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ENGAGING STUDENT'S LEARNING THROUGH A BLENDED LEARNING ENVIRONMENT

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Abstract

Within the furniture manufacturing industry a high proportion of occupational accidents are as a result of non-compliance to machining regulations and incorrect work practices. Safety training plays an important role in reducing accidents and promoting a safety culture within this sector. This article details an action research study undertaken during the first year of a new Degree in Timber Product Technology, which set out to evaluate the impact a blended learning environment and reusable learning objects (RLOs) could have on promoting safe work practices and a safety culture amongst students. A constructivist approach was taken and the module design was underpinned by Kolb's model of experiential learning, placing more responsibility on the learners for their own learning and encouraging them to reflect upon their experiences. The findings of this study suggest that students with prior industry machining experience required a change in their attitude to machining which was achieved within the practical labs, while students with no machining experiences were intimidated by the learning environment in the practical labs but whose learning experience was enhanced through the use of RLOs and other eLearning resources. In order to reduce occupational accidents in the furniture manufacturing industry the promotion of continuing professional development (CPD) training courses is required in order to change workers' behaviour to machine safety and encourage lifelong learning so as to promote a safety culture within the furniture manufacturing industry.

Keywords: Interactive learning environments, Teaching / learning strategies, Pedagogical issues, Improve classroom teaching, Lifelong learning.

1 INTRODUCTION

The European furniture industry is worth an estimated €126 billion, with 150,000 companies employing around 1.4 million people (Eurostat, 2009). The Irish furniture manufacturing sector is a small industry compared to its European counterparts; the most recent figures available from Heanue (2009) state that in 2006 the sector employed a total of 5,602 persons in 298 firms. This industry is a labour-intensive industry with 86% of the companies comprising of fewer than 10 workers (Eurostat, 2009; UEA, 2007). The nature of the work in these small and medium-sized companies sees work-pieces being machined manually, which can result in a hazardous proximity between the operator and the moving tool occurring (Hovden, Albrechtsen, & Herrera, 2010). Ratnasingam (2012) describes this as a 3-D environment which is "dangerous, dirty and degenerative". It is estimated that more than 100,000 workers are injured in European furniture factories, leading to numerous days of absenteeism and consequently a loss in productivity (UEA, 2007). Health and Safety Statistical information from the United Kingdom (UK) show that accidents involving contact with dangerous parts of machinery or the material being machined accounted for approximately one quarter of all the fatal injuries recorded in the woodworking industry, and approximately half of all major injury accidents (HSE, 1998).

Within the Irish context, little exists in the way of statistical information pertaining to occupational accidents in the furniture industry. Of the accidents reported to the Health & Safety Authority (HSA) in 2010, 1262 occurred in the manufacturing sector (HSA, 2011). This sector includes 23 different categories ranging from the manufacture of food products, fabrication of metal products, through to the manufacture of furniture. From this information it is unclear to what extent woodworking related machine accidents are occurring. In light of this the majority of the reports referred to within this article are from the Health & Safety Executive (HSE) in the UK.

The European Association of Furniture Producers (UEA) analysed Europe's safest countries in 2007 and identified a number of best practices used in promoting occupational safety, and concluded that suitable safety training plays an important part in promoting a "safety culture". The term "safety culture" is loosely used to describe the corporate atmosphere or culture in which safety is understood to be, and is accepted as, the number one priority within the wood machining industry (Cullen, 1990).

Wallen & Mulloy (2006) and Ho & Dzeng (2010) concur with the findings from the UEA, and state that an important element in promoting safety culture is the quality of safety training as it has a direct effect on workplace safety.

The Dublin Institute of Technology (DIT) in Ireland has been educating students in the timber industry for the past 100 years. Throughout this time teaching practices and emphasis on machine safety have evolved. According to Wallen & Mulloy (2006), one of the central paradoxes of education is the ability of learners to make use of newly acquired knowledge outside of the classroom or learning environment. Frequently, learners who appear to have acquired certain knowledge and skills and can answer questions in the classroom are unable to apply this knowledge and skill in work settings. In the furniture industry this can result in students attempting to operate machines in breach of regulations. This article details an action research study undertaken at DIT which hypothesised that blending traditional teaching practices with a student centred learning approach through the use of eLearning and the provision of re-usable learning objects (ROLs), would alter the way students operate woodworking machines and promote a safety culture amongst first-year students on a Timber Product Technology (TPT) degree.

