	Electronic whiteboards	64	2.6	3.6
	Instant messaging and synchronous chat tools	30	1.2	1.7
	Learning Content Management systems	137	5.6	7.8
	Learning Management systems	234	9.6	13.3
	Online testing and examination tools	228	9.4	13.0
	Synchronous or live presentation tools	93	3.8	5.3
	Video Streaming (lectures, content, experts etc)	153	6.3	8.7
	Web-based video conferencing	188	7.8	10.7
	I don't know	589	24.3	33.5
	Total	1759	72.5	100.0
Missing	System	666	27.5	
Total		2425	100.0	

36. In your organization, which of the following methods will be used to deliver training in the next few years? (Check all that apply)

The most important methods were considered to be instructor-led classrooms (20%), multimedia - DVD's and CDROM's (13%), self-paced online (11%). blended learning (12%), followed by asynchronous tools (9%). Instructor led online learning came in at 7%. A surprising 8% indicated paper-based correspondence courses. Of least importance was considered satellite and virtual reality. This is not really surprising considering that a good internet infrastructure would mean that satellite communications is not as critical (apart from communications to remote sites). Virtual reality is still in its infancy and although web sites such as Secondlife are popular, there is little current evidence so far of this technology being applied to the engineering area.

Surprisingly as they are new and rapidly growing technologies, wireless and virtual reality got short thrift with very low percentages.

Table 4.36

Methods of Training in the Future

		Responses		Percent of Cases
		n	Percent	
Methods of training in future(a)	Asynchronous tools	749	8.8%	31.3%
	Blended	982	11.5%	41.0%
	Instructor led classroom	1718	20.1%	71.8%
	Instructor-led online learning	580	6.8%	24.2%
	Multimedia (CDROM)	1116	13.1%	46.6%
	Paper-based correspondence	693	8.1%	29.0%
	Peer-to-peer online learning networks	455	5.3%	19.0%
	Satellite broadcast	93	1.1%	3.9%
	Self-paced online	977	11.4%	40.8%
	Streaming video	337	3.9%	14.1%
	Synchronous tools (eg chat, virtual classrooms)	330	3.9%	13.8%
	Videotape	256	3.0%	10.7%
	Virtual reality	64	.7%	2.7%
	Wireless technology	159	1.9%	6.6%
	Other	33	.4%	1.4%
Total		8542	100.0%	357.0%

a Group

Comments from the Other field generated important comments on the need for on-the-job training (mentioned twelve times), self learning using books, technical support via email, and none or minimal training provided by company. These comments are important as these training solutions are often neglected in the pursuit of advanced technology solutions which was the focus of the question.

4.2.5 Qualitative Results

37. Feel free to list additional comments relating to any of the items in this survey, especially regarding the future of e-learning and blended learning. Actual e-learning stories and future e-learning predictions are also welcome.

There were over 400 comments from the quantitative survey and some useful observations can be made. The comments were grouped together based on the commonality between the comments. This resulted in the following 19 categories:

- General e-learning problems
- Management support for e-learning is required
- Bandwidth and infrastructure are limitations for e-learning
- More marketing and awareness needed
- Motivation and incentive to complete e-learning
- Instructor-led classes better than online training
- Younger generation more open to online training
- E-learning and hands-on experiential learning
- Costs of e-learning should be low
- Accreditation of e-learning
- E-learning will grow in the future
- E-learning is effective
- Blended learning is important (as opposed to only one form of learning)
- No familiarity with e-learning, blended learning or training
- The survey has problems or is not appropriate
- Examples of e-learning and blended learning
- General comments about training and what engineers and technicians need
- Alternatives to online learning
- Miscellaneous comments

A summary of the comments is as follows.

General e-learning and blended learning problems (43 comments)

There was a large list of potential and real problems listed for e-learning. Many commented about the poor learning experience such as "boring" and "dull training". Most felt that face-to-face was the only training that could provide a proper learning experience. Many commented on the rigid e-learning experience which did not have the flexibility of instructor-led training. Other comments related to the failure of e-learning courses at their facilities, use of American standards when local country ones should be used, lack of follow up discussions, inability to ask follow up questions, doubts about whether people are indeed absorbing the required knowledge, lack of interaction possible with questions on the fly, and the difficulty of doing e-learning at work with all its attendant interruptions. One respondent was concerned about the lack of standardisation with e-learning delivery platforms.

Overall, from the comments, it is clear that most of these complaints were based on asynchronous online training, which were often simply a "book on the web" as opposed to a proper course, with no live instructors available to interact with. There would appear to be limited experience in synchronous and interactive e-learning as detailed in Chapter 2. Unfortunately, these negative experiences have tarnished the perceptions of these users about all e-learning, whether it be asynchronous or synchronous.

Management support of e-learning is required (13 comments)

There was an unusually high number of comments relating to poor management support for e-learning and new training initiatives. The consensus was that management did not provide time and resources for learning, there was minimal encouragement for completing e-learning courses and there was no interest in assessing and embracing any new learning technologies. Finally, companies preferred to hire fully trained people for the work tasks rather than investing in further training.

Bandwidth and infrastructure are limitations for e-learning (19 comments)

It was pointed out that e-learning would have difficulty operating on remote sites and countries with poor infrastructure, such as in Africa. This was mainly due to poor data communications links and inadequate computer facilities. It was emphasised by a number that this was an important issue and companies who had an excellent communications infrastructure and connection to the internet would have a great future with e-learning. Failure to have adequate working systems in place would result in a frustrating experience with e-learning.

More marketing and awareness needed (18 comments)

As suggested in Chapter 1, it was felt that blended learning and e-learning would be reasonably new concepts for engineers and other technical professionals. This assertion was supported by the number of comments on raising awareness of possible users and companies in the new technologies of training and thus to expand the offering of e-learning and blended learning courses. Many users had no idea of the essential characteristics and the differences between e-learning or blended learning and what they could do with these technologies. Some felt that the lack of awareness and minimal marketing of e-learning meant that there was a paucity of technical and engineering (as opposed to IT and management type) training courses available.

Motivation and incentive to complete e-learning (three comments)

There were comments about the difficulty in completing the programs especially when they are self-paced as there are no incentives in place. Young students have difficulty in completing self-paced learning.

Instructor-led classes better than online training (17 comments)

Admittedly, whilst this is an overlapping group with the e-learning problems category above, there were sufficient comments to make this a separate category. From the tenor of the comments, it is believed that most were comparing instructor-led training with the asynchronous e-learning variety. One comment indicated an experience with a synchronous presentation where it was said that it was monotonous and the instructor appeared to be reading from a book. There is no doubt that this reinforces the comments made in Chapter 2 under Myths that the instructor is probably even more important in a synchronous e-learning presentation than in an instructor-led training course. Other comments in comparing online training to instructor-led training indicated that the former involved a lot of reading, inflexibility in format, lower levels of motivation to complete, lower levels of enjoyment, a wider variety of instructor-led offerings, bland and boring presentations.

Younger generation more open to online training (five comments)

It was felt that the younger generation would be more accepting of e-learning due to their familiarity with computers and the associated technologies.

E-learning and hands-on experiential learning (13 comments)

As suggested in the literature review, some disquiet was expressed by the lack of hands-on experiences with e-learning. The general view expressed was that it was impossible to undertake training of engineers without hands-on practical experience with equipment. This was essential for the training of engineers and technical professionals, and this could only be achieved in a classroom environment. A useful and detailed suggestion was to split the topics into different categories: web-based to fit into the student's lifestyle, classroom to allow them to focus on one subject and hands-on to solidify the learning. Finally, one user noted that it ultimately depended on the person's learning style – but getting "trades staff to sit at a PC to learn is a challenge both in skill, attitude and time." Hands-on training with real equipment was thought useful to reinforce the theoretical learning.

Costs of e-learning should be low (19 comments)

A number of comments noted that it was important for e-learning to be priced affordably. A lower price would encourage far more users. The advantages for companies in paying considerably less than for an instructor-led classroom was also mentioned. Other concerns to do with costs were the significant upfront investment companies had to make to purchase a suite of e-learning programs and the risk of purchasing unknown e-learning materials,

Accreditation of e-learning (four comments)

A number of respondents were concerned about the status of e-learning in terms of suitable accreditation, compared to that of classroom sessions.

E-learning will grow in the future (12 comments)

There were a number of assertions that use of e-learning would increase significantly in the future. There were no significant reasons attached to this, besides the need to train more people.

E-learning is effective (51 comments)

There were a large number of comments about the effectiveness of e-learning – these were of a similar number to the negative ones, indicating a mixed response. These advantages were based on lower costs, minimal travelling, convenience, time flexibility, coping with students with different abilities and knowledge levels and excellent graphical displays. A few commented on how more powerful training could become in using e-learning to prepare students before a classroom session (thus forming a blended solution). One noted that it was important to apply e-learning for its educational benefits; but not simply as a method of cutting costs.

