Investigating the Feasibility of Creating a Piece of Software for Practical Electrical Classes that Engages Learners of Different Learning Styles

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Investigating the feasibility of creating a piece of software for practical electrical classes that engages learners of different learning styles

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Abstract

This paper looks at feasibility of creating a piece of software for practical electrical classes that engages learners of different learning styles. Traditional practical electrical classes are usually delivered using text based resources, but due in part to the advances in technology it is possible to provide information in a variety of formats. The starting point of this research was to evaluate the preferred learning style of the typical apprentice learner by using a learning style questionnaire based on the Vark model. The Vark model represents four learning styles Visual, Auditory, Reading/Writing and Kinaesthetic. The results from the questionnaire then influenced the design of a workshop interface to suit the learner's particular learning style. The final design was influenced by expert opinion in the area of learning styles as well as subject area experts. The interface was evaluated by 28 electrical apprentices and six lecturers who all agreed that the interface presented a new and innovative approach to delivering information within a practical workshop setting. The study concludes that it is possible to create a workshop interface that engages learners of different learning styles.

Keywords: electrical; information communication technology; learning styles; virtual learning environment; WebCT.

1 Introduction

1.1 Introduction

The major technological advances of the last few decades are beginning to have an impact on adult education throughout the world including Ireland. The use of Information and Communication Technology (ICT) is now encouraged (to various degrees) by the stakeholders of the adult educational community as a tool to improve education and to help attain the objective of 'Life Long Learning' and 'Second Chance Education'. These major technological advances along with a greater understanding of how learners learn and the importance of delivering information in various forms have posed the question, how do we harness these newly presented opportunities? With the development of a new electrical workshop, it is hoped to leverage the advantages provided by these new technologies.

Most research in the area of Learning Styles and ICT has focused on using new technology designed with learning styles in mind, in a typical classroom or as part of a Virtual Learning Environment (VLE)/Distance Learning Project. The objective of the research was to develop a learning interface for use in a new practical workshop within the electrical apprenticeship area. This interface will be designed to help prepare the apprentice for the Motor Control and Wiring exam at Phase 4 level. It is also hoped to allow or show greater consideration of the learners' learning styles.

In this paper we use the following abbreviations:

BUA: A partnership between National Learning Network, the Discovery Centre in Cardiff, and the Institute of Technology Blanchardstown

HMI: Human Computer Interface

ICT: Information and Communication Technology

ITB: Institute of Technology Blanchardstown

Vark model: Visual, Auditory, Reading/Writing and Kinaesthetic learning styles

VLE: Virtual Learning Environment

1.2   Context background

In order to understand the benefits to be realised through the use of Information and Communication Technology (ICT) it is important to understand what it means as it has come to acquire a variety of meanings. Hennessy seems to capture the broadest sense of what is meant by ICT when she writes that:

> *The term ICT encompasses the range of hardware (desktop and portable computers, projection technology, calculators, data logging and digital recording equipment), software applications (generic software, multimedia resources) and information systems (Intranet, Internet)* (Hennessy et. al 2005)

This will be the definition of ICT used through out this paper. The use of ICT is of particular relevance to future electricians. Engineers Ireland believes that it is essential in the practice of engineering (Engineers Ireland, 2003).

1.3   Apprenticeship in Ireland.

In Ireland, Fás the department, with legislative responsibility for training   introduced a standards-based apprenticeship system in 1991. Prior to this there was no formal mandatory apprenticeship system. The standards based apprenticeship system is a competency-based system which is divided in to seven phases. The odd numbered phases 1-3-5-7 are the On-the-Job phases. These consist of working with an employer over a four year basis. The even-numbered phases 2-4-6 are the Off-the-Job phases. These consist of 22 weeks within a Fás training centre for Phase 2 and 11 weeks in an Institute of Technology for both Phase 4 and Phase 6. The purpose of the Off-the-Job phases is to deliver the theoretical components of the trade as well as to allow for the practice of specialised craft skills. (Fás, 2001)

1.4   Motor Control and Wiring Module

The Motor Control and Wiring Module on which this research is focused, was delivered during Phase 4. This module is delivered in a workshop, which is timetabled for seven hours a week. By the end of this module the learner must be able to:

1. Select and install the panel wiring cables, accessories and protective devices required for 'star-delta' and 'rotor resistance' starting of induction motors.
2. Install the control circuits required for 'inch/jog' and 'forward-reverse'.
3. develop and interpret schematic diagrams of the listed motor power and control circuits. Fás (2001).

At the end, these objectives are measured by a three and half hour practical exam. The practical class in preparation for this exam operates as follows:

1. An Overall Health & Safety Talk
2. Word document made available similar to what would be presented as per the exam.
3. Introductory talk on the circuit to be constructed on that day highlighting specific points of notes i.e. safety considerations, or common mistakes special considerations.
4. The Learner would then construct the circuit with little or no interaction with the lecturer.
5. Testing of circuit carried out in conjunction with the lecturer.
6. After the circuit has been tested it is then stripped out.

When this is completed the apprentice is finished for the day. If the apprentice does not complete the circuit before the day is over he/she must still remove any work already completed as another class uses the workshop later in the week. It is hoped that with introduction of this interface, incorporated into the newly designed workshop, apprentices will be able to work at their own pace and select tasks in the order that makes most sense to them.

1.6   National BUA Centre

The National BUA Centre was established in 2003 as a result of a unique partnership between National Learning Network, the Discovery Centre in Cardiff, and the Institute of Technology Blanchardstown. It provides assessment and support to people across the full spectrum of Specific Processing/Learning Difficulties (SPLDs). The National BUA Centre promotes inclusive education nationally through the development of its unique screening facility together with comprehensive educational, vocational and functional activity support services for third level students and adult learners with Specific Processing/Learning Difficulties. (BUA, 2007) The screening process that BUA (2004) employed was designed to highlight learning styles/channels associated with individual students. They categorised the styles/channels in the following way:

1. Visual learners
2. Auditory learners
3. Kinaesthetic learners
4. Creative/Imaginative learners
5. Logical learner
6. Meticulous learners
7. Approximate learners
8. Group style learners
9. Solo learners

A screening process was carried out on a group of 32 electrical apprentice students during term 3 in 2005. It was found that Apprentice students can be generally classified into two main learning styles/channels: Visual Learners and Kinaesthetic Learners.

Following on from this introduction, section two reviews the writings of accredited researchers in the field of learning styles and theory's as well as interactive multimedia systems. Section three then describes the research methodologies used and supporting reasons for selecting them. Section four details the findings of the research and discusses the implications of the full development of the workshop interface. Section five discuses the conclusions from the research and presents a list of recommendations

for the full implementation of a workshop interface for use with electrical apprentices that takes consideration of their learning styles.

2 Literature Review

2.1 Introduction

This review creates an awareness of the issues concerning the creation of a workshop interface, with specific attention to learning styles and the techniques and methodologies used to develop a workshop interface. The literature review is divided under these two sections and is sub-divided as can be seen below. Firstly learning styles is described and two of the most common models VAK and Kolb are illustrated. This section then explains Gardners' theory of multiple intelligences and how he believes that there are eight different forms or modes of intelligences. Particular attention is paid to the two intelligences most closely aligned to Visual and Kinaesthetic learners. This section concludes with a literature review of the two main learning theories Behaviourism and Constructivism. This section of the research paper gives an overview of the leading research in the development of the interface. The primary methodologies utilized are discussed, which include analysis of needs, purpose of the interface, collection of resources, design and creation of interface, and evaluation and revision of the creation of the interface.

2.2 Learning Styles

A learning style is a specific way in which a person learns. Cooke defines it as, *"a student's way of responding to and using stimuli in the context of learning."* Keefe (1989) (quoted by Griggs, 1991) further defined it as;

> *"Composite of characteristic cognitive, affective and psychological factors that serve as relatively stable indicators of how a learner perceives, interacts with, and responds to the learning environment."*

Although most people have a combination of styles, a certain type is usually dominant and the student will learn better using that particular style. Kirkwood (1998) believes an individuals learning style is the most influential factor in determining how they learn that. There are in excess of seventy instruments, which are used to categorize learning styles.

2.3 VAK or VARK

The VAK model is the most common learning style model. VAK stands for Visual, Auditory, and Kinaesthetic and refers to how people take in information. Occasionally, an additional learning style category of Reading/Writing is included.

Visual learners learn by seeing things. They respond well to the written word, visual presentations, graphs and charts, displays, videos, and computer based presentations. Most people are categorized as dominant visual learners. This may be reinforced by teaching methods in secondary education that rely on writing down notes from a chalkboard, reading, and more recently the use of computers.