2 THEORETICAL FRAMEWORK

The pedagogical approaches used in student education can vary greatly depending on the nature of the learning required. Students in the area of wood machining require more than practical demonstrations and lecture notes; they need to develop their psychomotor and cognitive skills that allow them operate machines safely (Ferris & Aziz, 2005). The research study detailed in this article was built on Kolb's cycle of experiential learning supporting the students in learning by doing. This constructivist approach to learning places more responsibility on the learners for their own learning. It involves students in more decision making processes as they learn by doing rather than just by listening and performing meaningless tasks which are often not in context (Rogers, 2002). David Kolb's theoretical model of experiential learning has particular relevance for disciplines that employ more active or experience-based learning and teaching approaches such as wood machining.

Since the early part of the twentieth century educators have shown that students learn more effectively if they are actively involved in the learning process rather than simply being passive learners. John Dewey challenged educators to develop educational programs that incorporated real life learning experiences. In the 1960s and 70s many psychologists, sociologists, and educators believed in the value of experience during learning, not as a replacement to the theory lectures but as an addition to them. In recent years, David Kolb promoted the use of experiential learning, stating that learning is a multi-dimensional process. He describes "Learning as the process whereby knowledge is created through the transformation of experience, knowledge results from the combination of grasping experience and transforming it" (Kolb, 1984, p. 41).

2.1 Project / Module Design

The Irish construction industry experienced unprecedented high levels of employment during the construction boom, escalating in 2006 to approximately 138,000 persons employed in this sector, but there has been a dramatic decline in employment by 50% in 2010 (Mc Grath & Shally, 2011). While the furniture sector is not categorised as being in the construction industry, it is strongly influenced by this sector and is also experiencing a dramatic decline in employment. There are currently a significant number of young unemployed construction crafts-workers and redundant apprentices in the Irish labour force. The rationale behind developing a new Timber Product Technology (TPT) degree in such a volatile environment was to up-skill unemployed craft-workers, and to train secondary school leavers wishing to pursue a career in the timber industry. There was particular demand from the latter group because as employers were reluctant to employ apprentices they were unable to receive relevant training within this industry.

The TPT degree commenced in 2011 in the Dublin Institute of Technology, in the Department of Construction Skills with an intake of 24 students. This course is a level 7 Ordinary Degree as awarded under the National Qualifications Authority of Ireland (NQAI). The program educates students for the woodworking industry, in the area of furniture and joinery, and provides graduates with the practical and theoretical knowledge to start up their own company or work in middle management within this sector. The first year of this programme provided students with a high level of practical skills, ranging from jointing techniques using hand tools through to wood machining, manufacturing both furniture and joinery components. The students also engaged in a variety of theoretical subjects such as academic reporting skills, timber materials, mathematics, and regulatory environment.

Within the first semester of year one, the modules ‘Wood Machining’ and ‘Regulatory Environment’ are closely aligned and run in tandem. Students acquire the psychomotor skills required to operate machines safely in the wood machining labs while also gaining the theoretical knowledge of safe work practices and machining regulations within the regulatory environment theory lectures. A traditional teacher-centred learning approach is used within the practical labs as a result of the associated machining dangers. Harden and Crosby (2000) describe teacher-centred learning as the focus on the teacher transmitting knowledge from the expert to the novice, primarily a one-way movement of sharing knowledge and learning from teacher to student. Within the practical labs it is essential that the students adhere to the machining regulations and safe work practices. The teachers must be in control of the learning process as systematic planned instructional design is very important and teaching techniques are stressed (Harden & Crosby, 2000). The class was divided into three groups of eight during the wood machining labs and received eight hours of wood machining training per week. The students undertook a practical assessment at the end of semester, which assessed student accuracy in wood machining, their knowledge of machining, and ensured that the students adhered to safe work practices when operating machines.