Blended learning is important (as opposed to only one form of learning) (18 comments)

A large number of respondents felt that blended learning was an excellent approach in allowing an appropriate mix of classroom and e-learning. Presumably, this group included those disaffected with e-learning on its own, and who felt that combined with instructor-led training, blended learning represented an effective solution. Some pointed out that they first did an e-learning course covering the theory and bringing the respondent up to the right level before engaging in a practical hands-on course.

The one user noted that they felt it was far more successful than classroom learning on its own in transferring of knowledge and skills. Another suggested that blended learning compensated for the inadequacy of e-learning in only allowing limited discussions between participants and instructor. There was a suggestion that blended learning allowed for more training-on-demand and catered to a wider range of student abilities.

No familiarity with e-learning, blended learning or training (15 comments)

There were numerous comments about the lack of familiarity with e-learning and blended learning. This lack of knowledge was anticipated in the quantitative survey; hence the questions have been made as straightforward as possible and an opportunity given to skipping most of the questions when unsure about how to answer them.

The survey has problems or is not appropriate (17 comments)

There were a number of comments about the inadequacies of the survey. Many felt that the lack of knowledge of the topics meant that the questions would not be answered correctly. This was dealt with in the previous comment. There were a few problems with some of the survey questions which caused some angst. A few questions did not allow multiple choices and some felt that this was unreasonable (Question 35). Others commented about the survey being too lengthy.

Examples of e-learning and blended learning (61 comments)

A range of experiences with e-learning and blended learning were described. The noteworthy ones included:

- The Royal Australian Navy uses e-learning for Windows applications, Occupational and Health and Ethics training. No technical topics are covered at this stage.
- A study of communications networks was done via a recorded lecture which the student could access at a convenient time.

- Safety training and testing for contractors was done via e-learning. This supplemented the face-to-face training.
- It is used for compliance training in the company's environmental management systems and computer type applications.
- An associate degree in electrical engineering is undertaken using e-learning. Problem solving is done as a team, where the class members are scattered around Australia and overseas..
- All of the e-learning training is done with safety rules, confined spaces, fire fighting, team building and leadership. Nothing is done with technical course e-learning in this particular firm.
- E-learning is used for inductions where many people cover the same material and the questions force one to read the materials and thus pay attention to the course.
- One company operates a business school with an external provider but at present attendance is selective and limited.
- Internet-based exhibitions and presentations are provided but these are variable in quality.
- E-learning focuses on ethics, safety, security but the quality is very poor.
- Quality of online courses is very poor (repetitive and rigid questions) but they have been made compulsory by the company.
- E-learning was aimed at teaching employees standard operation procedures (SOP's).

It would appear from the above, that a considerable number of e-learning applications are oriented towards safety training and ethics training. No mention was made of detailed corporate technical training provided by the firm itself and certainly nothing using hands-on experiential training, although there was some mention of technical college (TAFE) and university level training.

General comments about training and what engineers and technicians need (34 comments)

This category had a large number of comments which varied across the spectrum of training; not necessarily dealing with e-learning and blended learning. Many of the world-wide trends with work and training were discussed such as the increased mobility of staff and the need for training to be focussed on a specific job. The use of competency assessments to protect the firm from poor performance by individuals was also noted. The complaint of organisations (especially smaller ones) not encouraging or paying for training was raised. Some pointed out that most of their training is conducted informally by reading books, magazines and reading on the web; as opposed to a formal training course. The importance of on-the-job training was reinforced with one user suggesting "we use the 70/20/10 rule here 70% hands-on experience, 20% mentoring/guiding hands, 10% courses to hand". Concerns about impending retirement of many in the workforce were mentioned and the need for training to maintain the integrity of the operation.

Alternatives to online learning (five comments)

There were a few comments made about the importance of alternatives to e-learning which is spontaneous searching of the internet and reading up of information available. This is certainly a growing and successful way of gathering information and knowledge increasingly facilitated by the internet and should not be ignored in future surveys.

Miscellaneous comments (39 comments)

This cannot really be considered a category but a "catch all" listing of the comments which had difficulty fitting into any of the other categories. Many noted that they would like to have Masters and doctoral degrees offered online and to have further qualifications in industrial automation. A number noted the need for more information about e-learning and blended learning.

38. As part of this survey we plan to interview some of the participants to better understand your training application, if you have attended training in the area of blended learning or e-learning in the past 24 months. Please let us know if you would like to participate in this 20 minute telephone interview.

There was a significant response here to this question with over 530 respondents (24%) indicating that they were willing to be interviewed which demonstrated a groundswell of support for the research. However, due to the excellent qualitative data received from the original survey, this was not considered necessary.

4.3 Conclusion

The survey instrument examined the responses from over 2,400 respondents in four categories of background information, current training situation, and status of e-learning and blended learning, and the future of blended and online learning. The wealth of both qualitative and quantitative data helped form a detailed picture of the training environment of the working engineer and technician on a worldwide basis which will be assessed in the conclusion contained in next chapter.

Chapter 5

Conclusions

5.1 Introduction

Whenever assessing results, in applying Occam's razor (Heylighen, 1997) one should always look at the information available for the simplest explanation or apply the principle of parsimony, in creating an appropriate model. There was a considerable amount of both qualitative and quantitative material derived from the initial survey with approximately 2,400 respondents and the conclusions that can be drawn from this are discussed in the following sections. The overall sample size is significant compared with other surveys of engineers and technicians on e-learning and blended learning completed on a worldwide basis and these results thus have some credibility. The conclusions are then used to build a series of recommendations in order to effectively apply these new training technologies for training of engineers and technicians in a corporate setting.

The thesis of this study, was that blended learning would improve the reaction, achievement and return on investment (ROI) of industrial automation training compared with that of either the classroom alone or e-learning alone. Blended learning in this research comprises synchronous video conferencing and classroom instruction with an emphasis on a hands-on experience or "learning by doing" in industrial automation.

The results of the survey provided an excellent picture of blended and online learning for engineers and technicians throughout the world. Overall, there appeared to be concern about the quality of e-learning, as derived both from the quantitative results and the associated qualitative comments. Although the use of e-learning in engineering and industrial automation is considerably less than for other areas such as business and IT, the use of e-learning and blended learning was far greater than anticipated and there is significant growth in the use of these new technologies.

The results derived here were analysed with reference to the data in the literature review (Chapter 2) and compared with those from equivalent surveys such as that from Kyong-Jee, Bonk, and Zeng (2006), hereinafter referred to as the K-J survey, who surveyed 239 training professionals in the USA using a 49-item survey. A few other surveys will also be referred to where their findings impinge on the particular results discussed in the following sections

It should be noted that the survey respondents in this research were relatively unsophisticated as far as e-learning was concerned, so a direct comparison should be treated with caution. Most of the respondents' primary job function was as an engineer or technician. A relative few could be considered to be training professionals; although a large proportion (56%) indicated that they have presented courses. This assertion that the respondents are relatively unsophisticated in terms of e-learning is supported by the answers to Questions 15 ("Do you know what e-learning and blended learning is" ?) and 16 ("Have you attended an e-learning or blended learning training course in the past 36 months" ?) where over 60% indicated in the negative or did not know what e-learning or blended learning meant (compared to 70% in the K-J survey who indicated they had attended an e-learning course in the past 24 months).

There were two main sources of information derived in the survey and the sequence followed in the discussion is oriented around the quantitative survey. The qualitative comments are used to support or rebut the quantitative results and allow some degree of triangulation to strengthen the overall research conclusions.

In the following sections; first the main conclusions that can be drawn from the survey are considered; then the hypotheses posed in Chapter 1 are assessed. After this, additional insights about the research problem are evaluated. The implications for overall theory in the parent disciplines and the broader field are summarised. The implications for policy and practice in industrial automation and engineering are then covered with a number of recommendations. Other limitations that became evident during the research that were not considered in Chapter 1 are then listed. Finally, a few suggestions are made for further research.

5.2 Conclusions About the Research Questions

The survey was broken down into four main sections:

- Background information on the respondent and organisation
- Current training status
- Current situation with online learning and blended learning
- Future projections of online learning
- Final qualitative comments

The qualitative comments, are discussed in the appropriate questionnaire section below. There is a mass of results in Chapter 4 that need to be coalesced into a few useful conclusions in terms of the initial research objectives.