Auditory learners are best suited to activities involving listening or dialogue. They prefer discussions, debates, lectures, and rehearsing. This style of learning is often reinforced in higher education. The third style of learner, Kinaesthetic, learns best by

doing and activity based learning. They prefer moving, role play, and repetition of action. They should be encouraged to take breaks and move around rather than sitting still for too long. They prefer practical tasks/approaches rather than theoretical exercises. Learners who feel they learn best by processing text are categorised under the heading Reading/Writing. They find the best way to internalize information is by reading text and then writing about what they have learned. Some people are referred to as multi-model learners because they have more than one strong (dominant) learning style. One of the best known instruments using the VAK model has been developed by Dunn and Dunn. (Fleming 2007)

2.4   Kolb based experiential learners

The Kolb model develops a theory of learning that combines a four tier learning cycle with learning style inventory that classifies learners into four groups with distinct two-dimensional learning modes. For Kolb the four stages of the learning cycle are Concrete Experience (CE), Reflective Observation (RO), Abstract Conceptualisation (AC), and Active Experimentation (AE). After completing the Learning Style Inventory, learners are placed into learning styles based on their two dominant learning modes. These four modes are Diverging (CE/RO), Assimilating (AC/RO), Converging (AC/AE), and Accommodating (CE/AE). Another popular model based on Kolb's cycle of learning theory combined with a learning inventory is the Honey and Mumford model. (Atherton, 2005). As noted above there are over seventy models in existence used to categorize learning styles. Each one has developed its own spectrum of learning. It must be noted that there is a large amount of scepticism regarding the validity and usefulness of all learning style models. Detractors have pointed out many flaws, such as limited research and testing, testing subjectivity, and lack of any evidence that these models can improve educational results.

2.5   Multiple Intelligences

These learning styles/channels in some way can be likened to Howard Gardner's Multiple Intelligences Theory. Gardner described intelligences to be *'a bio psychological potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in a culture.'* (Gardner, 1999b 33/4) Gardener outlined eight ways of thinking and knowing, thereby naming eight intelligences, as below:

1. Linguistic Intelligence   5. Musical Intelligence
2. Logical-Mathematical Intelligence   6. Intrapersonal Intelligence
3. Spatial Intelligence   7. Interpersonal Intelligence
4. Bodily-Kinaesthetic Intelligence   8. Naturalist Intelligence

Comparing the Multiple Intelligences to the learning styles/channels it can be seen that visual learners are associated with spatial intelligence and kinaesthetic learners to bodily-kinaesthetic intelligence.

2.6   Spatial Intelligence

Spatial intelligence makes it possible for people to perceive visual information, transform this information, and to recreate visual images from memory. Well developed spatial capacities are needed for the work of architects, sculptors, and engineers. The students who turn first to graphs, charts, and pictures in their textbooks, who like to

'web' their ideas before writing a paper, and who fill the blank space around their notes with intricate patterns are also using their spatial intelligence.

2.7   Bodily-Kinaesthetic Intelligence

Bodily-kinaesthetic intelligence allows individuals to use all or part of the body to create products or solve problems. Athletes, surgeons, dancers, and crafts people all use bodily-kinaesthetic intelligence. The capacity is also evident in students who relish gym class and who prefer to carry out class projects by making models rather than writing reports.

Gardner demonstrates that students learn in identifiably distinctive ways, and shows how necessary it is that subjects should be taught through a variety of means and strategies. He argues for a form of learning that will allow students to demonstrate their understandings in meaningful ways, which are more suited to their learning styles and intelligence profiles. Gardner refers to casualties in learning, that is, the large number of students who are motivated to learn but whose own learning styles or profiles of intelligence are not in tune with prevailing instructional practices. (Gardner, 1991) These learning styles and intelligences must be stimulated for the students to learn best and therefore it is recommended that course material and their delivery should be designed with this in mind. Educational psychologists suggest that, in general the more one engage the senses of the learner, the more they learn. For example, learners will remember more of what is said if visual reinforcement is provide. The sense of sight is particularly important, and this fact should be taken into account in the design of learning material.

2.8   Learning Theory

Learning theory is defined for educational purposes as the theory or study of how people learn. (Wikipedia, 2007) It is subdivided into the two main categories of behaviourism and constructivism.

2.9   Behaviourism

The principal claim of behaviourism states that people learn through conditioning. Conditioning is a change of behaviour realised through action and response type exercises. This can be in formal ways such as the dog obedience school or informal such as how we respond to pain or pleasure. Learning is the development of new behaviour through this conditioning and requires no inner mental processing. The three major proponents of behaviourism were Pavlov, Watson, and Skinner.

Pavlov developed the theory of 'conditioned reflex' also known as classical conditioning. This theory was experimentally shown by the linking of two actions to a response. After a certain time when one action is presented the response will occur. This was demonstrated in his well known experiment where he trained a dog to salivate at a certain sound that had earlier been associated with feeding (Braslau-Schneck, 1998). While Pavlov (1920) was interested in conditioned responses in animals, Watson attributed all human behaviour to conditioning and showed how complex emotions like fear could be conditioned in a person. In his famous 'Little Albert' experiment he showed how fear, a non-physical reaction, could be linked to an object that was previously viewed as neutral. This was accomplished in the still controversial experiment where he scared a young boy by associating a fear with a neutral object. When later shown the object, the child was seen to be conditioned to be fearful.

Skinner is credited with the development of radical behaviourism, which believes that voluntary human and animal behaviour can be conditioned. This differs from Pavlov and Watson, who were studying involuntary behaviour.

2.10 Constructivism

Constructivism is the theory that people construct their own view of the world based on experience and their own understanding. Each person has his/her own mental image of the world they exist in and learn through experience and processing of their experiences. This is clearly differentiated from Behaviourism by its emphasis on the importance of mental processing. Early constructivism can be traced to Giambattista Vico in the 18th century, who believed that people could only truly understand what they themselves had constructed. He felt that he was a 'teacher of himself' (Costello, 2003). Later constructivists include Piaget and Dewey. Piaget developed the theory of stages of cognitive development. He believed that children went through four stages of learning, each based on the one that came before. As each stage was mastered and internalized, the developing mind would gain greater complexity and move on to next, more complex, stage. (Atherton, 2005). As a psychologist and educational reformer John Dewey promoted experimentation, problem solving and critical thinking as integral components of learning. Dewey's ideas were also referred to as pragmatism.

2.11 Analysis of needs and purpose

There were three primary considerations in the development of the workshop interface. All three considerations were underpinned with reference to expert opinion in the area of Human Computer Interface principles (HMI). The task of HMI as defined by the International Engineering Consortium (2007) *'is to make the function of the technology self-evident'* .

The first consideration was the need to be useful in the delivery of knowledge and in this case the curriculum as proscribed by Fás. Cook (2001) states that the 'knowledge content of the system is crucial to successful design'. In order to reach this objective the interface had to contain a circuit diagram, which the user could easily, read. It was also imperative that all support information was easily accessible which included task descriptions, equipment lists, health & safety guidelines, and testing forms.

The second consideration was to develop material that took account of the learning style of the user of the interface. Normally the information contained within the interface is delivered in textual form by the use of a handout at the beginning of a workshop class. However as will be seen from both the data obtained from the VARK questionnaire as well as the collaborating evidence produced by BUA, most apprentices preferred information delivered in a visual/ kinaesthetic mode. In order to complement this preference, information was produced mainly in a visual form with a strong use of photographs, drawings, and diagrams. With the use of animated diagrams which were controlled by the user, as well the full function of the interface being controlled by touch screen, it was hoped to build on the preference of the visual/kinaesthetic form of learning. Electrical diagrams by their very nature consist of information delivered in a visual form, with the diagrams then made interactive it allows to user to interact with them in a kinaesthetic manner. By designing the interface in this manner it satisfies Cooks' (2001) belief that the *'user must be central to the design system.'* It is believed

that computer animated diagrams may help students to understand a subject and create a unique learning experiences (Bagnasco *et al.*, 2003).

The third and final consideration was to help re-create the typical engineering environment of a maintenance electrician enrolled in this type of work. In engineering sectors, the need to match the skills or capability of the engineering labour force with the needs of industrial production contexts is not a new requirement (Pascail, 2006). Boyle(1997) also argued that *'learning tasks should be embedded in problem solving contexts that are relevant in the real world'*. In order to achieve this goal, the steps displayed on the interface were typical of how maintenance workflow is controlled within a high volume engineering environment.