The regulatory environment module comprises of a two hour lecture per week with the class of 24 students. Within this class the students explore information pertaining to wood machining regulations, safe work practices, and workplace safety legislation, and aims to promote a safe work culture. A student-centred learning approach was introduced in this module allowing students construct their own knowledge, which was facilitated by the lecturer (Rogers, 2002). Gibbs (1992) stated that student centred learning, "gives students greater autonomy and control over choice of subject matter, learning methods and pace of study" (Gibbs, 1992, p. 23). In addition to this constructivist approach to teaching, a blended learning environment was created which accommodated students learning styles. Blended learning is commonly defined as an integration of traditional face-to-face and online approaches to instruction (Garrison & Kanuka, 2004; Graham, 2006; Mac Donald, 2008).

This blended learning environment consisted of theory lectures using PowerPoint presentations including a series of embedded videos and lecture notes that consisted of tasks that the students completed during the lecture, which aimed to cater for students differing learning styles. In addition to the lecture the students were also required to submit assignments and partake in asynchronous discussions within the college’s virtual learning environment (VLE) ‘Blackboard’. The VLE provided the student with links to additional information on the content discussed within the lecture as well as providing links to related websites and YouTube videos. Students could also recommend literature or multimedia resources that they encountered while constructing their own knowledge and share this information with their peers. The VLE was also used as a way of hosting a series of reusable learning objects (RLOs) which were designed to provide students with just-in-time learning in relation to wood machining regulations and best work practices. RLOs are any digital resource that can be reused to support Web-based learning. These are small, 'bite-sized' chunks of eLearning, focussing on a particular narrow topic (Valderrama, Ocana, & Sheremetov, 2005). RLOs are extremely important in producing diverse educational contexts for online users (Kurubacak, 2007), however, their inclusion requires a shift in how content is designed developed and published. Pedagogical principles of teaching and supporting students learning must be employed in the design and development of RLOs, (see section 2.2 for details relating to their design for this project) . This module was assessed using summative and formative assessments, these consisted of a 90% summative end of semester assessment, and 10% formative assessment of short assignments and discussions within the VLE, and the completion of the RLO assessments.

Within the Wood Machining and Regulatory Environment modules a number of teaching approaches combined with a blended learning environment have been implemented, all underpinned by Kolb’s model of experiential learning. The students were exposed to a full learning cycle as expressed by Kolb, these included ‘concrete experience’ within the practical labs, ‘reflective observation’ within the regulatory environment theory lectures, ‘abstract conceptualisation’ through the use of the VLE and RLOs, then concluding the cycle by ‘active experimentation’ by physically operating the machinery themselves. Prior to students completing the active experimentation stage they were required to successfully complete an instant feedback assessment through the RLOs, before they could operate the relevant machines independently. The rationale for developing this resource was twofold, firstly the students can assess their knowledge of machining regulations prior to operating the machines, and secondly the lecturer receives a certificate of completion from each student which is retained as a safety record. Without this assessment the students could potentially have operated the machines for a full semester without undertaking any formal assessment of their wood machining knowledge. The following sections explain the approach taken during the design and development of these RLOs.

2.2 Design and development of the RLOs

During the design and development of the RLOs, a generic instructional design model was used in order to produce a sound pedagogical resource. The ADDIE model describes a thematic approach to instructional development, where the acronym stands for the five phases Analysis, Design, Develop, Implement and Evaluate. A reflection process also takes place following each stage prior to conducting the subsequent operation.

2.2.1 Analysis

The first phase of this process was to analyse the dangers associated with woodworking machines and identify machines where accidents were occurring, then identify the learning objectives appropriate to the specific machines. The woodworking machines selected for the RLOs were based on accident reports and statistics from Eurostat, 2009; Holcroft & Punnett, 2009; HSA, 2011. Within these findings, the circular saw and cross-cut saw were two of the machines categorised as being of high risk.

2.2.2 Design

During the design process, learning objectives were established and a Storyboard was created to plan the overall appearance, theme and structure of the RLOs, the resources also included text based content, narration and interactive images so as to cater for students learning styles as expressed in Kolb's Learning Style Inventory. The final stage of the RLOs consists of an instant feedback assessment which the student must pass before they were permitted to operate the machinery. Cohen (1985), Dalziel (2001) and Hummel (2006) acknowledged that in the context of online learning environments, the design of appropriate feedback is critical for student learning, this ensures the student has gained satisfactory knowledge of all the learning outcomes. The quizzes where generated within Articulate Studio 09, and consisted of numeric input multiple choice questions, drag-and-drop questions, and interactive images, requiring the student to identify breaches in the machining regulations as illustrated in figure 1.

