Student Teachers of Technology and Design: Can short periods of STEM-related industrial placement change student perceptions of engineering and technology?

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Abstract

This is a report, on a small-scale case study, of a programme of short industrial placements (5 day block) for student teachers of technology and design in Northern Ireland. Such placements increase student awareness and understanding of the nature of Engineering and Technology and therefore better prepare them to teach these subjects, as integral elements of STEM (Science, Technology, Engineering and Mathematics). The aim was to discover if a short period of industrial placement would change student perceptions of industry, engineering and technology. Prior to the placement, undertaken in collaboration with industrial partners, the students revealed preconceived ideas about engineering, technology and industry. During placement students had opportunities to 'work-shadow' engineers and technologists and to contest their predetermined views and opinions. This study reveals that previously held views were challenged in terms of definitions contested, roles and function considered, perceptions challenged, and awareness increased.

Key words

placement, perceptions, engineering, technology, industry, awareness

Introduction and rationale

The UK Government, in general, and the locally devolved administration in Northern Ireland, in particular, are keen to promote a STEM agenda, the aim being to promote economic regeneration to produce a high value-added economy that is globally competitive (STEM Report, 2009). In this context, the acronym 'STEM' stands for the interdisciplinary relationship that exists between Science, Technology, Engineering and Mathematics. Within schools, in Northern Ireland, responsibility for the delivery of two of these key elements, Engineering and Technology, rest with the Technology and Design teacher and consequently there is an inherent linkage between the two cognate areas. The STEM Report (2009) comments on the need to promote positive attitudes to careers in science, engineering and technology and that Technology and Design teachers have an important contribution to make in achieving this. The decision by pupils to study STEM subjects will be partly influenced by the teachers who deliver them. It is important that the teachers are fully equipped with the knowledge to contextualise their subject and make it relevant to the learner (STEM Report, 2009) and therefore it is important that they should have 'real world' experience in these areas.

School placements are an important part of teacher education programmes (Abbott, Huddleston and Foley, 1993; Ladd, 2007; Stachowski & Mahan, 1998) as they allow the aspiring practitioner to apply their subject knowledge and to develop classroom skills and expertise. Work-based learning is not unique to teacher education, it is central to other professional courses such as medicine, dentistry, engineering and architecture. In order to enhance the student learning in technology, Williams (1998) argues there is a need for focussed education-industry links. Likewise Harrison (2011) intimates that teaching and learning in technology and engineering can be enhanced through the increased engagement of teachers with industry. The importance of students having opportunities to gain experience in real world environments is reinforced by Varnado & Pendleton (2004). One way of equipping teachers of STEM subjects, including those of Technology and Design, to contextualise their knowledge is to provide him or her with a period of industrial placement. Such placements give the teacher, or in this case the student teacher, opportunities to gain: (i) industrial experience; (ii) an increased understanding of industry; (iii) experience of STEM in the 'real world'; and (iv) further personal and professional contextual knowledge in their subject. Furthermore such placements are of greater importance for student teachers of Technology and Design who have little or no industrial experience!

Therefore, in addition to School Based Work placements, it was decided that the Year 3 B.Ed. student teachers of Technology and Design would undertake a short (one week), compulsory, industrial, engineering focussed, placement. The key aim being to provide the students with opportunities to engage in subject-based experiential learning; this report investigates if student perceptions of engineering, technology and industry changed as a result.

Literature review

For technology and design students to be effective classroom practitioners it is important they have a theoretical understanding of both engineering and technology and of the relationship between these areas. This literature review seeks to explore a number of key themes, albeit briefly, in relation to engineering and technology.