As the needs and special considerations for the interface were being considered, the idea of including some form of testing within the interface was suggested. After deliberation it was decided that the existing use of WebCT was enough in the area of testing. Cunningham (1991) agreed with this decision when he argued that; 'when instruction is embedded in situations where students are involved in realistic or actual tasks, assessment arises naturally from those situations.' It was also anticipated that this would keep the focus on the interface as a tool to help apprentices to complete their practical tasks using information most suited to their learning style. It also helped to create an impression of the typical working environment. The need to complete the practical tasks would encourage the full use of the interface, as opposed to simply passing exams. The use of sound built into the interface was also explored but Boyle (1997) advocates restraints in the use of sound. Due to the noisy environment of the workshop it was decided that sound would not be appropriate.

2.12 Collection of resources

The next step in the creation of the workshop interface was the difficult process of collecting the necessary resources. Appropriate resources may include comprehensive learning guides with overview of essential topics, schedules and assessments, worked examples and virtual simulations, activities and exercises (Subic and Maconachie, 2004). The process started with collecting all available documentation from Fás on the topic area. Documentation regarding all practical tasks required to be completed during an electrical apprenticeship were also collected so as to create a interface with special thought to adding these seamlessly in the future.

This documentation consisted of the electrical syllabus 'Trade of Electrician Overview Manual', the apprentices On-The-Job Task Book, and several electrical Phase 2 training manuals, produced by Fás. At this stage photographs were taken of all the practical equipment used in order to complete the tasks set out as part of the Motor Control and Installation Module. Freeware from the Internet was employed consisting of videos that showed some key skills that were a helpful addition to the interface. Additional resources such as a CD that the researcher created, consisting of a complete set of notes as well as important information for Phase 4 Electrical, were also gathered.

Information on touch screens was also collected in order to be confident that the Workshop Interface would be compatible with the industry standard touch screens currently available on the market. Though it was never envisioned that touch screens would be purchased for this research due to cost restraints, It was deemed important that touch screens were compatible as it is expectation that this paper will provided a

basis for the discussion of investing in touch screens for the electrical workshops in the near future.

The collection of resources also included the collection of appropriate software for the creation of the workshop interface. After several trials, with several software packages, it was decided to use the following. Due to the very visual nature of the interface, an appropriate graphics software was fundamental to the success of the creation of the interface. Vaughan (2001) believes that graphic tools *'are perhaps the most important items'* and *'the graphic impact of your project will likely have the greatest impact on your end user.'* Fireworks (2002) was selected due to the combined features of being object oriented and bit mapped. *Illuminatus Opus Pro* was selected as the main authoring tool as it allowed material of multiple formats to be collected together. Amazon (2007) reviewed the software and agreed that the 'real strength of Illuminatus Opus is in its flexibility'. Boyle (1997, pg.139) also stated that an authoring tool must *'combine all the media resources within a structured framework.'*

Table: 2.1 Table of selected software

Software Type	Software Title	Specific Use	Reason for selection
Authoring Tools	Illuminatus Opus Pro	Creation of menu driven interface	Ease of use, Flash was trialled but was found too complex for a project of this scale
	Macromedia Flash	Creating animated wiring diagrams	Ability to replicate electrical drawing and then animate them
Graphics	Macromedia fireworks	Editing images	Ease of use, same interface as Macromedia Flash

Flash (2006) was selected for two main reasons, firstly is that is has very few browser issues, it plays well in both Internet Explorer and Mozilla Firefox. Secondly it allows for the creation of animations, Macromedia Flash has a well establish reputation as an animation application. (Green, Chilcott, 2006). In all cases ease of use was the main factor in selecting the software. Boyle (1997) believes that the usability of the authoring tool will depend on the experience of the designer.

2.13 Design and creation of interface

The design of the interface was based on an object-based multimedia flow system. This was accomplished by gathering relevant resources, combining these resources to create objects, and finally by placing these objects, in order, to create a flow system. This system is traditionally thought of as a Behaviourist model, though through the use of this type of system in conjunction with the practical electrical wiring element it would more closely align itself to the Constructivist model. (Cook 2001) In creating the sitemap it was decided early on that the user should be able to access all information with no more than three touches of workshop interface from the home page. A list of information required to complete a typical electrical task was then formulated. This list formed the basis of the sitemap and also helped to inform the decision taken to keep these topics accessible from all pages on the interface. In order to accomplish this, a menu was created for the top of the interface and this position was kept constant throughout the interface. These topics for the menu can be seen in the sitemap coloured light blue. Each topic also required information specific to that topic and the headings for this information formed the sub-menu (top to bottom menu). This list can be seen in the sitemap in black.

Interaction was one of the main ingredients of the design of the interface. Molin and Pettersson (2003) write that interaction 'is what distinguishes a multimedia system from a mere digitized video film. Flash was used to make the electrical wiring circuit diagrams interactive in order to allow for greater learner interaction with the subject material.
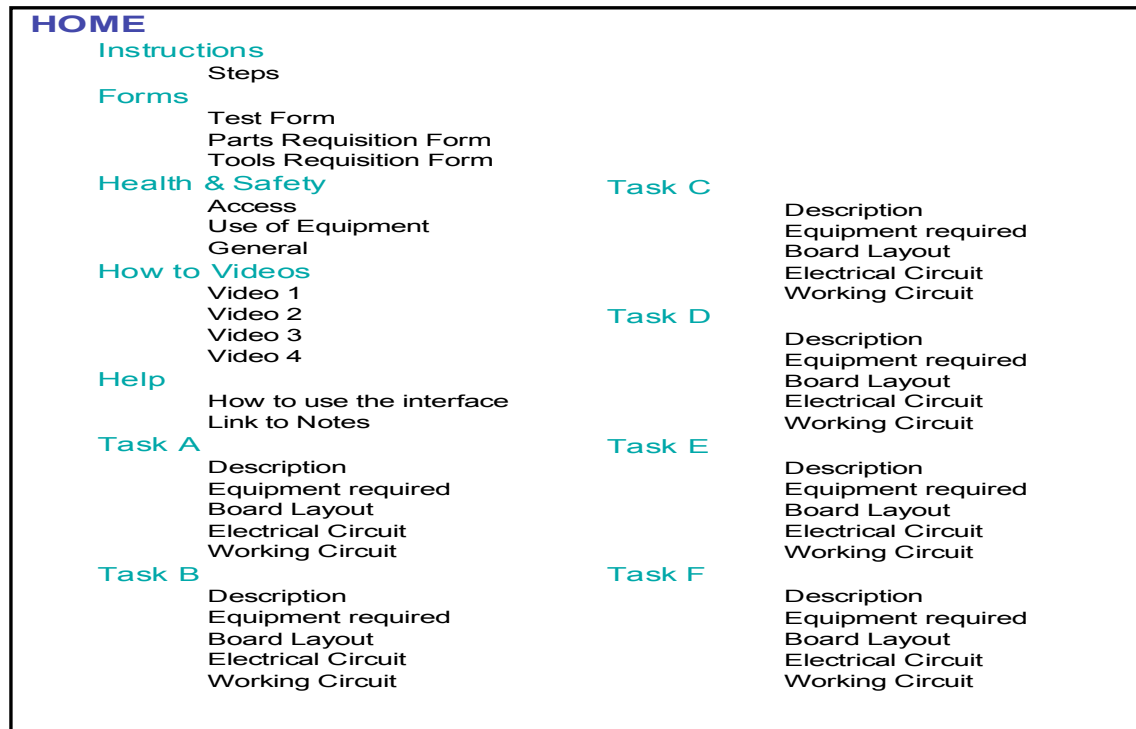

Figure: 2.1 Navigation image

There were several considerations taken into account while designing the actual layout of the screen. It is important to provide learners with ease of access and navigation through resources, and appropriate interfaces and capability of interaction (Volery and Lord, 2000). The most significant was to use large easily accessible buttons on all screens. Experience has shown that one of the major frustrations while using touch screens to unintentionally press the wrong button or not being able to press the desired button due to overlapping hotspots. While creating the 'Working Circuit Screen' it was found to be impossible to use large buttons while at the same time presenting the appropriate information. It was decided for the trial to use mouse-activated interaction and to undertake to solve this if and when touch screens were actually purchased.
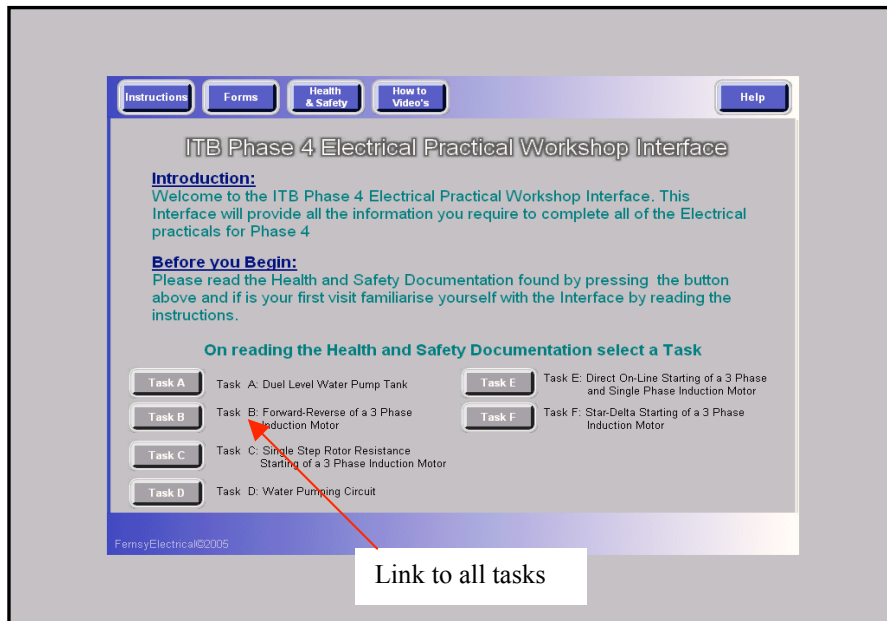
Figure: 2.2 Home page image