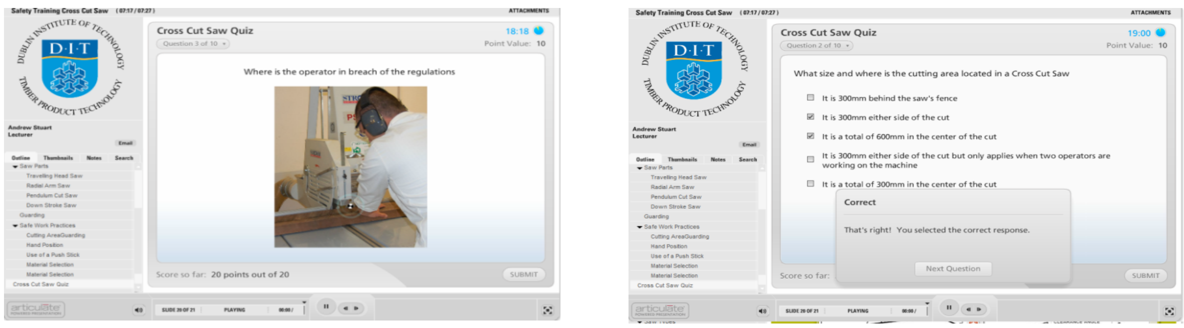

Fig. 1. Screen-capture of RLOs Instant Feedback Assessment

2.2.3 Development

The development phase in the ADDIE model addresses the tools and processes used to create instructional material. The RLOs were created using Articulate Studio 09. This rapid eLearning software is a plug-in to Microsoft PowerPoint and allows for the construction of quizzes and interactive content, and has publishing facilities. Images containing a number of hotspots which when activated provide the student with additional information pertaining to regulations and safe work practices. This assists the student in the connection between the image and the appropriate regulation. The RLOs were then tested for technical difficulties, content level in relation to learning outcomes, and functionality, prior to their implementation.

3 METHODOLOGICAL APPROACH

In order to ascertain the effects a blended learning environment, which incorporated self-paced RLOs, had in promoting a safety culture among students in the area of wood machining, an action research methodology was used. Action research enables practitioners to use reflective practice and the implementation of change as a vehicle from which to launch a research project from the practice setting. McNiff and Whitehead (2006), describe action research as “a form of enquiry that enables practitioners everywhere to investigate and evaluate their work” (McNiff & Whitehead, 2006, p. 7). The action research approach used in this study is described by Kemmis and McTaggart (2000) as participatory research. Participatory research is an adaptive plan of Kurt Lewin’s action research model and is a spiral process which involves a non-linear pattern of planning, acting, monitoring and evaluating. Selecting this action research model allowed the practitioner analyse their research and evaluate the data in order to make informed decisions through enhanced understanding.

3.1 Research Methods

When using an action research methodology data collection methods are selected that provide the most relevant information for the research. This can lead to data being gathered from multiple sources with a combination of qualitative and quantitative data being obtained. The methods selected for this research study consisted of participant observation, questionnaires and semi-structured interviews. These three methods were deemed the most appropriate to assess whether students’ knowledge and understanding of machine safety had changed, to observe if their work practices had changed, and to analyse if the implementation of the blended learning environment and RLOs promoted a safety culture in the practical labs.

The participant observations took place in three stages over a 12 week period. The first stage observed the students during their initial training in relation to the machining process and machine safety. The students received a number of practical demonstrations from the lecturer and each student completed a series of machining procedures under one-to-one supervision. The second stage observed students after they used the RLOs in order to assess the level of correctional feedback required and to observe if their knowledge and understanding of machine safety had changed. The final observations took place in week 10 of 12 to assess if correctional feedback was still required and to observe students’ knowledge and understanding of machine safety after receiving more experience in operating the machines.