Engineering and technology – a question of definition

Defining engineering and technology is difficult. Definitions do not always help understanding but sometimes it is necessary to attempt to clarify the meaning of words, especially when they are used in different contexts (Layton, 1993). This is no less the case for the terms 'engineering' and 'technology'. The term engineering is not well defined nor its scope delineated and likewise the same is true for technology (Barlex, 2000; Barnett, 1994; Black & Harrison, 1995; Evans, 1998; Owen-Jackson, 2002; Ropohl, 1997; Yeomans, 1998). McCormick comments "the nature of technology is not easy to pin down, and the definitions that exist do not give us much guidance as to what activities it includes" (1990:45) and by Medway "the term technology itself is unhelpfully fluid" (1989:3). According to Gardner (1994, 1995) the determination of a definition for the word 'technology' is complex because of the variations in meaning that exist within the English language to explain it. Indeed, Hansen and Froelich (1994) argue that the German word 'Technik' provides a better understanding, an idea highlighted by Norman (1998) and Ropohl (1997). Jarvis & Rennie argue that "the word technology, a word in common use both in school and daily life, conjures up different images in different minds" (1995:40). Indeed Smithers & Robinson (1992) even suggest that the problem with technology in the curriculum is that it lacks an identity.

Siu (2003) purports that the terms engineering and technology actually refer to the same type of activity. However, Harrison (2011) claims they are discrete subjects in their own right and that both provide practical contexts for the development of other STEM elements. DeVries (2005) highlights the existence of many engineering disciplines but these still do not help establish an understanding of what technology is. On the other hand McGrann (2008) argues that many of the things that concern technologists are also important to engineers.

What is engineering?

For Technology and Design students to be effective in their subject, it is important they have an understanding of what Engineering is and is about. Difficulties in describing engineering abound. According to Knight & Cunningham (2004), there is a lack of understanding of engineers and engineering as a profession. Trevelyan (2009) suggests that engineering is a technical and a social discipline and that the two are inextricably intertwined. Engineering is sometimes described in terms of the outcomes produced. Therefore, according to Nguyen (1998:65), "engineering is a profession directed towards the application and advancement of skills based upon a body of distinctive knowledge in mathematics, science and technology, integrated with business and management and acquired through education and professional formation in an engineering discipline". Similarly Varnado & Pendleton (2004:2) describe engineering as the "science and art of applying mathematical and scientific principles, experience, judgement, and common sense to design things that benefit society and humankind and solve practical problems". In other words the ultimate goal of engineering according to Nguyen (1998:65) is to develop and provide "infrastructure, goods and services for industry and the community". Harrison (2011:18) suggests that engineering is "the knowledge required, and the process applied, to conceive, design, make, build, operate, sustain, recycle or retire, something of significant technical content for a specified purpose; - a concept, a model, a product, a device, a process, a system, a technology" DeVries & Stroeken (1996) suggest that engineering has transformed from being 'Technik' a craft-based activity to 'Technologie', a scientific discipline.

Sometimes engineering is considered in terms of its perceived linkage with science and, in fact Knight & Cunningham (2004) argue, that images of engineering are adversely affected by its close association with science. Trevelyan (2009) suggests that engineering practice tends to be based on the usage of known scientific principles, usually those from the physical sciences. The applications of such principles allow engineers to determine what is and is not possible.

Views of engineering

If Technology and Design teachers are to promote positive images of engineering as elements of STEM, then it is important to have an understanding of typical views held by others. Roth (1996) reports that pupils had difficulty in describing an engineer and in defining their role, typical stereotypical images of engineers related to dress, appearance and gender. Likewise, Knight & Cunningham (2004) report that older students hold preconceived ideas about engineers and engineering and that such perceptions can have an adverse impact upon engineering. Interestingly, Wankum & Brandt (1993) suggest that even engineering students have an insufficient understanding of engineering as a profession and, as a result, important work needs to be done to inculcate positive messages with them.

The role of the engineer

Although surrounded by products of engineering, there is a lack of understanding as to what engineering is all about. Knight & Cunningham (2004) argue that as students do not have contact with engineers, they tend to have poor conceptual understanding of what engineers do or indeed what engineering is. Sometimes engineers are defined by the role they perform, engineers "are involved in the implementation, application, operation, design, development and management of projects and processes,

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although the type of work that engineers do will vary depending on the chosen field of study" (Hguyen, 1998:66). Trevelyan (2009:1) suggests that the role of an engineer is to "coordinate other people to deliver the products and services for which they are ultimately responsible". Knight & Cunningham (2004) use a range of adjectives to categorise the functions that engineers perform i.e. builds, fixes, creates, designs, improves, calculates and invents.