5.2.1 Background Information

The target audience was mainly engineers with a smaller proportion of managers and very few tradespeople and operators. As the respondents were sourced from reasonably randomly constructed databases, it can be assumed that they were fairly typical of the engineering fraternity; admittedly with a bias towards electrical, industrial automation and mechanical engineering (i.e. a minimal number would be from civil engineering, for example). The dominant job function was in engineering maintenance (59%) followed by research and development (14%). This compares with the K-J survey, where there were 20% executives and 22% managers (giving a total of 42%). Most of the K-J survey respondents were in the corporate training or corporate HR departments with titles such as chief learning officers, training managers, trainers/instructors; which represented less than 10% of the respondent numbers (human resources plus training selections in Question 2) of this survey.

One of the noteworthy issues was the few females (4%) in engineering. This compares with the K-survey which had 67% male respondents; a significantly greater number of females due to the focus being on training professionals as opposed to the engineering environment. There is no doubt that females are considerably under-represented in engineering. This is of concern as the “newer”, perhaps more femalefriendly engineering technologies (such as industrial automation) are strongly represented in this sample (as opposed to the more traditional disciplines such as civil engineering). However, there is evidence of a stronger enrolment of younger females against younger males in engineering compared with earlier years.

As noted in section 1.1.4, there is evidence that the bulk of engineers are older and the engineering workforce is aging and there are insufficient young engineers and technicians entering the workforce to overcome this shortfall in workers. The overwhelming bulk of respondents were in the over 30 year age group. There is also evidence that the traditional western economies (North America and Europe) are experiencing an even greater aging workforce than in the other regions. There are going to be problems encountered in transferring the wealth of knowledge and expertise contained in the aging workforce across to the younger workers. Furthermore, these numbers imply that there is a need to accelerate the number of young entrants joining the engineering workforce as there is going to be a serious shortage of engineering personnel over the next decade.

The USA and Canada (North America) have a particular problem with an aging workforce that require serious attention. A recent survey, discussed earlier in section 1.1.4 by Wilkins (2007) pointed out that in the developed countries such as the USA and the UK, the engineering and technical workforce is getting older and eventually retiring. He felt that manufacturing and engineering do not appeal to the young person today and this is adding to the shortage of good quality entrants to the workforce where the skills requirements are far greater than in the past. He pointed out that retention is as important to manufacturers today as recruitment. He proposed a strategy of capturing both the organisational and experiential knowledge of their workforces and implementing a coherent and effective training program. Many in the qualitative survey noted that the younger generation were more likely to be enthusiastic about e-learning than those who were older, and in many cases, less computer literate.

The most active areas for employment for engineers and technicians would appear to be manufacturing, consulting and contracting, oil and gas, and public utilities. This contrasted with the K-J survey which found respondents mainly in communications, consulting, health, IT, government and non-profit organisations (which had nil respondents in this survey). Almost a quarter of the respondents came from firms with fewer than 100 employees followed by those of 101-500 employees. The K-J survey had equivalent responses with 25% being from firms with fewer than 100 people. But significantly there were significantly a greater number of larger companies in the K-J survey. This is possibly a reflection of the K-J survey focussing on companies in the USA, which are larger. Another reason could be that the K-J survey targeted companies with training departments, which could mean larger companies, as smaller companies do not typically focus on training (as per earlier partially anecdotal comments).

The educational level was strongly oriented towards graduates or advanced degree holders who made up most of the sample. The respondents were drawn from a reasonably wide geographical region across North America, Europe, Africa with over half from the Asia Pacific region. This has no real significance apart from reflecting the main sources for the survey. The K-J survey only drew their respondents from the USA.

5.2.2 Current Training Status

There was a mix of instructors (11%), learners (45%) and both (45%) in the sample. Based on the job titles not being overwhelmingly instructors and the department they work in; it is likely that most of those who classify themselves as both instructors and learners are only instructing as a part time activity.

Training budgets are growing significantly and this is probably associated with the current boom (2007) in engineering on a worldwide basis. The greatest growth in training in the different regions is in Africa. This could be linked to the shortage of skills in these countries and the need to upgrade the expertise of their engineering personnel. The more mature markets of North America and Europe focussed on maintaining their budgets with no significant increases planned.

The quality of formal education from universities appears to be more highly regarded than that from trade/technical schools, vendors, on-the-job training and distance learning. Distance learning (of which e-learning is a component) received an average rating together with a large number indicating they did not know much about it or its application. The perceptions are that distance learning is not particularly appealing. Perhaps even more ominous is the misunderstanding of exactly what distance learning means. There was also some misunderstanding about the key role that e-learning plays in modern distance learning. There was important mention of the importance of more informal methods of gaining knowledge from on-the-job training using technical papers, books and one's peers.

The number of hours of training is seemingly adequate with an average of 65 hours per year (40 hours for the mode). What is of concern, however, is the significant number, mainly associated with smaller companies, who receive none or minimal training. Many respondents were critical of their management's neglect and attitude to training. Both respondents and their subordinates had a similar amount of training. In contrast, Wilkins (2007) charted the number of hours for USA industrial automation and manufacturing workers and had a mode of approximately 20 hours. Wilkins felt that the annual training hours provided, remain a tiny percentage of total hours worked but should be more. Most of his respondents (65%) of his survey indicated average training of 40 hours per annum and this result compares reasonably favourably with that found in this research. He felt that the level of training needed to be expanded significantly; but did not suggest what a target number of hours per year should be.

5.2.3 Current Situation with Online Learning and Blended Learning

A significant proportion (30%) of engineers and technicians had never heard of e-learning and this is some cause for concern, especially when the perceptions of the remainder are not always favourable (as is evidenced in the later questions and qualitative comments). Only 37% of the total number of respondents had attended an e-learning course (either synchronous or asynchronous) in the past three years. This is quite a low number compared with other industries such as financial and human resources. The study (discussed in section 2.1.3) conducted by M. Phillips of 140 Australian organisations (2006) found that 72% of the respondents used e-learning in structured training. This is higher than the results in this research as Australia is probably more developed in respect to e-learning when compared with the average in the Asia Pacific and African regions. This contrasted somewhat subtly with the K-J survey where, 68% of those had attended an e-learning or training conference during the past 24 months, but not necessarily attended an e-learning session.

If the response rate is adjusted to exclude those who did not attend any e-learning course, (unsurprisingly, due to the nature of the e-learning medium) the most popular one was computer-based, closely followed by personal development and then instrumentation/automation. In the other category, in addition to the defined training, there was a particularly rich selection of e-learning courses that engineers and technicians have attended ranging from occupational safety, management, business, project management and environmental. Hence, there is a wealth of other types of e-learning courses being attended.

The initial reaction to the best completion rates with courses is that the rates are disappointingly low (28%); but appear to line up with those discussed in the literature review in Chapter 2. However, once the respondents who did not take part in any e-learning are discarded, this response rate improves to 63% which is considerably better. Although this rate is still considerably lower than for equivalent classroom sessions. It is seen that highly supportive respondents are more likely to complete their courses. The E-learning Guild survey (*The blended learning best practices survey*, 2003) suggested a completion rate of 22% (for 81% to 100% of respondents) for "self-paced pre-work", which in the context of the survey is assumed to be a form of asynchronous e-learning.

Although there are more non-paying participants of e-learning courses, a significant proportion (41%) of e-learning courses have been paid for. This gauge was used to assess how seriously possible users viewed the product based on the commonly held perception that much of what is available on the internet should be free (and this is also extensively supported by the qualitative comments). There were numerous comments about the costs of e-learning, with many suggesting it should be cheaper.

There is a good deal of support for online learning with 70% of those who knew what e-learning was indicating they were supportive (or highly supportive) of online learning. Though, this percentage drops to about 51% when the total number of respondents is considered. The supportive percentage is certainly considerably lower than K-J's survey which indicated a considerably stronger enthusiasm for e-learning with 90% of the respondents being supportive or optimistic. This is probably because the K-J survey was investigating training managers or human resources professionals, who were more likely to be favourably disposed towards new learning technologies as this is their primary employment focus.

Approximately 40% of the total respondents claimed that they had at least some knowledge of the online learning efforts in their organisations. This is not a particularly high number, but was probably impacted by the lack of application of e-learning in their organisations. There are many comments about the need to raise the awareness of e-learning and blended learning technologies to raise both the usage and range of technical courses on offer.

The average duration for an e-learning session was from 30 to 60 minutes, which in the author's experience is acceptable for optimum results. There were a significant number who had sessions longer than two hours. It is uncertain whether this was for multiple sessions; but this does indicate that the use of e-learning is for fairly lengthy transfers of knowledge.

The duration of use of either online learning or blended learning was reasonably consistent, and it would appear that most (of all the respondents) had no experience or did not know what either form of learning was (65%). Hence, there is enormous opportunity here to take advantage of this technology as most would not be aware of the benefits it offers.