The second method used in triangulating the data was questionnaires. The questionnaires were distributed on week 8 of 12 after the students had submitted their assignments on the VLE and completed the RLOs, with a 79% return rate (19 of 24).The questionnaire consisted of 16 questions which were subdivided into four sections, including questions on student demographics, computer access and proficiency, work experience in the timber industry and machinery proficiency. The final section consisted of three 5-point Likert scale questions assessing the usability of the VLE, and three questions on the students’ experiences in using the RLOs.

The final method used in triangulating the data was semi-structured interviews using a purposeful sample of five students. Creswell (2012) defines purposeful sampling as a qualitative sampling approach in which researchers intentionally select individuals and sites to learn or understand the central phenomenon. The students were selected on the basis of age diversity, trade related experience, educational qualifications and computer literacy, and the interview were used to probe for additional information. It was pilot tested and evaluated in individual interviews with other timber related students outside of the sample, which led to refinements of the interview questions.

3.2 Data analysis

Throughout the observations data was gathered and recoded using field notes, i.e. brief notes describing the students’ interaction with the machinery and identifying important interactions between the students and the lecturerThese notes were then written up in more detail after leaving the practical labs. Early data analysis was performed simultaneously with data collection. After completing the first two rounds of observations the data was probed further within the questionnaire. The questionnaire consisted of 16 questions, 14 produced quantitative data pertaining to student’s age, educational background, computer usage and accessibility, wood machining proficiency, and usability of the VLE and RLOs, and this information was analysed in a spread sheet using descriptive statistical methods (means, averages, and percentages). The remaining two open-ended questions produced narrative data that was analysed prior to conducting the interviews, and any interesting comments were probed further within the interviews. The interviews were voice recorded and then transcribed verbatim for Thematic Content Analysis.

3.3 Findings and Discussions

Three main themes emerged from the observations, questionnaires and interviews, including: Student interaction with the VLE and RLOs; Student behavioural change in order to alter incorrect work practices; and Student awareness of a safety culture.

Theme 1: Student interaction with the VLE and RLOs.

The blended learning environment which the students were exposed to aimed to accommodate students learning, through the use of practical labs, face-to-face lectures, and the VLE and RLOs. The students preferred different elements of the blended learning environment depending on their prior qualifications. These divisions consisted of students with industry machining experience; students with level 6 qualifications having no industry machining experience; and the students with no previous machining experience.

The students with prior industry experience found the practical labs the most constructive, allowing them to fine tune their existing skills and make alterations to any unsafe work practices they may have received from industry. They also commented that the use of the asynchronous discussion forums enabled them to reflect upon their industry experience and identify where previous unsafe work practices were used and why they should be altered. This reflective practice enhanced their knowledge but also assisted their peers, especially the students with no industry experience. Collins (2009) describes mature students as requiring the need to be critical and creative thinkers, problem solvers and decision makers, with a need to practice regular self-reflection.

These students did not find the RLOs important to their learning, with one student commenting "the level of the content was too low, I would skip straight to the quiz at the end of the resource and sit the test, and if I did not pass I would then read through the content and re-sit the quiz". The development of the second RLO did not allow students skip through the content, and forced them to interact with each of the sections prior to completing the quiz. The students were required to achieve a pass rate of 80%, however the majority of the class achieved a grade of 100%.

The students with previous machining experience but no industry experience also found the practical labs the most constructive. However they lacked the confidence and skills to operate the machines proficiently, but appeared to have acquired no incorrect work practices as a result of their previous training environment. These students engaged in the asynchronous discussion forums with their peers that had industry experience and found this beneficial. One student commented "I found by discussing the topics with the students that had worked in the industry gave me an appreciation of safety training". This group of students appeared to have participated in the discussion forum extensively. These students also engaged in the use of the RLOs, commenting that "the use of pictures along with the text helped to explain each part of the machines and link the relevant machining regulations". A number of these students used this resource as a way of studying for their end of semester summative assessments as it assisted in linking the practical and theory information together.