Another possible approach to understanding the role of an engineer is to consider the content of the courses they study. Siu (2003) highlights, what he considers to be, the essential elements for inclusion within any engineering curriculum and hence an indication of the role performed; typically engineers must be competent to operate equipment, demonstrate a comprehensive theoretical understanding of a rapidly increasing knowledge base and have the ability to illustrate their thinking and ideas.

Nguyen (1998) suggests that engineers:
- Possess a knowledge of engineering principles and laws
- Apply knowledge and convert theory into practice
- Be skilful and practical
- Understand the impact of their work on the environment
- Have familiarity with quality assurance procedures
- Understand the language of engineers
- Operate within economic and political structures
- Communicate effectively using a range of tools
- Possess a range of transferable skills

It could be argued that the knowledge, skills and competencies demanded of engineers are no less than those demanded of Technology and Design teachers (GTCNI, 2007); this is the focus of this study.

What is technology?

Definitions of technology abound. Hansen & Froelich (1994) argue that technology can be considered from different viewpoints, typically, historically, anthropology, sociologically, philosophically and educationally. Varnado & Pendleton (2004:1) describe technology as "the entire system of people and organisations, knowledge, processes, and devices that go into creating and operating technological artefacts, as well as the artefacts themselves". Technology is the outcome of complex connections between areas such as engineering, science, law, ethics and politics.

Views of technology

Again for Technology and Design teachers aiming to promote a positive message of their subject, it is important they have an awareness of the views held by others in relation to this area. Wolter (1989) suggests that young children develop attitudes to technology due to the perceptions they form. Similar views are expressed by McCarthy & Moss (1994), Rennie & Jarvis (1995), Riggs (1995) and Spendlove (2002). Furthermore, Wolter argues that boys and girls tend to associate technology with manufacturing. Pupils consider 'technologists' to be 'scientists', the type of person who undertakes 'difficult things'. Young people associate technology with activities such as inventing, making and working with electricity, terms such as 'difficult' and 'hi-tech' are used to separate technical things from non-technical. Whilst familiarity with technology is an important factor in determining the attitude of young people towards it, yet still conceptually understandings of technology are not clear. Harrison (2011:18) argues that technology is "an enabling package of knowledge, devices, systems, processes and other technologies, created for a specific purpose.

Relationship between technology and engineering

It is important that Technology and Design students have an understanding and knowledge of Engineering and Technology, and of the relationship that exists between these two areas. According to Harrison (2011) engineering is a mix of mathematics, engineering science and engineering practice, delivered in universities as an academic subject whereas, he suggests, this is not always the case, with technology. Traditionally engineering has been viewed within strict boundaries however more recently such divisions have been reduced through the introduction of multi-disciplinary areas like mechatronics (DeVries & Stroeken, 1996). In this respect, engineering and technology are similar because both are practical in nature and are related to product design.

It is important that student teachers of Technology and Design have structured exposure to the industrial workplace so that they can gain a 'real-world' context for the work they will undertake with pupils. Harrison (2011) argues that learning experiences for school students must be augmented by proper engagement with industry; this is just as important for student teachers. Industry and education are mutually dependent upon each other, if the learning experience of the student teacher is to be enhanced then it is critically important that they be given relevant experience in the industrial environment.

Relationship with science

Technology and Design, in Northern Ireland, is located within the Area of Study designated as 'Science and Technology' (CCEA, 2007) but yet debate surrounds their relationship. There is a general recognition that the two areas are linked (Harrison, 1995; Stein et al., 2000 &

2007), however the precise nature of that relationship is disputed (Davies, 2003; Hansen & Froelich, 1994; Rennie & Jarvis, 1995).

An understanding of the relationship between technology and science is fundamental to any study of technology education, a view supported by Gardner (1994, 1995) and McCormick (1993). One way of highlighting the difference between science and technology is to consider the goals they serve (McRobbie et al., 2000). The goal of science is to generate new knowledge and understanding whereas with technology, it is to satisfy human needs through the creation of objects and the application of processes. Technology and science have a unique relationship, one that is neither synonymous nor mutually exclusive; the relationship is a contributing partnership between two areas (Hansen & Froelich, 1994). Hasna & Clark (2009) suggest that "the distinction between science and engineering is poor". In order to ensure the effective delivery of Technology within the classroom, it is important that teachers have a clear understanding of what technology is and how it relates to science (Harrison, 1995; Jarvis & Rennie, 1996; McCormick, 1993).