Text on all printable screens were of a San Serif text so words would be more easily seen, also a mixture of small and capital letters were used in order to be read more easily. *'Studies have shown that words and sentences with mixed upper and lowercase letters are easier to read'* (Vaughan 2001).
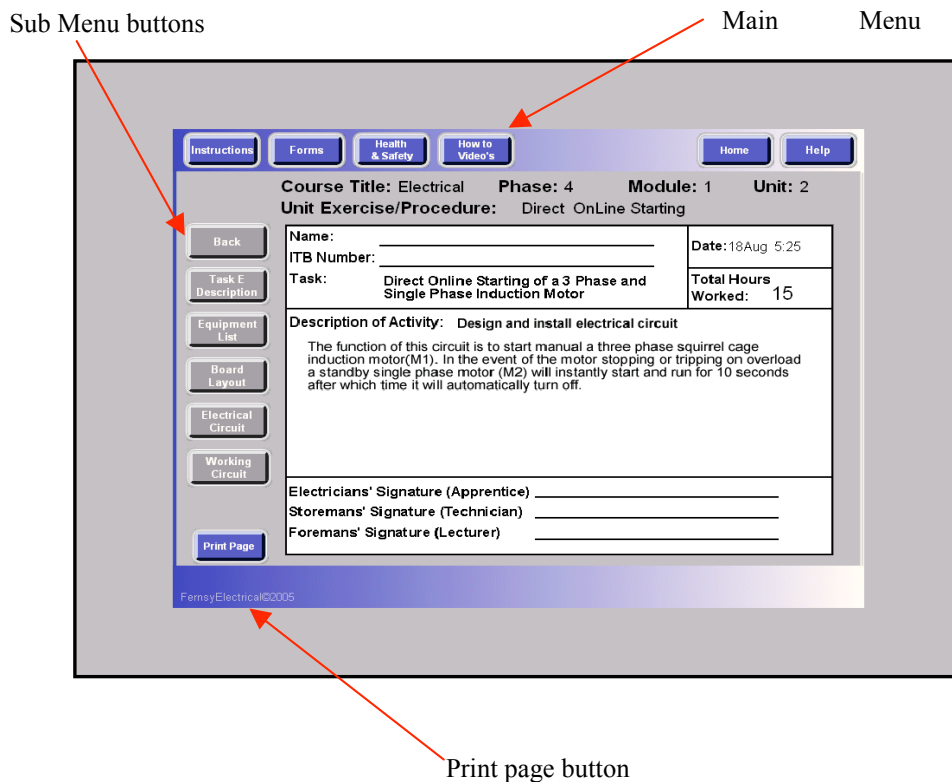

Figure: 2.3 Work instruction image

2.14 Evaluation

As part of the assessment and evaluation of the workshop interface, questionnaires and interviews were carried out. Also several meetings with interested colleagues (focus groups) took place before, during, and after the creation of the interface. Many of the improvements suggested have already led to the enhancement of the Workshop Interface.

2.15 Conclusion

This review endeavoured to inform the creation of a workshop interface with specific attention to learning styles and the techniques and methodologies used to develop a workshop interface. The first section of the review described the different learning styles and the specific attributes that characterised each style. Gardners' theory of multiple intelligences was then described and how these compare to the learning styles. The first section finished by describing two of the main learning theories Behaviourism and Constructivism. The second section of the literature review provides an overview of the leading research in the development of the interface. It illustrates how this research will contribute to the creation of the interface.

3   The Research Methodology

3.1 Introduction

This section of the research paper gives an overview of the techniques and methodologies employed to research the dissertation topic. The primary methodologies can be loosely categorized as desk research, qualitative research and quantitative research. The desk research focused primarily on the literature review of learning styles and their place within education to date. The literature review covered central topics such as different learning styles, multiple intelligences, and two main learning theories. Drawing on the literature review, the qualitative research involved carrying out a number of semi-structured interviews with key informants within an Irish Institute of Technology. Focus groups and questionnaires were also utilized to collect information from a diverse group of individuals which included apprentices, lecturing staff, management, and experts in teaching and learning techniques(WebCt users, BUA), as well as interested parties involved in the creation of learning materials. Quantitative findings from questionnaires were also extrapolated though the intention was not intended to generate precise statistical significance, but to indicate important themes relating to learning styles and their significance to apprentice learning.

The section first looks at the fundamental research questions behind this paper that were explored to help clarify specific objectives of the research and more specifically the creation and suitability of the interface. An explanation then follows as to why the predominant research approach taken was qualitative, as opposed to quantitative. In addition, this section looks at how the qualitative data was collected and analyzed, how the research was managed, and how issues such as ethics, credibility and bias were dealt with. Finally, there is a reflection on the learning from the research methodologies used in the thesis, including how the researcher would do things differently for future research projects.

3.2 Pre-Software Creation (Support)

Returning to the underlying aims of this paper, the intention was to search for evidence that the use of ICT specifically created to target the typical learning styles of an apprentice, would improve the overall learning experience. This could only take place after a suitable piece of software was created. No evidence was found of a workshop interface that had been created for apprentice training in Ireland; thus it was deemed necessary to draw on the skills and experience of those who have been involved in the use or creation of ICT for education as well as learning style specific experts. To this end several key informants were interviewed before the creation of the software. Therefore, there were a number of questions (Appendix 1), which required investigation before the creation of the workshop interface. These questions formed the basis for the interviews. However, the interviews were deliberately kept semi-structured to encourage a flow of information, both expected and unexpected. By attempting to answer these questions, it became possible to base-line where ITB currently stands in relation to ICT, learning styles and apprentice education.

3.3 Pre-Software Creation (Student learning styles)

Prior to the creation of the workshop interface it was necessary to determine if there is a learning style specific to the type of learners who enrol within an apprenticeship system. In order to achieve this, a standard VARK questionnaire was employed. Several meetings were arranged with BUA, to discuss the implications of creating an interface directed by the use of learning styles.

3.4 Post-Software Creation

After use of the workshop interface, questionnaires were used to collect information from both apprentices and lecturers. The questionnaires were designed in a manner to collect both qualitative data and quantitative data. Two focus group discussions were also held.

3.5 Quantitative Versus Qualitative Research

Mertens (1998) suggested that research is "one of many different ways of knowing or understanding". There are many different research paradigms available to the prospective researcher. A research paradigm is a set of assumptions about the nature of reality, knowledge, and the goals and aims of the research process combined. Paradigms represent a distillation of what we think about the world, yet often cannot prove. Researchers' actions are based on the underlying assumptions of each paradigm.

The relative value of qualitative and quantitative inquisition is well debated (Patton, 1990). One of the reasons the qualitative approach appealed was that qualitative research takes the view that the researcher and the data are intertwined and that no dividing line exists between the two.. It made sense, therefore, as the researcher was actively involved in the creation and implementation of the workshop interface both on an emotional and physical basis to follow a research tradition that fit with this reality. According to Dukta (1995:10) *"there is no substitute for an informed, authoritative person who can relate to respondents on their own terms".* Stokes advises (2000:48) *"If the focus of the research is on gaining a broad understanding of marketplace issues, then a qualitative methodology is an ideal starting point".* The point is reinforced by Alizadeh, Perry and Riege (1997) who suggest that, since only observable phenomena can be researched by quantitative means, critical realism (qualitative research) rather than positivism is a more appropriate research paradigm for studying external world

phenomena such as inter-organisational links, communicative networks, interpersonal relationships and participation in collaboration activities.