A significant proportion (56%) felt that online courses were not more engaging or motivating than face-to-face and classroom designs. It is possible that this would have included those who had never attended an e-learning session and believed this to be the case without first hand experience. But the large number of 'Don't knows' (34%) indicated that most would have filled in this category; so this is not perhaps a significant problem. However, unreal perceptions are as, they would still determine the take up of e-learning (and blended learning). In addition, 36% had earlier indicated that they had not attended an e-learning course over the past three years (Question 16); so there is some agreement here in the percentage of respondents. Only 10% felt online learning was more engaging than the face-to-face classroom. K-J's survey noted that a greater number of the respondents (70%) indicated that e-learning courses were not as engaging or motivating as face-to-face courses. As discussed in section 1.3 (Myths about distance learning and e-learning), Mendenhall (2007) suggested there is no significant difference between the different forms of instruction (face-to-face learning versus e-learning). The body of evidence from the qualitative results, would appear to indicate that most of the respondents have been exposed to the traditional asynchronous e-learning using poorly constructed courses; hence the dissatisfaction with the e-learning courses.

Overall, the qualitative comments, especially, give a somewhat disquietening and bleak view of e-learning with at least half of the respondents viewing e-learning negatively, presumably due to the poor e-learning experiences they have had in the past. It is suggested that most of the poor experiences have resulted from earlier versions of asynchronous e-learning courses (as opposed to synchronous e-learning) where learners have been confronted with less than perfect training materials ranging from a "book on a web site" to poorly designed and non-interactive course materials. However, there is one survey discussed (*Synchronous e-learning survey results*, 2006) earlier where even synchronous e-learning provided boring content. This is backed up by one of the qualitative comments where one respondent remarked on the boring instructor who presented very poorly.

As a contrast to the previous question, when asked in absolute terms (without comparison to other forms of learning) what the overall quality of online courses was, a cautious 38% indicated that they were "somewhat engaging/interactive" or "extremely interactive/engaging". But a significant 20%, indicated that they were boring or somewhat boring.

In assessing the mix of the different forms of training, the breakdown was as follows: face-to-face classroom-based (50%), synchronous e-learning (0%), self-paced online (10%), offline (10%), mentoring/coaching (10%), print-based learning (10%), audio/video (0%) and other (0%). The fact that self-paced online is greater than synchronous e-learning would appear to suggest that the traditional forms of online training have been used by these companies and that there is significant room to expand the synchronous approach. This compared sharply with the K-J survey which found that 25% indicated that e-learning was the dominant form of training in their organisation and 50% believed this would be the dominant form in 2010. This question is revisited in a later question.

In examining the impact that hands-on training has made with remote labs and simulation software for those familiar with e-learning and blended learning, a large number (27%) used simulation software as part of their e-learning efforts. Only a small proportion (6%) used remote labs. This shows that there is a sizeable engineering population in the world today, who could benefit from this form of technology, in terms of addressing the earlier comments about boring e-learning content and making it far more interactive. In the comments field under the Other category (containing about 30 comments), there are telling comments: "Tried to but found it difficult" and "software didn't run correctly on my computer"; indicating that the technology has been difficult to apply but perhaps the time is propitious to demonstrate it in this research that it is possible and easy to apply. In the general qualitative comment field, there was considerable discussion on the major deficiency of e-learning being that it did not allow for experiential learning with real equipment; which is critical for engineering training as contrasted with that for other fields of endeavour such as banking, insurance and law, where it is possibly not such an issue. These comments are supported by the research done by M. Phillips (2006) discussed in section 2.1.3, where many noted the need for more "hands-on" training and concerns as to whether e-learning would be able to provide this.

As expected, the results indicated that the training departments were more likely to use remote labs; whereas the human resources personnel had a higher likelihood of using simulation software. The precise reasons for this difference are difficult to gauge; but it is likely that the training personnel would be keen to try new learning technologies of which remote labs are one. A relationship was also identified between engaging e-learning sessions and in using remote labs. Obviously, this result is merely an indication and no great store can be placed by it.

A small percentage (9%) indicated that they were performing return on investment (ROI) calculations on training against 43% who were not. This accords with the general market results as can be seen in section 2.6 (Return on investment (ROI)) where the Brandon-Hall research organisation felt that 11% of firms actually performed ROI calculations. Sitzmann et al. (in press) pointed out that the use of e-learning and blended learning should be encouraged even if the only difference between this and other alternatives such as face-to-face are the cost savings. There was no evidence in any of the comments (both qualitative and quantitative) that e-learning was more expensive than instructor-led training; the major concern being the lower quality.

5.2.4 Future Projections

Over half indicated that spending on online learning would increase during the next few years against a small number who indicated expenditure would contract. It is thus suggested that there is a significant interest in the technology and it would appear to be following an expansionary path.

Despite there being some problems with the posing of this question, there was only a small minority who indicated they would not consider using e-learning to enhance their classroom experience (in blended learning format). A tiny number (but perhaps, noteworthy) would even consider e-learning as the sole source of learning for their organisations. This is difficult to understand; but at the risk of speculating somewhat, perhaps there are peculiar requirements in their particular industries such as remote or widely scattered offices which makes instructor-led training difficult. This agrees to a certain extent with K-J's survey which indicated that blended learning would become the dominant form of training in the next few years.

The most significant problem for online learning was not directly related to e-learning production itself but was insufficient management support (16%). Other problems listed included boring and low quality content (14% against that of K-J's survey which had 20%), fast changing technology (13%), and cultural resistance (13%). Admittedly, the respected ASTD (*Synchronous e-learning survey results*, 2006) survey focussed only on synchronous e-learning and it was to a small sample of 145 training professionals, but they identified the key issues as being technical problems (53%), lack of learning engagement (49%) and interactivity (48%). Other ones included bandwidth limitations (31%). With the use of synchronous e-learning and the direct contact with an instructor, it is surprising that lack of learning engagement and interactivity is so high. This perhaps suggests that the role of the instructor is being neglected or that synchronous e-learning is not necessarily a solution in addressing these shortcomings of asynchronous e-learning. In another survey M.Phillips (2006), in commenting on barriers to e-learning in section 2.1.3, listed “too time consuming”, “lack of computer literacy” and a preference for “hands-on”. Certainly, there were numerous qualitative comments agreeing with the need for computer literacy (especially for less developed areas such as Africa); but no mention of time consuming. The need for a “hands-on” training experience has been discussed earlier.

The qualitative comments on the main problems with e-learning and blended learning included rigid, boring and dull training and lack of interaction with the instructor. It is believed that most of these issues can be addressed with good quality synchronous e-learning.

There was perceived to be a lack of support of management in assessing and then pressing on with the use of e-learning and blended learning. This may be more about budgetary pressures under which managers operate in being unable to commit to expenditures on unknown technologies due to lack of information on e-learning rather than actual deficiencies in management.

There was concern about whether e-learning would be effective on sites (and countries) with poor data communication links and weak supporting infrastructure. Companies who dealt with this issue would have satisfactory experiences with e-learning. It is felt that with the rapid increase in the use of broadband this will become less of an issue.

The level of knowledge of the respondents may make it difficult to accurately answer the two questions about the future of e-learning and blended learning. Currently, blended learning was considered to be less than 20%, with a predicted 20% to 40%

in three years time. Similarly, for online training, most felt that less than 20% of employee training currently had an online component with a predicted 1% to 20% in five years time. There appears to be no change, but there has been a shift in the spread to the greater percentages. Hopefully, this reflects a good understanding of the differences between the two. These results contrasted with K-J's survey where 25% of the respondents stated that e-learning was the dominant form of learning in their organisation. The prediction for five years time of 20% does not come close to K-J's 50% who indicated that e-learning would be the dominant form of training. It should be noted that K-J's survey was taken in 2004; so there is some skewing of time in the comparison. The E-learning Guild's survey (*The blended learning best practices survey*, 2003) conducted in February and March 2003, when blended learning was still in its infancy, noted that only 15% were using blended learning "for the creation and/or delivery of educational content". As discussed in section 1.1.1, E.I. Allen et al. (2007) found that blended learning courses were still not more numerous than those using solely online instruction. This was for universities and colleges as opposed to the corporate environment in which this research took place.

As far as which online learning technology will most dramatically increase in the next few years, the results were fairly scattered. Learning Management systems enjoyed the highest response, followed by testing and video conferencing. If all three forms of synchronous e-learning are grouped together, a total of 25% is arrived at for synchronous e-learning. Asynchronous e-learning was not considered particularly highly with a negligible response. This may reflect the disillusionment with poor asynchronous e-learning to date. However, a significant number (one third) indicated uncertainty with future directions of online learning technology.

The final question, focussed around which methods would be used to deliver training over the next few years. Inevitably, instructor-led classrooms (20%) were the most popular, followed by multimedia such as DVD's and CDROM's (13%) and self paced online (12%), blended learning (12%). Online instructor-led training is still considered particularly low at 7%; although when added to synchronous tools of 4%, it comes up to a total of 11%. These results probably reflected the continued emphasis on asynchronous e-learning. A surprisingly large number (8%) indicated that paper-based correspondence courses are being used.