The students with no machining experience were apprehensive when operating the machines in the practical labs, commenting that "there is too much to learn in such a short period of time, setting up the machines in line with the regulations, identifying the machine parts and safely carrying out the machining process, it is very easy to make mistakes". These students did not appear to have gained a deep understanding of machining when compared to their peers but had performed well considering their short exposure to machining. However they were reluctant to participate in the discussion forums on the VLE as they felt they had no relevant information to add to the discussions. However they used the RLOs extensively, and one student commented "I realise the importance of safety, but I require more time to take on board all of the regulations, the RLOs allowed me learn this information in my own time and assess my learning through the quizzes". A number of these students commented that they used the RLOs as a way of familiarising themselves with the associated machines before entering the practical labs, giving them more confidence when operating the machines. From the data gathered the students preferred different elements of the blended learning environment depending upon their previous machining experiences, with no one element providing a holistic educational experience. However 95% of the students considered the VLE and RLOs easy to navigate, and 79% of the students considered the information provided increased their safety awareness within the practical labs.

Theme 2: Student behavioural change in order to alter incorrect work practices.

With the change in the economic climate in recent years, more students have entered Irish third level education, and according to Harmon & Foubert (2010) 60% were undergraduate students and 31% were studying part-time. More than a quarter 26% indicated they entered higher education as mature students. These mature students bring with them a set of skills and life experiences that can benefit their peers, but may also require a change in behaviour in order to benefit from new learning experiences (Richardson, 1995). Within the context of this study, this change process took place for the mature students within the practical labs and during the reflective assignments submitted in the VLE, while they found the theory lectures and RLOs less effective.

The first year on the TPT Degree saw a diverse student cohort where 21% of the students were between the ages 31 – 40, 42% of the students were between the ages 22 – 25, with only 26% of the students being between the ages 18 – 21. These students gained a variety of educational qualifications prior to entering the course, 26% of the students possessed industry wood machining experience; 64% of the students completed a Level 6 qualification but acquired no industry experience and the remaining 10% of the students had acquired no wood machining experience.

This diverse student cohort initially required a teacher centred approach to learning in the practical labs, as a result of the associated machining dangers and to alter students' behavioural practices when required. Students with industry experience had become complacent to safety regulations and attempted to conduct a number of incorrect work procedures in the practical labs that they acquired while working in industry. These incorrect work procedures required more than introductory machine safety training as described by Wirth and Sigurdsson (2008) who argued that in order for skilled workers to change their work practices and have a lasting effect they must complete a behavioural change process. Hudson (2007) describes Prochaska & DiClemente's (1983) trans-theoretical model of behavioural change as an emphasis on getting those involved to have an active personal desire to change rather than a passive requirement to meet the goals of management. The teacher centred learning approach used in the practical labs allowed the lecturer to change students incorrect work practices, while also allowing the remaining students gain the knowledge and understanding required to operate the machines safely. This change process was visible in students' attitudes and their work practices during the observations, and was in line with Prochaska & DiClemente's trans-theoretical model of change.

Theme 3: Students perceptions of a safety culture

The third theme to emerge was in relation to student's perception of a safety culture within their work environment and whether their knowledge and understanding had changed. Zohar (1980) refers to a safety culture as a shared set of safety–related attitudes, perceptions, and behaviours among individuals in an organisation. During the interviews the students were asked if they perceived a safety culture existed within the TPT Degree and if so which area of training they found most influential. The majority of students stated that the practical labs where the most influential as the lecturing staff would not allow them enter the labs without wearing appropriate personal protective equipment (PPE). They also commented that "the work environment promoted a safety culture through legislation signage, safety posters and correct housekeeping". The practical labs meet the same specifications as industry standards and as such the safety legislation is required to be enforced.

As the students gained additional knowledge and understanding of the legislation and its rationale for enforcement through the regulatory environment module their perception of a safety environment changed. This blend of practical enforcement, visual observations of correct work environments, and the theoretical understanding of the associated legislation, were all essential elements in promoting a safety culture. From the analysis of data 79% of the class stated that the use of the VLE and RLOs allowed them to reflect upon the material covered in the regulatory environment module and practical labs, gaining a better understanding of the legislation and regulations and why they were enforced. One of the students commented "if I was just forced to comply with the regulations without understanding the reasons why, I would not be as committed to safety when working in industry". Ho & Dzeng (2010), UEA (2007) and Wallen & Mulloy (2006) concur with these findings, stating that these elements are important factors in quality safety training in order to promote a safety culture. The students' attitude and behaviours to workplace safety had changed throughout the duration of this research, and the final observation in the practical labs revealed that none of the students required correctional feedback in relation to wearing PPE. However on occasion some students requested conformation that the machines were setup correctly, and required additional one-to-one demonstrations prior to operating them.