Therefore, a deliberate decision was made that the research methodology would be primarily based on qualitative techniques and it was understood that the outcomes would not claim to be representative in terms of the answers that would be forthcoming. Furthermore, the analysis of the VARK learning style questionnaires and workshop interface questionnaires demonstrated competence in quantitative analysis, as it was felt important to demonstrate an ability to use both techniques.

3.6   Managing the Research Process

The initial scoping of the project took considerable time, as it involved assessing alternative fields of interest. In selecting the general topic, several important factors were weighed-up. These are:

1. That the timeframe for the research was kept to 20-24 weeks. This had to be balanced with other time-commitments including work, other assignments, family, rest and sport;
2. To select an area that was not entirely new to the researcher, yet would provide significant learning opportunities;
3. To select an area that was relevant to the researcher's current employers.

Having narrowed the research down to the general topics of Learning styles, ICT and Motor Control Installation Phase 4, some time was spent refining the scope of the research, yet encompassing these general areas. A useful tool that helped to clarify the objectives was to write a project objective statement, which in turn became the basis for the title of the project. It was decided to use the following statement:

> *'To investigate the feasibility of creating a piece of software for practical electrical classes that engages learners of different learning styles'*

Although research projects by their nature are open-ended, the project objective statement nevertheless provided a mechanism for scoping exactly what was required to do over the defined timeframe. The Institute of Technology Blanchardstown offered their full support, as did BUA; the only proviso was that the results of the findings would be made available to both ITB management and BUA support staff. As part of the planning process, a work-schedule was prepared (Fig. 3.1). Although due to a family bereavement the schedule was not adhered too, it helped to monitor progress and define a suitable order in which to tackle key deliverables.
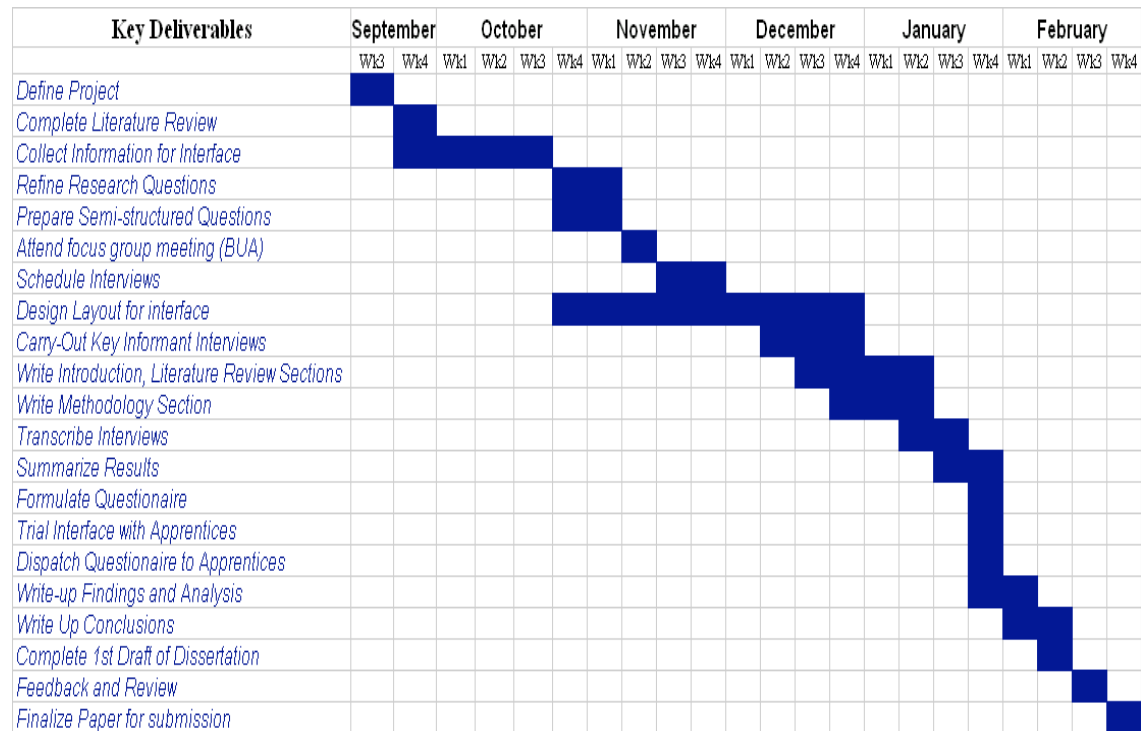
Key Deliverables	September		October				November				December				January				February			
	Wk3	Wk4	Wk1	Wk2	Wk3	Wk4	Wk1	Wk2	Wk3	Wk4	Wk1	Wk2	Wk3	Wk4	Wk1	Wk2	Wk3	Wk4	Wk1	Wk2	Wk3	Wk4
Define Project	■																					
Complete Literature Review		■																				
Collect Information for Interface			■	■	■																	
Refine Research Questions						■																
Prepare Semi-structured Questions							■															
Attend focus group meeting (BUA)																						
Schedule Interviews						■	■	■														
Design Layout for interface									■													
Carry-Out Key Informant Interviews										■												
Write Introduction, Literature Review Sections											■											
Write Methodology Section												■										
Transcribe Interviews													■									
Summarize Results														■								
Formulate Questionaire															■							
Trial Interface with Apprentices																■						
Dispatch Questionaire to Apprentices																■						
Write-up Findings and Analysis																	■					
Write Up Conclusions																		■				
Complete 1st Draft of Dissertation																		■				
Feedback and Review																				■		
Finalize Paper for submission																					■	

Figure: 3.1 Schedule of Key Deliverables

3.7   Data Collection

Denzin and Lincoln (1994) encourage the qualitative researcher to *"use the tools of his or her methodological trade, deploying whatever strategies, methods or empirical materials are to hand"*. In my data collection phase telephone and face-to-face meetings were used to conduct the semi-structured interviews and focus group meetings. A commonly used qualitative technique is the use of one-to-one interviews or group (discussions). Qualitative interviews can be used either as the primary mechanism for data collection, or in conjunction with observation, document analysis, or other techniques (Bogdan and Biklen, 1982). Qualitative interviewing utilizes open-ended questions that allow for individual variations in responses. Jancowitz (2000) writes about a number of methods in qualitative interviewing, including: 1) informal, conversational interviews; 2) semi-structured interviews; and 3) standardized, open-ended interviews. Erlandsen et al (1993:86) advocated that the semi-structured interview is *'guided by a set of basic questions and issues to be explored, but neither the exact wording, nor the order of the questions was predetermined'*. The typical style of open ended questions in these interviews provide a greater depth of data than structured interviews in that they attempt 'to understand the complex behaviour of members of society without imposing any a priori categorisation that may limit the field of inquiry' (Fontana and Frey, 1994: 362). Semi-structured interviews are, therefore, particularly useful when it is important to understand the construct that the interviewee uses as a basis for their views or beliefs about a particular topic, a factor that is eminently significant in this research.

Interviews were tape recorded and later transcribed for analysis purposes. Dukta (1995:28) stresses the importance of using a recorder: *'The use of a tape recorder*

reduces the almost unavoidable bias created by an interviewer documenting his or her own work'.

A questionnaire was created to be used by apprentice learners and academic staff post interface creation in order to evaluate its effectiveness. Its purpose was to articulate some form of summary statistics upon reflection of the use of the interface within a workshop situation. Dukta (1995) highlights the importance of the questionnaire design stating: *'It is exceptionally difficult to create a questionnaire that is both accurate and relevant. The skilful preparation of such a questionnaire will contribute significantly to the success of the research'.* It is important to note that although part of the analysis from the questionnaire is quantitative, it merely reinforces some of the common themes that emerged from the qualitative analysis, i.e. the semi-structured interview, questionnaire and focus groups. By combining the qualitative analysis with the quantitative analysis backed-up by the literature survey and the analysis of the views expressed in the pre-workshop interface creation interviews, it was felt that the issues had been tackled from enough different vantage points to achieve sufficient data triangulation, which would help to illuminate important findings and conclusions from multiple standpoints, thereby enhancing the credibility of the findings.

3.8 Ethics

Examining peoples' opinions, attitudes and preferences requires sensitivity, particularly in cases where comments are driven by emotions, as opposed to logic. Although there was never anything inherently confidential in what was set out to investigate, it was set out with the intention of adhering to the principle of informed consent. All key informants were informed of the background and purpose of the study, were given a copy of their interview transcripts, and asked to validate the interview summaries. It was also clarified that they had the option to request confidentiality and anonymity of any information that they provided. To avoid any complications arising directly from quoting an individual interviewee, it was decided not to publish the transcripts of the interviews or questionnaires. By doing this, it not only avoided unnecessary pointing to "who exactly said what" but it also avoided unwarranted clouding of the qualitative analysis that ensued.