Why are engineering and technology important?

Political pressure for the placement of Technology and Engineering in the curriculum rests on two arguments: educational and economic (Barlex, 2000; Davies, 2003; Donnelly, 1992; Eggleston, 1993; McCormick, 1993; Stein et al. 2000; Yeomans, 1998) and again highlighted in the STEM Reports (DfES, 2004; STEM Report, 2009). Educational arguments for the inclusion of technology in the curriculum rest on the value of the subject for its own sake (Hennessy & Murphy, 1999; Medway, 1989; Williams, 2000; and Wright, 2001). Economic arguments for the inclusion of technology within the curriculum focus on the preparation of young people for the 'world of work' where the subject is seen as having vocational currency, for example the production of a technologically trained workforce (Eggleston, 1993; McRobbie et al., 2000; Yeomans, 1998). In addition, technology in the curriculum will hopefully (i) stimulate positive attitudes towards industry; (ii) aid the process of economic regeneration (Hendley & Lyle, 1996); and (iii) meet the needs of an increasingly technologically-based society (Williams & Williams, 1997). According to Hasna & Clark (2009) education and, in particular, technology education is an important economic and social activity. The main aim of including Engineering and Technology in the curriculum is to encourage creativity and innovation so that the economy of the country can successfully compete against others (Siu, 2003). Similar views are also expressed by Varnado & Pendleton (2004) and Hasna & Clark (2009).

The context of this study

The participants in this study were all trainee teachers undertaking a four-year honours undergraduate degree [B.Ed. (Hons)], main subject Technology and Design. Within each of the four years of their degree programme students study Technology and Design, Education and Professional Studies, a subsidiary subject and undertake extended blocks of supervised school placement. In Scotland, students studying a four-year B.Ed. degree in Technology must undertake a minimum of 24 weeks in school placement and a further minimum of 6 weeks on industrial placement. Industrial placements are an integral part of such programmes (GTCS, 2006). Whereas, in Northern Ireland, the Department of Education for Northern Ireland regulations state that undergraduate students, on a four-year B.Ed. (Hons) degree are expected to teach in at least two schools and normally spend 32 weeks on school placement activity, a minor amount of that time may be spent in other educational settings for enhancement purposes (DENI, 2010). Consequently, this placement was organised in addition to the student's normal school placement activity. The main subject aspects of the course provision deals with a range of technology-related elements such as, product design and analysis, materials and manufacturing, technology systems [electronics, pneumatic and mechanical control], Computer-Aided Design and Manufacture. As the students involved in this study entered their teacher education degree programme straight from school their knowledge, experience and understanding of industry was at best limited. This reality mirrors the comments of Wilson, Pirrie & McFall who report "many teachers currently working in schools have followed a traditional route into teaching, moving from school through university or college of education to school again" (1996: 32). Each of the case study students had three 'A' levels, or equivalent, including Technology and Design. The students involved in this project, three female and eight male, with an average age of 21 years, were midway through the third year of a four-year degree programme. On teaching placements, and in the context of future employment, the students are required to relate many of the theoretical elements that they deliver to industrial contexts; this is particularly difficult if they have little or no practical experience of such contexts.

The industrial placement programme

This project, of providing student teachers, with a short period of industrial placement (a five-day, one-week block) was to encourage them to reflect on engineering, technology and industry. A number of regional companies agreed to facilitate the placements and to provide 'real-world' experiences of industry. Students were allocated on a geographical basis. It was hoped the students would gain an increased awareness of industrial practice and have opportunities to dispel misconceptions about engineering and technology. In addition, students would have opportunities to engage with scientists, engineers and technologists in a 'real-world' environment and observe 'good industrial practice' and as a result become better informed STEM ambassadors (STEM Report, 2009).

Prior to the one-week placement students were briefed about the tasks to be undertaken, typically; gain an overview of their host company; investigate different job roles; and reflect on the work done by engineers and technologists. Ultimately, the success of the placement depended on the willingness of the companies involved to accommodate the students. The host organisations received no financial return from the university and likewise, the host organisations did not pay the students while on placement.