5.2.5 Hypotheses

The four hypotheses proposed were examined from both a qualitative and quantitative point of view using the statistical results in the previous section as well as the large number of qualitative comments received.

H_1 Synchronous e-learning produces an improved student reaction compared to that of classroom instruction alone.

This can be answered by examining Question 25 which stated:

In general, are online courses more engaging or motivating than face-to-face courses and classroom designs?

The results of this question are that a significant number of respondents (57%) felt online courses were not more engaging compared to 10% who felt that online training is more engaging. Hence this hypothesis is disproved and the converse could be stated:
Online courses are less engaging or motivating than face-to-face courses and classroom designs.

H_2 Remote labs or simulation software are not used extensively as part of e-learning courses for engineers.

This can be assessed by reviewing Question 28 of the survey. In terms of the overall number who filled in the survey, approximately 75% either did not know what it meant or were not using either. A small 4% have used remote labs and a reasonably large 20% were using simulation software. Hence, it can be assumed that this hypothesis is confirmed.

H_3 There is currently no extensive use of e-learning and blended learning for engineers and technicians.

This hypothesis can be addressed by examining Questions 33 and 34, where the mode (approximately 30% of respondents) indicated 1 to 20% of training was online or blended learning. This would justify this hypothesis, as this would mean effectively 10% of the training is either online or blended which is quite low.

H_4 There is significant growth in blended learning courses for engineers and technicians.

As with the previous hypothesis, this can be addressed by examining Question 33, where it is predicted that the mode of blended learning will increase to 20 to 40% in five years time. This is always difficult to assess when using categorical data, but effectively this could mean a growth of 10% to 30% in five years time if the midpoint of each of the modal ranges is taken. This is significant growth and hence the hypothesis is confirmed to be correct. As an aside, it is seen that the online learning does not demonstrate the same growth rate with the modes being the same for both today and five years time. This is somewhat anomalous as online learning is effectively part of blended learning; but this could mean that the respondents do understand the differences and intend to apply online learning tightly integrated with other forms of instructions such as classroom learning (thus creating a blended learning experience).

5.3 Conclusions about the Research Problem

There were many additional insights uncovered, especially during the examination of the open ended qualitative comments (mainly Question 37), which were not directly considered in the literature review in Chapter 2.

The need for a greater understanding of what e-learning and blended learning were and how to take advantage of these new technologies was emphasised by many respondents who had a poor knowledge of these topics. They felt the poor awareness of e-learning resulted in a poor supply of courses using this technology (especially in technical subjects) and a concomitant low level of demand from engineers and technicians.

There was much discussion on the advantages of instructor-led training compared to e-learning and the difficulty of e-learning ever replacing these technologies.

There appears to be a major issue with weak management support of e-learning and newer training technologies. This ranged from weak communications of corporate e-learning strategies to the engineers and technicians, investment in these resources, making time available during work hours and encouragement to complete these subjects.

Bandwidth and infrastructure limitations are perceived to be a major limitation in applying e-learning on remote sites and countries with poorly developed telecommunications infrastructures.

There was also strong support for e-learning with many indicating enthusiasm for this new technology and keen to harness the potential here. There was a wide spectrum of applications in areas unheard of, using e-learning seemingly very successfully. As a riposte to the comment made in the section 2.2 (Historical review of e-learning and blended learning) about the lack of evidence of significant activity or growth in e-learning, this survey has indicated a considerable amount of engineers and technicians using the technology (73% of the survey respondents indicated knowledge of e-learning and there was a diversity in the applications listed in the qualitative section); although admittedly many were not particularly happy with the results.

Many noted the importance of informal learning from internet research, knowledge Net Portal, books, discussions with colleagues, on-the-job training and forums. On-the-job training was particularly regarded as important and judging by the number of comments was important in terms of the overall training process. Typical comments were as follows: "….so much learning for me is unstructured looking up specific topics on the web as a form of self-taught learning". This is obviously a rapidly growing area of knowledge and training and was commented by many participants. Whereas in the past, a book was probably fairly one dimensional in accessing knowledge, having an interactive discussion with an expert on the internet is undoubtedly a completely new dimension to acquiring knowledge. In reference to the discussions in section 2.10 on explicit, tacit knowledge and hands-on training, it is arguable as to whether the knowledge is anything more than explicit. However, the use of remote labs and simulation software could change this situation.

There were recurrent comments about the reluctance of companies in general to pay for training. In many cases, they expected to have fully qualified staff who do not need training. A typical comment summarises this point: "In my experience, most UK companies are very reluctant to fund any training course at all other than for apprentices or for very junior trainees etc".

There were numerous comments about the need to keep online courses low cost or free. Typical comments abounded such as: " E-learning is suitable when it comes for free like those courses of the plantweb university". The unacceptably high cost of some e-learning courses was noted, especially, considering many were paying for the training out of their pocket.

There were many suggestions that the younger generation would be more susceptible and amenable to the new forms of learning encapsulated in e-learning and blended learning. It was pointed out that they are more computer literate

5.4 Implications for Theory

Although the full picture of the research's findings has been provided in the previous section, it is worthwhile examining how this research has made a contribution to knowledge not only in the immediate field of blended learning within industrial automation but has implications for theory within the broader parent disciplines of engineering training and indeed, training in general.

The main goals of the research were to demonstrate that blended learning would improve the reaction, achievement and return on investment (ROI) of industrial automation training compared to that of only through either the classroom or e-learning.

The research revealed that engineers and technicians have a poor knowledge of the current technology and benefits of distance learning, and what impact e-learning has on it, in making training more interactive. This is especially in terms of the ability to use synchronous e-learning to provide a live online instructor and to make the learning sessions far more interactive.

The current e-learning technology allows for hands-on training with remote labs and simulation software, which was generally commented on by a large number of respondents as being critical to engineering training, could be applied in a large number of other training applications such as business and medical.

There is a significant impact fuelled by the growth of the internet in providing online informal training resources ranging from chat rooms, online materials, discussion forums and peer support.

The quantitative results provided some further implications for theory. The research confirmed other findings about the aging of the engineering workforce mainly in North America. The perceptions of the engineering workforce towards distance learning (which includes e-learning) would appear to be not particularly high. The completion rate of e-learning courses were still poor compared to those in the classroom and there was a feeling that online courses were not as engaging as those from the classroom. The average duration of an e-learning course from 30 to 60 minutes, whilst short, was considered acceptable for optimum results. Finally, there was strong growth in the future suggested for blended learning (and less so for only online learning).

In addition, the open ended qualitative comments from the research revealed many additional insights such as the need for a greater understanding and awareness of the e-learning technologies available. Management support (including further investment in training and underwriting company time and resources) for these new forms of learning was perceived to be poor. Infrastructure limitations (such as bandwidth and hardware) were deemed to be major obstacles in applying these technologies in remote locations and Third world countries. There was evidence of strong support for the technologies with a wide spectrum of e-learning applications being undertaken in the engineering and technology areas. Although not a focus of the research, there was however, a strong awareness of the importance (and in many cases perceived superiority) of informal hands-on on-the-job training to the other forms of training such as classroom and e-learning. Finally, the susceptibility of the younger generation to these new technologies and resultant success in using them in the future was noted.

5.5 Implications for Policy and Practice in Industrial Automation and Engineering

Flowing from this research, a number of recommendations are suggested below in a number of areas, ranging from the state of the engineering workforce and engineering training, to the current state of e-learning and blended learning, to the future of these new technologies.

The aging of the workforce in engineering (and industrial automation) was evidenced in this work, and there are likely to be serious consequences for the future of industrial automation specifically and engineering in general. It is suggested that the governments of Australia, look at extending the working age further and increasing recruitment and retention of skilled workers (with a focus on females) in the engineering and industrial automation fields as a matter of priority.

A large number of respondents noted that they knew nothing of blended or e-learning technology and it is suggested that a significant marketing effort is made in the various engineering and industrial automation communities and engineering institutions to show how cost savings can be effected and how the learning experience can be enriched by using a blended learning approach.

The poor perception of e-learning and blended learning needs to be counteracted with high quality training materials and resources focussing on synchronous e-learning, simulation software and hands-on training techniques. It is vital that a concerted effort is made to promote high quality e-learning materials to the engineering community to convince them that it can indeed be a high quality and productive experience using interactive live synchronous instructor-led training. A suggested specification of a software package that can address these requirements is described in Appendix D.