In summary then, in this study the effect of a blended learning environment and specifically the use of RLOs was analysed and evaluated to ascertain if it could alter the way students operate machines, and promote a safety culture. According to Ho & Dzeng (2010), Wallen & Mulloy (2006) an important element in promoting a safety culture is the quality of safety training. Bearing in mind Njenga and Fourie's (2010) cautionary note that the use of VLE and RLOs do not create a standalone educational environment and cannot fully replace traditional teaching practices, the findings of this study have indicated that the use of a VLE and ROLs can have a positive impact in promoting a safety culture to first year TPT degree students and did alter the way students interact with the machines.

Section 3.3 has shown that the diversity within this cohort resulted in unexpected findings and interesting interactions among the students. The results indicate that, contrary to expectations the students with no industrial machining experiences operated the machines in line with the regulations compared to their peers with industrial machining experiences who didn't. The students with industry experience had gained a number of incorrect work practices which needed to be altered in order to comply with machining regulations. Richardson (1995) maintains that in order for mature students to benefit from new learning experiences they must first change their behaviours, while Lund and Aaro (2004) suggest that attitude changes can have a significant impact in injury reduction.

In this study, the behavioural change process that materialised within the practical labs saw the students receive correctional feedback from the lecturer, while the use of the VLE allowed the students reflect upon their work practices in order to assist in the change process. This was an important link within the students learning process. Traditionally students would leave the practical labs and not formally reflect upon their learning, which could result in the students missing out on a stage within the learning cycle as expressed in Kolb's model of experiential learning. These two student groups actively communicated within the asynchronous discussion forums in the VLE exchanging their machining experiences, which helped reinforce the abstract conceptualisation stage as stated within Kolb's experiential learning model.

The two groups of students with prior machining experience considered the practical labs as the most beneficial to their learning, however the findings indicate the students with no machining experiences were overcome with the quantity of information to learn within the practical labs and felt intimidated by the physical environment. These students found the RLOs were essential to their learning as it provided them with revision information prior to entering the labs and provided them with a way to self-assess their knowledge through the instant feedback quizzes.

4 CONCLUSIONS AND RECOMMENDATIONS

The high rate of accidents within the woodworking industry has seen a number of European countries develop new training programs, safety advertising campaigns and the enforcement of machining regulations (UEA, 2007; HSA, 2011). These interventions have had an effect in reducing accidents, however the accident rates are still unacceptably high in this industry. Over the past decade, Ireland's construction industry has promoted lifelong learning in the area of safety training, with the introduction of certified training courses for construction workers (Safe Pass) and Construction Skills Certification Scheme's (CSCS) which provides skill specific licences for construction workers which must be updated every 2-5 years. Within the furniture manufacturing industry no additional machine specific continuing professional development (CPD) training courses are required by employees. Wall & Ahmed (2008) maintain that for busy professionals who wish to access CPD training, traditional classroom instruction is not flexible enough and recommends a blended learning environment in order to bridge the gap between academia and professionals. The findings from this study have highlighted a need for additional training and the promotion of a lifelong learning culture in the furniture industry to ensure best practices given the dangerous nature of the work. This demonstrates how a safety culture can be promoted in an undergraduate degree programme and highlights the important role a blended learning environment and the use of RLOs can play. However this was the first iteration of this action research project and over the coming years further refinements of the blended learning environment are required. There is a need for additional machine specific RLOs to be developed which should include short machining videos, allowing the student observe the machining process prior to entering the machining environment. In addition a series of advanced RLOs are required in order to meet the needs of experienced machine operators. It is hoped that during the course of their studies the Timber Product Technology students will have gained a substantial grounding in machining safety in order to promote the importance of a safety culture within the timber industry and to highlight the importance of lifelong learning as a way of reducing accidents within this sector.

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