Methods

Placements were a compulsory but non-assessed element of the student's course. In total 11 students were involved and 10 placements were identified (one host organisation agreed to take two students). Students completed a short questionnaire in advance of their placement to determine their prior experience of industry and their perceptions of engineering, technology and industry. Students were asked to outline what experience they had of these areas and to describe their understanding of them, the key differences and similarities. During placement each student was visited and given opportunities to talk about the activities undertaken. Such comments were noted. At the end of the placement, each student submitted a portfolio reflecting on their learning. Also, upon return to the university each student was interviewed about their experiences interviews were recorded and transcribed (Cohen et. al., 2007). Due to the compulsory submission of the portfolio of evidence and the interviews, the response rate was 100%. Interview questions focussed on: (i) the nature of the activities undertaken; (ii) the learning that had resulted from the placement; and (iii) an exploration of personal perceptions of engineering, technology and industry and how these had changed due to placement. The qualitative data set consisting of pre-placement questionnaires, notes taken from tutor visits, portfolio of evidence submitted and the post-placement interview transcriptions were analysed thematically. Data collection was conducted in accordance with institutional ethical procedures. Perceptions solicited before, during and after placement. The underlying themes related to engineering and technology focussed on definitions, roles performed, and the similarities and the differences highlighted.

Results: Knowledge and understanding before placement

Given that these students are trainee teachers of Technology and Design it was important to ascertain what experience they had of technology and engineering prior to placement. Interestingly, a few of the students had no experience of industry and the rest had had limited exposure as a result of one or two–day school 'work experience' placements.

Before placement the student teachers highlighted phrases which described an engineer. The statements offered suggested difficulties in articulating their knowledge and understanding of this. Analysis revealed student statements fell into four categories, revolving around: (i) role; (ii) functions performed; (iii) processes undertaken; and (iv) outcomes produced. The role of an engineer was viewed in grandiose terms evident through statements such as an engineer is "*someone with tomorrow's mind*" (Student 4 - Male), the implication being that an engineer is someone who designs for the future. Such conceptual understanding was further reinforced by another student who suggested an engineer is someone who is involved in "*steering the way for the future*" (Student 8 – Male). However to be successful in either of these areas the engineer has to have the following characteristics "*genius, informed, problem solver, capable*" (Student 7 – Male). Other students defined engineers in terms of the functions they performed, again rather generic in nature. The function of an engineer was identified as "*someone who deal[s] with the structure and workings of items*" (Student 10 – Female) or as someone who "*oversees/solves problems/processes*" (Student 1 – Male). Others defined engineers in terms of the processes undertaken, typically, "*they have a specified skill that is used in solving problems; high calibre of work*" (Student 6 – Female); or as "*someone who uses maths, science & technology to overcome everyday problems*" (Student 3 – Male) or an engineer is someone who is involved in "*using science to solve problems in everyday life*" (Student 11 – Male). In essence, engineers employ processes that require the use of specific scientific skills. Some students considered it easier to define engineers by the nature of the outcomes they produced, typically, "*someone who uses maths, science and technology to overcome everyday problems*" (Student 3 – Male) or "*a person who makes life better or easier for people through design solutions and innovations*" (Student 2 – Female).

Likewise, students described a technologist and again, it would appear that they, as student teachers of Technology and Design, experienced some difficulty in doing this. The statements presented, like those of the engineer, are defined using the headings, role, function, process and outcome. Students saw the role of the technologist as being similar to that of the engineer, the technologist is "*capable, informed, genius, problem solver*" (Student 7 – Male). However, in terms of function a difference in emphasis became apparent; the engineer is involved in high-level thinking whereas the technologist is responsible for the implementation or operationalisation of such decisions. This perception is reflected in statements such as the "*technologist understands how the technology the engineers use works*" (Student 3 – Male) or the technologist is the "*constructor of ideas and makes it happen*" (Student 4 – Male). These statements reflect an interchange of the words 'technologists' and 'technician'. Again there is an implied perception that technologists perform lower order activities in comparison to engineers and such messages are reinforced by describing technicians by the processes they undertake. The technologist is "*someone who can make and repair many electrical, pneumatic items and who can machine materials in a variety of ways*" (Student 10 – Female) or they are "*a person who designs products and also manufactures a prototype*" (Student 2 – Female) however in order to do this they must be "*adept at technology partaking in research*" (Student 11 – Male). Student responses suggest that the output of a technologist is more functional than that of an engineer because they "*use technology in a practical way*" (Student 8 – Male) and "*design products and also manufactures prototypes*" (Student 2 – Female).