3.9   Credibility and Bias

Credibility tends to be more a function of the richness of the information gathered and of the analytical abilities of the researcher than of on sample size (Patton 1990). As pointed out earlier, the researcher can enhance the credibility of his / her findings through triangulation of data. Creswell (1994) argued that triangulation was based on the assumption that any bias inherent in particular sources of data, investigators and methods could be neutralized when used in conjunction with other data sources, investigators and methods. This research involved 'between' methods, drawing on both semi-structured interviews, a survey and relevant literature and a follow-up questionnaire. In qualitative research, the researchers regard bias as unavoidable and they are likely to state their biases openly.

As Brody (1992:179) states:
> *Since the naturalistic investigator is him or herself the research instrument, naturalistic inquiry cannot avoid observer bias .... Instead, open disclosure of preconceptions and assumptions that may have influenced data gathering and processing becomes an inherent part of the conduct of the inquiry.*

Greene (1994:539) regards bias as the qualitative researcher's greatest asset: "it is precisely the individual qualities of the human inquirer that are valued as indispensable to meaning construction". The researcher was aware that their own personal perspectives could influence how they viewed the importance of some findings relative to others. It could have been decided to increase the sample size of the interviewees to increase the level of objectivity and statistical significance of the result but at the end of the day regardless of the method of data analysis used researchers see data through *'the lenses we have at our disposal at any given time'* (Ely et. al 1991:143). Apart from having the interviews semi-structured, key informants were deliberately chosen on the basis of their specialized knowledge and experience. Depending on their role, job-title, organisation and their likely perspective on the issue of ICT and learning styles, some questions were more relevant to some interviewees than to others.

3.10   Overview of Research

The research for this study was carried out during term 3 of the 2004/2005 academic year. During this term Electrical apprentices had already become familiar to using computers by attending computer classes for a one and half hours a week, they also gained experience by using WebCt in a blended approach to supplement their traditional style classes. The research was carried out in an Irish Institute of Technology. This Institute of Technology currently caters for two groups of 16 for four trade groups which include Brick & Stone, Carpentry and Joinery, Electrical, and Plumbing. The participants for the interface trial were 28 Electrical apprentices and six lecturers, though the learning style questionnaires were completed by all 128 apprentices attending the Institute during term 3. The apprentices ranged in age from nineteen to thirty-six.

3.11 Data Analysis

Through the researchers engineering experience in dealing with qualitative research it was considered essential to take a very structured and objective approach to data analysis. However, it is fair to say that researchers tend to notice only those things that they are personally interested in Again, it is important to reiterate that the small sample size implies that the results probably do not have any statistical significance but merely help to articulate the degree of alignment among key informants on central themes and reinforce the qualitative findings. Qualitative research tends to be inductive in its analysis of data, implying that critical themes emerge from the data (Patton 1990). This implies that the research process requires some degree of creativity, as the challenge is to place the raw data into logical, meaningful categories; to examine them in a holistic fashion; and to find meaningful ways to communicate this interpretation to others. Having had each taped interview transcribed, the interviews were then listened to several times, along with reading the transcripts, to ensure that the transcript material was an accurate interpretation of the interview. Having someone else transcribe the interviews saved considerable time and also instilled some objectivity into the interpretation of the interviews.

3.12 Summary

The research methodology used in this paper combines quantitative and qualitative techniques, with the overriding emphasis being on qualitative research. Having said that, the analysis of the literature review represents a major part of the research as it sets the scene for the appropriate research questions. Qualitative analysis was based on key

informant, semi-structured interviews, focus groups and the interface evaluation questionnaire. Quantitative analysis was limited to the results from the Vark learning style questionnaire and the interface evaluation questionnaire.

Having reflected on the research that was carried out, the following are highlighted as critical success factors, which the researcher would try to incorporate into any future research projects in order to improve the quality of the research:

1. balance well-defined goals and objectives with a degree of open-mindedness and flexibility in relation to the questions and answers that the research uncovers.
2. gain a strong mandate and support for the research.
3. prepare a schedule of interviews well in advance and have a careful selection process for key informants (they must provide a balanced set of expertise).

4   Results and Findings

4.1   Introduction

It is important to reiterate that the qualitative research for this thesis has been based on semi-structured interviews with key informants and focus groups. Informants were selected due to their knowledge of educational issues affecting all students and several were selected due to their expertise of the specific difficulties facing apprentice students. At the end of the day, the data generated through the interviews and focus groups is of opinion only. It is also essential to bear in mind that the sample size was very small, 28 Electrical apprentices and six lecturer's trialled the electrical workshop interface. The sample size in relation to the learning style questionnaires was also very small; 128 apprentices. The fact that an interface such as this has never been created before and the informants have little experience of using ICT within a workshop, a certain novelty factor may taint the results. There are two main themes emanating from the research; one being the discussion taking place surrounding Learning styles as well as an evaluation of the students learning style questionnaires; and secondly the relevancy of the workshop interface in meeting the needs of the individual learner.

4.2   Brief discussion on interviews

One issue that emerged from the research work was that individuals involved in education had different perspectives on what was the meaning of "Learning Styles". Some viewed it strictly as a tool to label students regarding their preferred style, others believed that it is a tool that was to be used during the first week of classes and then forgotten about. Still others believed that aligning all educational resources to suit particular students' learning style would revolutionize education. Though there was disagreement on the use and definition, all contributors agreed that through the use of "Learning styles" educators would be better equipped in responding to the individual differences of each learner. It was also agreed that "Learning styles" allows for the broadening of the definition of intelligence.

The discussion also entertained the idea of using VLEs in the delivery of courses. A majority agreed that they could have a positive impact on allowing learners to progress at their own pace and also allow them to access resources that better suited their individual learning style. A negative factor that continuously arose in conversation was the issue of resources. A common problem in the area of VLEs, one interviewee stated:

> *'I've always argued that they'll give you millions to build buildings but I've never managed to successfully convince them to give us millions to achieve the same end result by using a VLE infrastructure. So ultimately that will be our main constraint.'*

All participants agreed that with this negative attitude towards the use of VLEs and also agreed that it will take individuals at local level to progress the use of ICT in education.

4.3   Discussion on learning style questionnaires

An easily available VARK learning style questionnaire was administered to 128 apprentices enrolled at an Irish Institute of Technology in apprenticeship courses ranging from Brick & Stone, Carpentry & Joinery, Electrical, and Plumbing.
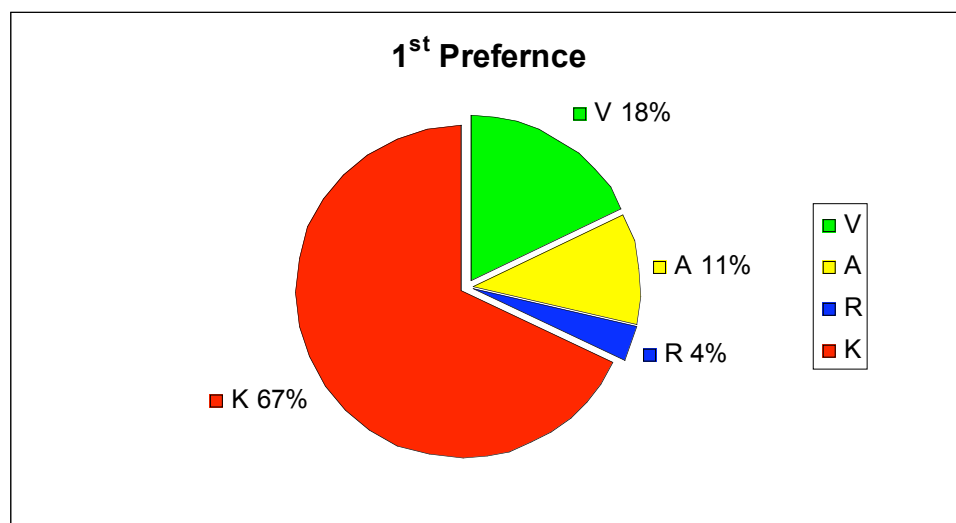

Figure: 4.1 Learning style 1ˢᵗ preference

As can be seen from the above chart 67% of the apprentice learners categorised themselves as primarily Kinaesthetic learners with a further 18% categorising themselves as Visual learners. It was soon very evident that the overriding preferred style was that of Kinaesthetic and Visual and this would need to be taken into account in the construction of the interface.

The second preferences also showed an inclination towards Visual (43%) and Kinaesthetic (11%) with also a strong second place showing for Audio (29%). This strong showing for Audio was also reflected in many of the discussions and responses from the questionnaires, as will be shown below.