It is important that e-learning for engineers and technicians has a strong hands-on component to allow the participants to gain skills in working with real equipment. This is distinct from the e-learning requirements for the other corporate sectors such as banking and insurance. A suggested specification of a software package that can address these requirements is described in Appendix D. But at the very least, it is expected that an application sharing facility would be provided by the instructor to allow the students to view and interact (with no discernible time delays) with the application program running on the instructor's computer.

Poor management support of the new technologies of learning was often mentioned as a reason for the poor take up of blended and e-learning. The business case for improved learning and lower costs should be driven home by the various engineering institutions and societies' leadership to show this enormous opportunity in improving training of engineers and technicians. Management is perhaps naturally hesitant about embracing this form of training as it is new and unproven. There is evidence of increased expenditure on engineering training by corporations and advantage can be taken of this in promoting e-learning and blended learning. Research such as this can be useful in promoting more effective knowledge dissemination.

5.6 Limitations

Section 1.11 has already outlined the major limitations of the research that were as a result of the research design. Other limitations that became apparent during the research were as follows:

The initial survey was aimed at industrial automation professionals, a small discipline in engineering, but tended to also include a smaller and uneven distribution of engineers and technicians from other disciplines. This resulted in some uncertainty about the significance in some of the results such as types of online courses undertaken. For example, the smaller number of civil engineering courses entered into in Question 17, does not necessarily mean that this is true for the entire engineering population.

There was insufficient knowledge (apart from some anecdotal information) about the type of online courses that engineers and technicians undertook and this meant that Question 17 (What of the following courses have you taken as online ?), could be more finely delineated and more appropriate and include popular online courses engineers were taking such as safety, project management, financial and business.

The survey clearly indicated that the online training of interest was for corporate short courses; but many respondents also described their experiences at university level. This would have distorted the results to some extent.

There were some unusual findings for hours of training per year with a number of respondents indicating that they spent thousands of hours training (and obviously little on productive work). This would have distorted the final average number of training hours per respondent had these numbers not been (to some extent, arbitrarily) removed in the analysis (all hours greater than 1000 hours per annum were excluded). Hence there is some uncertainty about the average number of hours training per respondent.

The survey focussed on formal training but many pointed out that informal methods of training were more important for them. This would have added a degree of uncertainty to the average number of hours training listed in the figures.

A few suggested that the survey instrument had some limitations. This may have impacted on the quality and accuracy of the responses and the number who completed the survey. Other limitations were that a number felt that they were unable to answer the questions as they were outside their area of expertise or they had no familiarity with e-learning, the question on quality was too simplistic, and more questions should have allowed for a “Do not know” category

The survey had respondents in many different countries and it was obvious that some of the questions were possibly misinterpreted. For example, in Question 11, in assessing the overall quality of formal education, distance learning was not correctly understood as including e-learning, and this should have been spelt out more clearly.

Many of the respondents had difficulty understanding the difference between the level of the job and the job function and this question should have been simplified or combined as the results would have been somewhat misleading.

As remarked in an earlier section, the selection of region of the world, was too broad and should have been made more specific. For example, Australia although part of Asia Pacific has arguably more in common with Canada than Malaysia in terms of industries and level of education. This would mean that a number of statistical results would have limited value.

5.7 Further Research

As a result of this work, there are a number of areas that should be investigated in more depth. These are discussed in the following paragraphs.

The low number of females engaged in engineering and science should be investigated and ways of improving the recruitment process examined. Perhaps, e-learning and blended learning can be used to improve the interest level in science and engineering particularly during primary and high school

The distribution of the uptake of e-learning for engineering in the various countries should be examined on a country-based level. For example, the Asia Pacific, is not a homogeneous region and it is likely that Australia and New Zealand will mirror Western Europe and the USA more in attitudes, entry to engineering as a career, the take-up in new technologies, and in the aging of the population as compared to Malaysia, for example. Similarly, Eastern Europe is likely to be different to Western Europe and considerably more dynamic in new entrants to engineering.

Based on this survey, the picture of e-learning is not particularly positive and an investigation should be carried out into specific reasons why this is the case. Is it because of poor asynchronous materials (as is suggested in this research commentary) and the lack of synchronous learning or both? And how can this poor image be improved?

The precise relationship between knowledge transfer and retention when using more interactive e-learning techniques should be examined with experimental sessions and hands-on equipment (perhaps using the software package created in Appendix D) against traditional e-learning and classroom sessions.

The rapid growth in providing informal training resources such as chat rooms, online forums, and peer-to-peer through the internet should be investigated as to its use, benefits and impact on formal training structures (such as classroom and e-learning).

Finally, do the perceptions of e-learning (as compared with classroom instruction) in terms of the reaction improve when using a more interactive approach in performing the training? Leading on from this, what are the application areas (if any) where e-learning will give better reactions than classroom learning?

5.8 Conclusion

It is hoped that this research on blended learning for engineers and technicians will assist in improving engineering education in some small way, but as the noted management consultant, Handy (2006), noted from Voltaire: " How infinitesimal is the importance of anything I do, but how infinitely important it is that I do it" (p. 213).

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Appendix A

Suggested Email and Survey Instrument for Wordwide Web Survey

A.1 Introduction

This represents the web survey that was used to get a profile of e-learning and blended learning in a global context for engineers and technicians working in the field of industrial automation. Note that the items below that referred to "Select" indicated to a pull down menu on the web survey form.

A.2 Proposed Instrument

A.2.1 Email Sent Out to Canvass for Respondents

To: Colleague

From: Steve Mackay

Subject: I need your help for my engineering training research

Date: 16 July 2007

Dear Colleague

I would like to ask you for your personal support and assistance with a doctoral research project I am undertaking at Curtin University of Technology (Perth, Western Australia), part of which involves a global survey of attitudes to blended learning (a mix of online and classroom instruction) in the engineering and industrial automation workplace. This research will hopefully show us ways to increase training opportunities and dramatically improve the quality of training for engineers, technicians and other technical professionals and also to reduce training costs significantly.

As an incentive to undertake the survey, we are offering a complimentary 200 page "Best Practice in Industrial Automation" e-book (worth $40), copy of the results and a complimentary 90 minute Industrial Automation e-learning course (worth $99) later in the year, which we will advise you about by email. A copy of the survey results will also be made available to you.

I would appreciate it if you would undertake this survey now. I guarantee you that it is simple and easy to fill in and can be completed in 6 minutes (we have tested this). The survey form consists of a series of short questions, most of which will only require a box to be checked. I would be most grateful if you (or one of your associates) would spare (literally) a few minutes to complete the form with as much of the information as possible.

Please click on the site:

http://www.idc-online.com/researchsurvey.htm

to undertake the survey.

Please note that participation in the survey is purely voluntary and you may discontinue at any time and request that the data gathered is deleted. We would also emphasise that while we will be recording your information in the research project's database, all information gathered including names will be treated as confidential and not released to anyone else outside this research project and in advising you later on the complimentary e-learning training available.

My sincere thanks and appreciation to you for supporting this important groundbreaking survey that will change the way we approach training and learning, in the industrial automation business.

Regards
Steve Mackay CPEng

A.2.2 Survey Instrument Details

New Approaches and Technologies for Engineering Training ver2

(Preview Only)

Click here to continue a partially completed form.

The highly skilled engineering and technical workforce in most production environments is getting older and in many cases retiring and leaving for good. High quality training is essential to maintain production and availability and most importantly, to improve your ability to earn more, secure your job and achieve greater job satisfaction. New techniques such as online training (or e-learning) and blended learning (a mix of online learning and classroom instruction) are making a significant impact on training in business and we believe soon, the engineering and industrial automation environment and this research investigates ways of applying this to improve your skills and know-how quickly, effectively, enjoyably and at a lower cost than traditional classroom training.

In the field below, please type your e-mail address
- preferably the one used in the request that you may have received to participate in this survey:

E-mail Address: tech@idc-online.com

This is an anonymous survey. This survey's creator will not be able to tell which responses are associated with your e-mail address.

SurveyShare will not use e-mail addresses collected when you respond to a survey in any way, other than in the administration of that survey. Your e-mail address will not be shared or sold to others. It will not be used for any Marketing purposes, and you will not receive any e-mail from SurveyShare, Inc.