Students identified the similarities between technologists and engineers and highlighted the obvious connection that "*both work in industry*" (Student 8 – Male) and "*design and collaborate ideas together to make or produce what they set out to do*" (Student 4 – Male). Here the similarities focus on "*the type of work they do and the processes they use*" (Student 9 – Male) because both "*use the same theories*" (Student 11 – Male) and "*work with, and machine, different materials*" (Student 10 – Female). In essence the technologist and the engineer seek to "*design solutions to problems, to make something easier for the user*" (Student 2 – Female).

Students identified what they perceived as the key differences between a technologist and an engineer; they suggested "*engineer(s) create the technology whereas the technologists use them*" (Student 8 – Male). Such differences imply the existence of a perceived hierarchical structure, the engineer is perceived to have a higher status than the technologists. This viewpoint is reinforced by another student who suggests that technologists would "*be more hands on or practical*" the "*technologists delivers information but in a practical way*" (Student 1 – Male). Again such perceptions are reinforced by others "*an engineer would not usually manufacture their innovations*" (Student 2 – Female) and "*engineer uses more maths and science in practice*" (Student 11 – Male). Overall, the implication is that engineers operate at a higher level than technologists.

Results: Knowledge and understanding after placement

As student teachers of Technology and Design will be responsible for the delivery of engineering and technology in the classroom it is very important that they have a clear understanding and knowledge of the areas concerned. On their return to the university the students were interviewed to ascertain if their knowledge and understanding of engineering and industry had changed and their key reflections are.

With regard to changing perceptions of engineering one student eloquently summarised the problem as follows: "*this depends on your definition of engineering*" (Student 3 – Male). Others explained how their placement had impacted significantly upon their perceptions of engineering, many were struck by the sheer breadth of what industry defined as 'engineering', "*I didn't really know what an engineer was and then when I was out there, there were so many different types of engineer; there were machinists and there were the ones that do the actual drawings and design, they were programming the machines and there were just so many aspects to it*" (Student 2 – Female). Clearly, for this student, the range of activities that constituted engineering was illuminating.

One thing that had greatest impact for a number of the students was the breadth of the activities involved "*engineering in my placement factory was very broad, very broad, it wasn't what I would have imagined as in-depth engineering*" (Student 2 – Female). Another student reported that "*I was taken by the speed of processing, the quantity produced and the efficiency of production*" (Student 3 – Male). In most cases, students were amazed to see the size of the companies and how many people were involved in producing the final product. Furthermore they were surprised by the importance of team work, for example, the marketing and sales managers gave forecasts for the week and the plant managers and technicians scaled the production to meet the demand, this iterative and integrated process was clearly different from what they had imagined.

One student revealed that their initial perception of engineering was "*you just go in and fix the machines*" (Student 6 – Female). However, for this student their placement had changed this perception "*I tell you it's a very high tech job...it's very high tech and you need the brains to go on and do what they are doing in there...engineering it's so broad. For just [Company name] they've got just so many engineers, different types of engineers, just to make the company operate*" (Student 6 – Female).

It would appear that even a short period of industrial placement allowed the students to gain a better appreciation of what an engineer is "*you have to be able to think on your feet, that's where engineering comes from*" (Student 5 – Male). Another changed perception was "*I thought it was people working at machines and fixing machines that broke down but it's not there's the computer side of it, how to improve your systems, your preventive maintenance and things like that there. But you never really realise that engineering is that involved*" (Student 10 – Female). Furthermore this is expanded upon by another "*I knew that engineering was much more than nuts and bolts and that there are people working on big projects. In terms of time management and engineering, they had an engineer just for time management, JIT was an important part in the factory. For me engineering was all about say construction engineering, timing and making sure that everything was rolling along in terms of all that*" (Student 8 – Male).