This data interrogated from the VARK questionnaires collaborates with BUA's (2004) work in this area where they found after tests that the majority of apprentice learners they examined had a preference towards learning in a Kinaesthetic or Visual manner. A researcher from BUA stated; 'that the evidence shows that it will require possible innovative teaching / learning methodologies to maximise performance.'
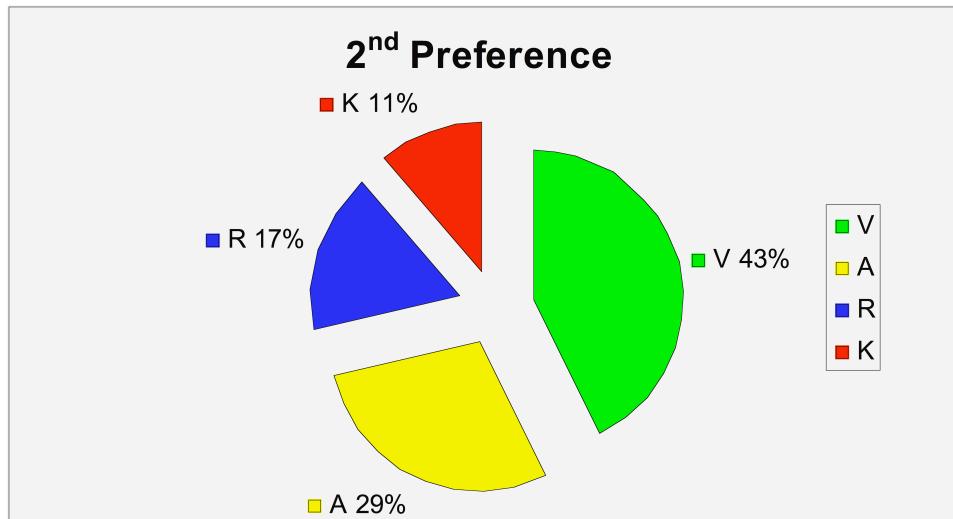
Figure: 4.2 Learning style 2nd preference

In order to gauge the effectiveness of the workshop interface, electrical apprentice students as well as a selection of lecturers were asked to complete a questionnaire; a total of six lecturers and 24 apprentices completed the questionnaires. The questionnaire was divided into three distinct categories; the structure of the interface, the content of the interface and finally the future use of the interface/ICT in this environment.
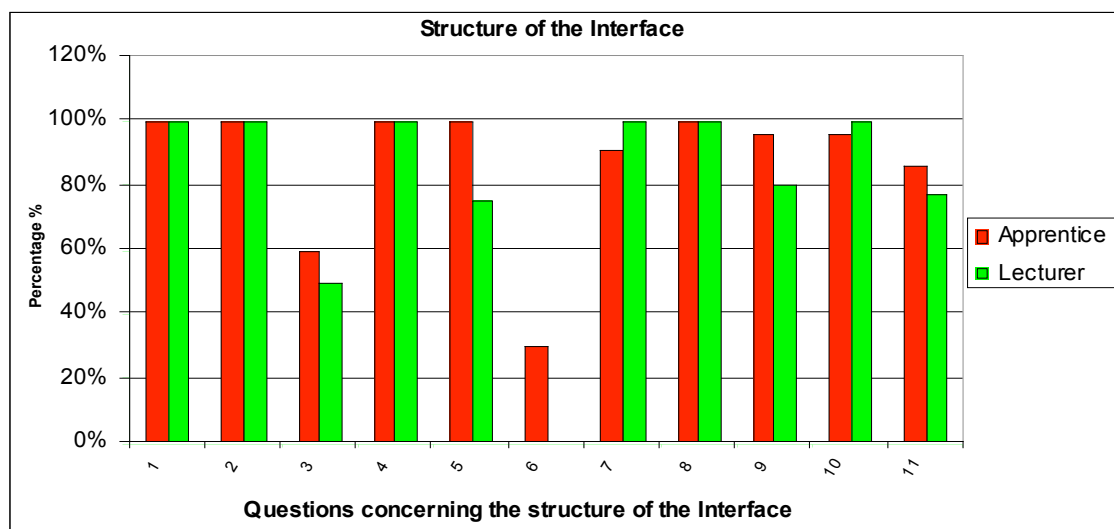

Figure: 4.3 Structure of the interface

4.3 Findings for structure of the interface

The first question asked regarded the navigation of the interface and both lecturers and apprentices rated it at 100%; this was important as an easy navigated interface was a key objective in the design. A follow on question concerned whether the information was presented in a clear and understandable way, again both lecturers and apprentice

learners 100% agreed that it was with one apprentice learner commenting *'that everything was well identified so could be easily understood'*.

Table: 4.1 Structure of the interface

No.	Question	App %Yes	Lect %Yes
1	Was the software program easy to navigate?	100%	100%
2	Is the information presented in a clear and understandable way?	100%	100%
3	Would you like to hear a narration guiding you while using the software?	60%	50%
4	Do you feel the interface is an improvement in the delivery of the material?	100%	100%
5	Is there enough interaction in this system?	100%	75%
6	Did you find it difficult referring to additional resources for information (e.g. the CD of notes, the ETCI rules).	30%	0%
7	Would you say the tasks/exercises were appropriate?	91%	100%
8	Are the on line help and directions clear?	100%	100%
9	Were the colours used helpful to highlight the important parts?	96%	80%
10	Did you find the screen layout interesting?	96%	100%
11	**Indicate the overall rating for the structure of the CD.**	**86%**	**77%**

Question three was a point of much debate that was contained both in the interviews as well as the questionnaire. It simply asked if the user would like to hear a narration while using the interface, many felt this would be useful as would appeal to their audio skills, several though thought that the noise within a workshop would add an extra distraction to an already noisy environment. This difference in opinion is evident with 60% of apprentice students and 50% of lecturers favourable to narration. All participants felt this interface was an improvement in the delivery of the material as is reflected in the 100% result and it was remarked by several of the apprentice learners that the interface tells and shows you (the user) exactly what everything is and how it functions.100% of the student felt there was enough interaction contained within the interface, but only 75% of lecturers felt the same. They cited the need for more interaction on the working electrical circuits and another lecturer made the excellent suggestion of showing real-life examples and applications of the electrical tasks that are required to be completed.

Question six also provoked much discussion; it asked if there was difficulty in referring to additional resources. One suggestion, which was acted upon, was to connect the CD of notes directly to the workshop interface; another suggestion was to obtain a softcopy of the National Rules for Electrical Installations (Irish electrical regulations) and hyperlink relevant material but it was felt this was beyond the scope of this project. A very positive response (91%/100%) was received when questioned about the appropriateness of the tasks/exercises, it was important that all users appreciated the importance and the reason behind the tasks/exercises they were asked to complete. All users agreed that the online help and directions were clear. It has been suggested that a proper help section similar to one found in all popular software packages be created for the interface. Most (96%) apprentices thought that the colours used in the interface were appropriate though only 80% of Lecturers agreed; two of the Lecturers suggested that the colours on the working circuit should be enhanced to highlight a live circuit better.

There was an agreed feeling (96%/100%) that the interface was of a professional design with one Lecturer stating it had a *'good similarity to other commonly available screen formats'*

More than 75% of both apprentices and students felt that the structure of the interface was more than suitable for the purpose it was designed, though as stated above, two areas of concern were the referencing of additional information and the question of whether or not to add narration.

4.4   Content of the interface

The first question in relation to the content of the interface queried whether the topic i.e. electrical workshop practice, was well presented and all users agreed that it was, with an apprentice learner stating that it was *'presented well and easy to work with.'*
When asked if the interface motivated the user to learn, all the lecturers (100%) agreed that it did, 16% of apprentice learners disagreed with this opinion stating; '*it could become boring after awhile*' and one also suggesting that there should be an incentive to finish all projects.
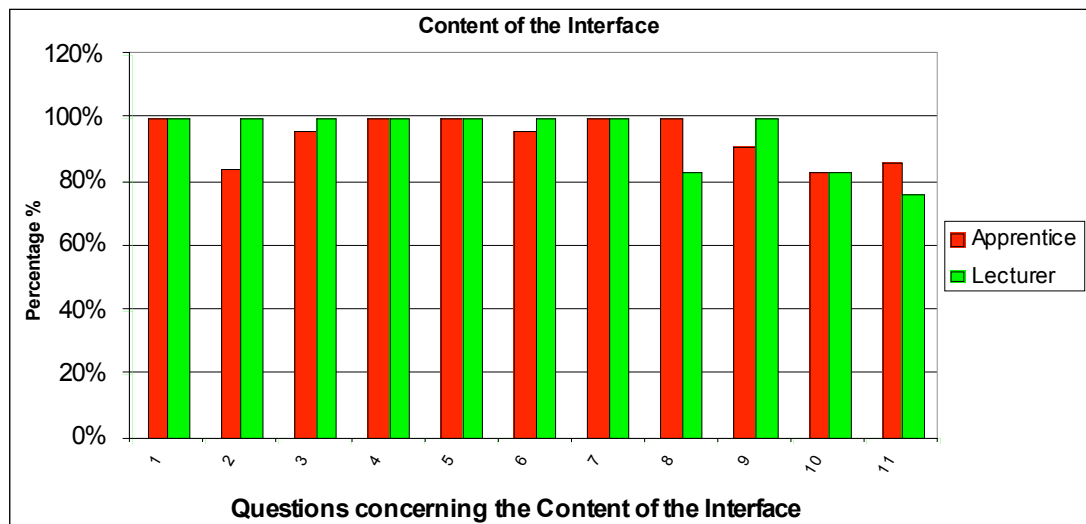

Figure: 4.4 Content of the interface

The completed questionnaires also illustrated an overwhelming agreement that the material was correct and up-to-date (96%/100%), that the information was well organised (100%100%), that they were aware of the topic that it was trying to demonstrate (100%/100%), that the material could be used outside the workshop (96%/100%) and the exercises were effective (100%/100%).