Continue

New Approaches and Technologies for Engineering Training ver2 (Page 1 of 5) (Preview Only)

★indicates a required answer

A. BACKGROUND INFORMATION ON YOU AND YOUR ORGANISATION

1) What best describes the level of your position ? (Please select the appropriate level) ★

- [ ] Management
- [ ] Supervisor
- [ ] Engineer/technician
- [ ] Trades
- [ ] Operator
- [ ] Other: ______

2) What best describes your job Function (Please select the appropriate function) ★

- [ ] Corporate/Administration
- [ ] Engineering
- [ ] Human Resources
- [ ] Maintenance
- [ ] Operations
- [ ] Purchasing
- [ ] Quality Control
- [ ] Research and Development
- [ ] Training
- [ ] Other: ______

3) Please indicate your gender ★

- [ ] Male
- [ ] Female

4) Select the age group you fall into ★

- [ ] Below 30 years of age

- 30 years to 50 years
- Over 50 years

5) What is the primary focus of your organisation ? (Please select the best fit) ★

- Agriculture, Forestry or Fishing
- Communications (advertising, publishing, entertainment, media)
- Construction or building
- Consulting or contracting
- Education
- Financial services, banking, legal, insurance or real estate
- Government /Public administration
- Health or medical services
- Food, hospitality, travel, tourism or recreation
- Industrial or manufacturing
- Information technology or technology services
- Military
- Mining
- Non-profit organisation, foundation or association
- Oil and Gas
- Pharmaceuticals
- Public utilities (Power, telecommunications, water, waste)
- Processing (eg Minerals, Beer, Chemicals or Food)
- Refining (eg Oil)
- Semiconductor
- Transportation (Railway/shipping/airways)
- Wholesale/distribution/retail trade
- Other: ______

6) How many people are employed in your organization ? Please select one. ★

- 1-100
- 101-500
- 501-1000
- 1001-5000
- 5001-10,000

☐ more than 10,000

7) What is the highest level of education that you have completed ? ★

☐ Some high school (or less)

☐ High school graduate

☐ Vocational/technical college/TAFE

☐ University Graduate

☐ Advanced degree (Masters or above)

8) In which region of the world are you located in your job today ? ★

☐ North America

☐ Europe

☐ Asia Pacific

☐ Latin America

☐ Middle East

☐ Africa

B. YOUR CURRENT TRAINING STATUS

9) Please indicate how you participate in training ★

☐ As a presenter/trainer

☐ As a learner/attendee

☐ As both

10) Over the next few years, do you anticipate an increase or decrease in your department's overall technical training budget ? ★

☐ Increase

☐ Decrease

☐ Will remain about the same

☐ Uncertain

11) Please rate the overall quality of the formal education that you have received from the following sources: ★

	Don't know	Bad	Poor	Below Average	Average	Good	Very Good	Outstanding
Trade/technical schools	☐	☐	☐	☐	☐	☐	☐	☐
Universities	☐	☐	☐	☐	☐	☐	☐	☐

Vendor's training	○	○	○	○	○	○	○	○
On-the-job training	○	○	○	○	○	○	○	○
Distance learning	○	○	○	○	○	○	○	○
Other	○	○	○	○	○	○	○	○

12) If you selected OTHER from the previous question, please indicate briefly what it is.

13) Please indicate the number of average yearly hours of technical training that you personally receive ? *

14) Please indicate the number of average yearly hours of technical training that a typical employee under your supervision receives (put N/A if no one is working for you). *

C. YOUR CURRENT SITUATION WITH ONLINE LEARNING AND BLENDED LEARNING (where blended learning means a mix of online AND classroom or on-the-job training)

15) Do you know what e-learning or blended learning is ? *

○ Yes

○ No

Pause

New Approaches and Technologies for Engineering Training ver2 (Page 2 of 5) (Preview Only)

★ indicates a required answer

16) Have you attended an online learning (e-learning) or blended learning training course in the past 36 months ★

- Yes
- No

17) What of the following courses have you taken as online (or e-learning) courses ? ★

- None
- Computer application/software
- New Hire orientation
- Personal development skills (e.g. time management)
- Mechanical Engineering
- Electrical Engineering
- Instrumentation, Automation and Control engineering
- Data Communications and networking
- Civil Engineering
- Other: ____________

18) What percentage of online courses did you complete ? ★

- None
- 20% or less
- 21% to 40%
- 41% to 60%
- 61% to 80%
- 81% to 100%

19) Did you or your company pay for the most recent online session you attended ? ★

- Yes
- No

20) What best depicts your attitude or viewpoint towards online learning ? ★

- I am extremely critical or pessimistic
- I am somewhat critical or pessimistic
- I have no opinion one way or another
- I am somewhat supportive or optimistic
- I am extremely supportive or optimistic

21) How much knowledge do you have related to online learning in your organisation? ★

- None/No Knowledge
- Low/Minimal knowledge
- Medium/Some knowledge
- High/Significant knowledge
- Extremely high/extensive knowledge

22) What is the average total duration of a typical online learning course you have attended (including possibly with multiple sessions)? ★

- Not applicable
- Fewer than 30 minutes
- 30 minutes to 60 minutes
- 1 to 2 hours
- 2 to 3 hours
- more than 3 hours
- Other: ____________

23) How long has your organisation been using blended learning (ie combining online experiences and face-to-face classroom sessions for one particular course) as part of its employee training? ★

- No experience
- 1 - 2 years
- 3 - 5 years
- 6 - 10 years
- More than 10 years

24) How long has your organisation been using fully online courses or programs as part of its employee training? ★

- No experience
- 1 - 2 years

- 3 - 5 years
- 6 - 10 years
- More than 10 years
- Other: ______

25) In general, are online courses more engaging or motivating than face-to-face courses and classroom designs? ★

- Yes
- No
- Don't know

26) What is the overall quality of online courses used in your organisation? ★

- Extremely boring/non-interactive
- Somewhat boring/non-interactive
- Somewhat engaging/interactive
- Extremely engaging/interactive
- Do not know

27) Estimate the overall mix of training by format that you have personally engaged in over the past year. Try and ensure the total adds up to 100% (but we will fix this, if this is too hard for you!). ★

Face-to-face, instructor led training	--Select--
Synchronous e-learning (instructor led, online)	--Select--
Self-paced, online learning (e-learning modules)	--Select--
Technology-based offline (CDROM, DVD)	--Select--
Mentoring, coaching, on-the-job	--Select--
Print-based learning (self-study of books)	--Select--
Audio/Video	--Select--
Other	--Select--

28) Have you ever undertaken hands-on training using remote labs or simulation software as part of your e-learning course? Please select which ones you have undertaken as part of your e-learning course. ★

- No or I don't know what you are talking about
- Hands-on remote labs on a computer remote to me

Simulation software to demonstrate concepts

Other:

29) Does your organization calculate return on investment (ROI) for online learning courses or initiatives ?

Yes

No

Don't know

Other:

D. FUTURE PROJECTIONS OF ONLINE LEARNING

(Please make your best guesses regarding the future of online learning)

30) How will your organizations spending in online learning change during the next few years?

Will decrease significantly

Will decrease a bit

Will be the same

Will increase a bit

Will increase significantly

Don't know

Other:

31) How will online learning be used in your organization in the next few years? Select ALL that apply.

Alternative to instructor-led (Classroom) courses

Follow-up to instructor-led (Classroom) courses

Sole source of learning

Supplement to instructor-led (Classroom) courses

None of the above: Will not use e-learning

Not applicable. Something else will emerge to replace e-learning in the next few years

Other:

32) From the perspective of your organization, what is the most significant online learning issue or problem that must be addressed during the next few years ?

Boring and low quality content

Cultural resistance

Fast changing technology

High costs

Insufficient management support and commitment

Lack of standards

Limited bandwidth

Limited organizational vision and planning

More hype than fact

Unethical vendors

Other:

33) What percentage of employee training in your organization is blended (i.e. courses that have online as well as face-to-face or conventional classroom components) today and how might this change in 5 year's time? ★

	0%	1 to 20%	21 to 40%	41 to 60%	61 to 80%	81 to 100% of employee training
Today (2007)						
5 year's time (2012)						

34) What percentage of employee training in your organization is fully online today and how might this change in 5 year's time? ★

	0%	1 to 20%	21 to 40%	41 to 60%	61 to 80%	81 to 100% of employee training
Today (2007)						
5 year's time (2012)						

35) In your organization, which online learning technology will most dramatically increase in use during the next few years? ★

Asynchronous or delayed discussion forums (e.g. webboard or webcrossing)

Electronic whiteboards

Instant messaging and synchronous chat tools

- Learning Content Management Systems and learning object libraries
- Learning management systems and courseware
- Online testing and examination tools
- Synchronous or live presentation tools (e.g Centra, NetMeeting, iQuokka)
- Video Streaming (e.g. lectures, content, experts etc)
- Web-based video conferencing
- I don't know

Pause

New Approaches and Technologies for Engineering Training ver2 (Page 3 of 5) (Preview Only)

★indicates a required answer

36) In your organization, which of the following methods will be used to deliver training in the next few years? (Select ALL that apply) ★

- [ ] Asynchronous tools (e.g. discussion boards, forums, surveys)
- [ ] Blended (combining online and classsroom)
- [ ] Instructor-led classroom-based learning
- [ ] Instructor-led online learning
- [ ] Multimedia (CDROM, CBT, DVD)
- [ ] Paper-based correspondence
- [ ] Peer-to-peer online learning networks
- [ ] Satellite broadcast
- [ ] Self-paced online learning
- [ ] Streaming video
- [ ] Synchronous tools (e.g. chats, instant messaging, virtual classrooms, webinars)
- [ ] Videotape
- [ ] Virtual Reality
- [ ] Wireless technology
- [ ] Other: ______

37) Feel free to list additional comments relating to any of the items in the survey, especially regarding the future of e-learning and blended learning and your experiences with these technologies.