Clearly there is the perception that engineering is old and dirty but this was challenged "*I thought this is going to be so such in the fifties, type of thing, I thought it would be very backward...but far from it, far from it!*" (Student 1 – Male). Despite previously held perceptions engineering "*can be very, very detailed or it can be just cloud thought. Everything, almost everything, every physical job will require engineering*" (Student 7 – Male). The value in the short period of industrial placement is perhaps best summarised in the statement "*for me being able to see that there [engineering] that has made me more aware that it's not just what it says in the book, or the prospectus or whatever. It gave me more of an understanding*" (Student 6 – Female).

Furthermore, students were asked if their perception of industry had changed as a result of the placement and if it had in what ways. Again, students revealed another interesting pre-perception that industrial employment was for low achievers "*I thought industry was for people who didn't really bother at school and just went out and got a job. But there are so many highly trained people in there. Whereas my perception of industry was 'okay' sure that there will do, in my placement they had to be very precise*" (Student 10 – Female). Such a view was reinforced by another respondent who reported that "*beforehand if someone had wanted or had the academic ability I would never have suggested an apprenticeship but it's a very 'hands on' practical base and it would be a better way for them to go into engineering*" (Student 1 – Male).

The size, scale and complexity of the industrial operation was a surprise to many of the students, "*when I walked into [Company name] it's just huge, it just blew my mind away, it's just wow – this place has to be this big to cope with the demand. You think it's going to be big but when you're actually walking around it and you see maybe dear knows how many blowing machines and then you go into the syrup room there's these big containers holding stuff about the size of this room, you know it just blows you away, the size of industry – I suppose it needs to be for the country to have what it has*" (Student 6 – Female). The placements did change student perceptions of industry "*there's a lot more to it than you would have thought and there are just so many more options than I would have realised, it opened my eyes to loads of different possibilities and that changed my view of industry*" (Student 9 – Male). For some students the experience whilst enlightening and useful had reinforced their view that they would not be interested in full-time work of that nature "*some of the work I found, for my liking, to be too repetitive but on the other there were parts of it that interested me, making up programmes and things like that I could see myself going into*" (Student 9 – Male).

In an attempt to develop student understanding of what an engineer and a technologist are, the students were asked to research the responsibilities associated with different roles within their host companies. One typical response was the "*engineer is the person who is responsible for the production of the product and its related manufacturing processes. They usually have an engineering degree and have a few years experiencing as an engineer*" (Student 2 – Female). This same student used the term 'floor staff' to describe others who had "*served time as an apprentice and their job function would vary depending on what tasks they do in the factory. After serving time as an apprentice this can be traded for a foundation degree leading to the option of carrying out a degree and excellent opportunities for a more vocational pupil in the class*". However the difference between the two positions become more apparent when they investigated the typical qualifications required to fulfil the role. For example it was reported that a technician completed an apprenticeship whereas the engineer completed an engineering degree. The students suggested that they had learnt a lot from the placement experience and that it had been worthwhile.

Discussion

The placement of student teachers of Technology and Design into industry for a short period of time had many advantages, not least it gave them invaluable opportunities to see 'industry in action', and for a significant number, for the first time. For example they were able to observe different processes and manufacturing techniques being employed. In addition preconceived ideas about engineering, technology and industry were challenged. This discussion will focus on four key themes, namely definition and clarity, role and function, perceptions and increased awareness.

Definition and clarity

Student responses demonstrate a lack of understanding about what the role of an engineer is. However, this is really not surprising given the apparent widespread confusion that appears to exist elsewhere (Knight & Cunningham, 2004). It would appear that there is a lack of clarity about what an engineer is, what a technologist is and, what their roles and responsibilities are and how these differ. Clearly one of the major issues is the need to establish, and agree on, an understanding of what the various terms, engineer and technologist, mean. It would appear the terms are, on occasions, used interchangeably and on others they are used to mean different things. Dictionary definitions do not necessarily clarify the situation because these also tend to indicate similar areas of engagement with a different emphasis. Therefore it is easy to appreciate many of the difficulties that students experience in distinguishing the differences between the two areas, in particular, when 'experts' have similar difficulties. There would appear to be a general acceptance that engineers and technologists both use and apply scientific principles but the inference is that work undertaken by an engineer is more abstract than that done by a technologist. The perception is that engineers deal with issues that are conceptually difficult whereas the technologists are more concerned with application, whether such a distinction is the case, the students appeared, from their short period of industrial placement, to gain this perception. It is important that student teachers, and indeed teachers, of Technology and Design have a clear understanding of the elements of commonalty between engineering and technology and equally important to know what the differences are if they are to be effective practitioners in this area.