When asked if there were sufficient pictures, examples, and animations there was much agreement, though this question solicited the most suggestions for improvement. The Lecturers recommended showing videos or pictures of differing standards of work (excellent, good, poor), as well as repeating the suggestion for videos showing real-life applications for the circuits. The apprentice learners put forward the idea of showing the contacts opening and closing on the working circuits and also advocated an animated walk-through of the final working circuit

Table: 4.2 Content of the interface

No.	Question		App %Yes	Lect %Yes
1	Did you like the way the topic was presented?		100%	100%
2	Did you feel motivated to learn more?		84%	100%
3	Is the material correct and up to date?		96%	100%
4	Is the information well organised?		100%	100%
5	Did you know what topic the software was trying to teach at all times?		100%	100%
6	Could the material be used in areas outside the workshop?		96%	100%
7	Are the exercises effective?		100%	100%
8	Is there sufficient	a. pictures?	100%	83%
		b. examples?	91%	100%
		c. animations?	83%	83%
9	**Indicate the overall rating for electrical content of the Software**		87%	77%

Finally, when asked to rate the overall electrical content of the interface the apprentices, as expected from the results of individual questions, rated it highly (86%). The Lecturers only gave it a rating of 77%. As it stands it's a very positive result but if an average of the individual questions was calculated a rating of 97% would have been achieved. This gives the impression that the questionnaire was deficient as lecturers were unable to fully articulate their views on the content of the interface.

4.4   Further use of interface

We can see from the graph all participants unanimously agreed (100%/100%) that the interface could be used successfully to teach other electrical subjects.
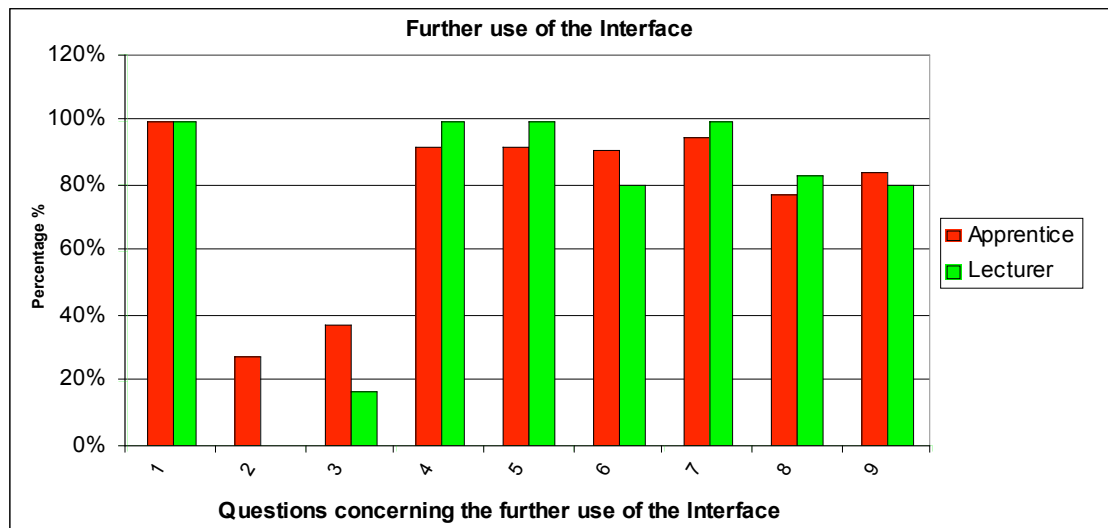

Figure: 4.5 Further use of the interface

Table: 4.3 Further use of the interface

No.	Question	App %Yes	Lect %Yes
1	Do you feel that the interface can be used successfully to teach other electrical subjects?	100%	100%
2	Can you see an interface like this replacing face-to-face teaching?	28%	0%
3	Did you experience any hardware or software problems while using the interface?	38%	17%
4	Did you find the interface enjoyable to use?	92%	100%
5	Do you feel in a more comfortable position to use similar types of software for learning in the future?	92%	100%
6	What features of ICT would you like to see in the future a. pictures	91%	80%
	b. animations	95%	100%
	c. narration	77%	83%
7	**Indicate the overall rating for the quality of the Interface**	**84%**	**80%**

When asked if they could see an interface such as this being used to replace face-to-face teaching, only 28% of apprentice learners felt that it could. Lecturers where even more negative, they felt that it could never replace face-to-face teaching. For example one lecturer stated; *'not fully, as confirmation of deeper understanding of a topic needs to be personally communicated to the student as a mix of emotions are available to a teacher as opposed to ICT'*. A different view from lecturers did surface through the interviews, most saw the benefits of using ICT of this style in education with the major difficulties highlighted surrounding the lack of resources:

> *'with VLEs' is that, all of the infrastructure needs to be in place and all the resources need to be in place.' and ' I would imagine that if you're talking about virtual learning and so on, I would imagine that to establish that is very expensive'*

A low number of participants have stated that they had difficulties in using the Interface and this was to be expected in its first trial as the interface was designed to only be an exploration of the feasibility of creating a useful piece of software for practical electrical classes that engaged learners of different learning styles. The majority of the participants agreed the Interface was enjoyable to use (96%/100%) and that they would feel more comfortable using similar types of software for learning in the future (96%/100%). When asked what features they would like to see in the future, all agreed the need for more pictures and animations and a majority asked for narration but as discussed earlier the form that this would take is unclear. Overall the participants rated the Interface quite highly (84%/80%) with one student proposing a further comment that the power and control circuits should be separated on the animations.

4.6   Weaknesses of the research

It was felt that the cohort of apprentices and lecturers that reviewed the interface were not of an adequate size to gauge an accurate outcome. In reality the study would need to cover all apprentices attending the college at a particular time. Although the Interface did cover one particular aspect of the course it did not cover nearly enough material to allow apprentices to get a full appreciation of using ICT. Much of the enthusiasm that

apprentices showed towards the Interface could be put down to the novelty factor rather than the concept.

5 Conclusions

This research paper set out with the goal of investigating the feasibility of creating a piece of software for practical electrical classes that engages learners of different learning styles. Prior to this research a learner would be presented with a majority of the information required for completing the module in a format that matched one learning style. With the introduction of a new workshop at ITB it was hoped to leverage some of the advantage of ICT to allow for the diverse learner by providing materials in a variety of formats. It was through the development of a touch screen operated workshop interface that this was hoped to be achieved. The evidence produced by the research points to a strong potential for the development of this interface that will meet these needs. The workshop interface that was created for electrical practical classes and evaluated by both apprentice learners as well as lecturers was met with a positive response. Apprentice learners more interested in mobile phones and Playstations found it a comfortable and enjoyable way to learn. They appreciated that the material was delivered in a way more suited to their individual needs. Lecturers could also see the advantages of using ICT, they discovered that through the use of ICT learners could take more ownership for their own learning and has also made them more aware of the need to deliver material in a form best suited to the learner.

6 Recommendations

The following are recommendations for the further development of this interface. Implemented in conjunction with each other these could allow for the creation of a self-directed learning environment which respects the needs of the diverse learner within a practical workshop.

The recommendations are:
- The installation of touch screens at workstations within the new practical workshops
- Allocation of resources to allow for further development and training
- Integration with the Institute of Technology's VLE
- Continued evaluation of Apprentice learning styles in the hope of creating an apprentice learning profile.
- Researching an appropriate tool for measuring the actual learning taking place.

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