38) As part of this survey, we plan to interview some of the participants to better understand your training application, if you have attended training in the area of blended learning or e-learning in the past 24 months. Please let us know if would like to participate in this 20 minute telephone interview. Again, all results will be kept completely confidential. In return for participating, we will ship you an engineering book of your choice (worth $110) from a choice of over 200. Do you want to

participate in a follow up telephone interview?

- [ ] Yes, you may contact me for a 20 minute (maximum) interview
- [ ] No, please do not contact me any further. This survey was enough !

Pause

Appendix B

Reaction Survey

Name______________________Male______ Female______
Age__________Occupational Title______________________
Online student__________Blended/Hybrid Student_______Classroom Student________
Course Name__________________________________

Level of experience with computers: (please check one)
Beginner:____________ Moderate:__________________ Expert:______________

Have you participated in online/internet education before: Yes________ No________
Preferred Learning Style: Visual__________ Listener________ Touch_________

Generate Evaluation (please circle one): Did the program meet (achieve) objectives?

1.0 Learning experience

Completely Generally Limited Success
Failed
Successful Successful
1 2 3 4 5 6
7

2.0 Learning objectives achieved:

Completely Generally Limited Success
Failed
Successful Successful
1 2 3 4 5 6
7

3.0 Faculty member responsive to my questions:

Completely Generally Limited Success
Failed
Successful Successful
1 2 3 4 5 6
7

4.0 Faculty member demonstrated expertise in the subject and professional knowledge:
Completely Generally Limited Success
Failed

Successful Successful

1 2 3 4 5 6 7

5.0 Learning team members helped me to understand and relate to course content:

Completely Successful | Generally Successful | Limited Success | Failed

1 2 3 4 5 6 7

6.0 Improved your understanding of course concepts, terms and theories:

Completely Successful | Generally Successful | Limited Success | Failed

1 2 3 4 5 6 7

7.0 To what extent have you received help, through coaching and/or feedback, with applying the knowledge and/or skills:

Completely Successful | Generally Successful | Limited Success | Failed

1 2 3 4 5 6 7

Method of education and Training

8.0 How effective and or successful was the delivery (instruction method) of this course:

Completely Successful | Generally Successful | Limited Success | Failed

1 2 3 4 5 6 7

9.0 As a result of this course, my performance on the course objectives has changed by _____% (please indicate +/-).

10.0 As a result of this course, my overall knowledge of this subject (course/content) has changed by____% (please indicate +/-).

11.0 What was the overall reaction to this program?

Excellent | Better than expected | Satisfactory | Below Average

1 2 3 4 5 6 7

12.0 General comments on the online, blended/hybrid or classroom instruction delivery method?

Appendix C

Evaluation of Interwise as a Virtual Classroom Tool

	Strongly Disagree	Undecided	Agree	Strongly Agree	Disagree
	1	2	3	4	5
1.I believe the opportunity to interact with my instructor in an Interwise course to be as satisfying as that of a traditional classroom.					
2. I believe the opportunity to interact with students in an Interwise course to be as satisfying as in a traditional classroom setting.					
3. I believe the feedback from the instructor on instructional questions to be as satisfying in comparison with a traditional classroom session.					
4. I believe the quality of the interaction with the instructor in an Interwise course to be as satisfying as that of a traditional classroom setting.					
5. I would have preferred to have taken my classes in a traditional classroom setting rather than through this web-based format.					
6. Interwise is more convenient for me than attending a traditional classroom.					
7. This instructional delivery method allows me to be self-directed and responsible for my own learning.					
8. Interwise allows me to share my job knowledge and experience.					
9. Interwise sessions have been problem centered and appropriate to my job.					
10. The Interwise tool is easy to use.					
11. I would take another class using Interwise.					

Appendix D

Summary of Requirements for the Video Conferencing and Remote Laboratories Software

D.1 Introduction

As part of the research an e-learning system was designed and written using a team of four programmers. This was to give additional insights into the work being done in the investigation. This was used for the experimental sessions comparing synchronous e-learning with classroom and blended learning and incorporated a remote lab facility – something which was missing from most other offerings on the market. A brief description is given below of the software that was written.

The video conferencing package was aimed at engineers and other technical professionals who wish to conduct training classes and collaborate in a synchronous way at different locations. The unique feature of this package was the remote lab facilities provided as well as the engineer-oriented video conferencing facilities.

The software package was used both in a blended form (remote practical sessions and video conferencing facilities for existing instructor-led courses) and to provide dedicated e-learning facilities for a range of courses.

Typical users are able to watch and hear course content, communicate their questions to the instructor, present their own PowerPoint slides, and record/playback audio and video sessions with moderate system requirements. They are also be able to go directly to a remote site and conduct experiments. Instructors can communicate with students, do PowerPoint presentations, and use the whiteboard functions to present their courseware to the students.

D.2 Objectives of the Video Conferencing Software

All participants should be able to see, text and talk to each other. All participants should be able to use a whiteboard area to draw or to import a PowerPoint presentation to present to others. In addition, participants should be able to go directly to a pre-determined site and take control of a remote computer in order to conduct practical hands-on experiments or to video conference with other eminent instructors at remote locations.

D.3 Scope of the Video Conferencing Software

The package has the following features:

- Video and audio conferencing for all users - all users should be able to see each other and talk to each other. Note that the video conferencing will be limited based on the available bandwidth as two people (only) in full duplex mode will already place very heavy demands on a 128k uplink
- All users should be able to send text messages to each other.
- All users should be able to record audio and video content for subsequent playback.
- A whiteboard should be provided for use by the instructor and participants on a ‘pass control when required’ basis.
- All users should be able to upload their PowerPoint slides for presentation as needed. User would have to convert the PowerPoint slides into another format to be defined by the developer. This format would be more suitable for the uploading the slides.
- All the participants should be able to communicate to the instructor their agreement/disagreement using emoticons.
- Remote Lab Facility: Students should be able to take control of a remote computer via a lab client on their own PCs, in order to conduct hands-on experiments. This will be in conjunction with a universal hardware panel they will hook up to a USB port (on their own PC) which will enable on/off switches and analog inputs/outputs to be interfaced with the Remote Lab

server. Every student should have the equivalent facility of running a Remote Lab server on their computer, where other users can access their hardware and test set-up.

- Students should be able to view a list of active Remote Lab sites throughout the world on another screen where they can go to a particular Remote Lab website and interview engineers and technicians working on remote sites and see what they are doing, using mainly video and voice.

  This will occur for example, where an instructor-led course on loop tuning and process control is being conducted in Sydney. The basic tuning lab is initially conducted on IDC hardware in West Perth and then another remote lab site is selected where an engineer in Olympic Dam gives a 10 minute real live demonstration of their process control system working with a conveyer and crusher. The remote lab in both Olympic Dam and Perth, as well as the course in Sydney would need the universal hardware panel connected so that the necessary lab sessions can be performed.

D.4 Software Structure

The system will consist of a server application and a client application.

The server will perform the following:

- Authenticate users that connect to the server (log in) using username and password.
- Provide the networking connectivity between all clients

The client application will:

- Consist of several modules viz. whiteboard, participant info, audio video connectivity etc.
- Provide a graphical interface (or front-end) to the various modules
- Connect to the server application for authentication and connectivity with other users

D.5 Project Deliverables

The project was broken down into eight deliverables as follows:

- Audio and video connectivity
- Participant info window module
- Whiteboard module with import and display of PowerPoint slides (that have been converted off line)
- Application sharing module
- Text messaging module
- Web tour module
- Remote lab module
- Interconnectivity between all modules

D.6 Use Case Model Survey

The software requirements specification made use Use Case Modeling to capture the requirements of the e-learning package. The Use Cases were broadly divided into the following main categories:

- Common Use Cases – pertaining to the common user actions of login, registration and exit
- Participant Info window Use Cases – pertaining to the participant info window
- Whiteboard Use Cases – pertaining to the use of the whiteboard facility
- Audio and Video Use Cases – pertaining to the audio and video conferencing
- Application Sharing Use Cases – pertaining to application sharing and region sharing
- Text Messaging Use Cases – pertaining to the text messaging facility
- Web Tour Use Cases – pertaining to the Web Tour feature
- Remote Lab Use Cases – pertaining to the Remote Lab facility