Understanding of role and function

This study indicates the value in placing student teachers of Technology and Design into industry, even for a short period of time. Such placements give students invaluable opportunities to observe good practice in the 'world of work', particularly in the area of engineering and technology. Placements may not allow students to define any more clearly the terms, engineer or technology, or for that matter describe their respective roles but they did provide them with a stronger appreciation of the work undertaken by each, and of the tasks they perform. Through the placements students were able to gain a greater understanding of the important work undertaken by engineers and technologists and of how their work contributes to society and the economy. Student teachers were given opportunities to observe those working in industry, both engineers and technologists; and as a result they gained a greater appreciation of the processes worked through, the methods employed and the tasks undertaken. Observation is a very powerful medium for learning. The benefits of the placement for student teachers of Technology and Design are immense and as a result the students are more aware of the issues, even if they do not have the answers. Overall, student awareness was increased. One student reported "*I learnt an awful lot about the engineering side of things and sort of seen the links it does have with schools. Before I didn't really, I thought I go do it and then forget about it but I think it is a good opportunity now I can sort of say to the pupils that's there and maybe try and get them in for a wee bit of work experience and see what they can do*" (Student 2 – Female).

Perceptions

Prior to placement, the students appeared to have the perception that work in industry was male-orientated. Indeed such a view is possibly reflective of society at large. As indicated earlier, the stereotypical image of the engineer being 'male, holding a spanner and wearing dirty overalls'; was dispelled by the placement experience. One female student teacher of Technology and Design reported "*I thought it was a good opportunity to see what's out there because I really didn't have much of a clue as to what an engineer was. Because when I was finishing school mum sort of said 'what about applying for engineering?' and I said no that's boy's job. But when I was out there, there were quite a few girls doing it too; the girls were out on the shop floor*" (Student 2 – Female). The students were surprised to discover the significant number of females who were involved in industry. Another student reflected on the size of the manufacturing operation and they said they were "*amazed to see the size of the company and how many people were actually involved in producing the final products. Everyone worked together as a team, with marketing and sales giving forecasts of the week so that plant managers and technicians could scale the speed of production in ratio with the demand for the week*"(Student 6 – Female). Students witnessed different working

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environments some of which were very clean with female engineers who were smartly dressed and working at a computer engaged on some high level activity. Interestingly, this element of disbelief was expressed by both male and female students alike.

Again perceptions exist in relation to the nature of the activity that someone would undertake in industry. For one student the placement reinforced her views "*factory work would not be for me, it could be quite confined and monotonous*" (Student 3 – Female). However, more positively "*the placement was relevant in the sense that you could see the raw product, the whole process, through to the finished product; something you would see in the shop – all process in between and the different working patterns that are used in the factory*" (Student 3 – Male) because "*I didn't expect there to the different levels of machinery that there was; it's just colossal the amount of machinery that is there and the money that has been spent on machinery*" (Student 3 – Male). This was reiterated by another student who said "*the scale, the speed and the opportunity to see around, definitely, getting in there*" (Student 6 – Female). Ultimately the challenge is to determine how best engineering can be promoted as a worthwhile and rewarding career, giving student teachers of Technology and Design the opportunity to gain some industrial experience is a proactive step in this direction. Hasna & Clark (2009) argue that a "limited awareness of engineering translates into a low mind share and the lack of science/engineering differentiation into a low voice share for engineering as a discipline in its own right".

Increased awareness

The placement was successful in increasing student awareness of engineering and industry at a personal and a professional level. The students gained an increased understanding of the work of industry and also of the work that engineers and technologists perform. One student summarised this by reporting "*I got a real practical idea of what engineering is, more so than what I knew before I went in. With it being a larger company the opportunities of progression right down from the apprentices coming in who could end up as a manager at the end of the day just through a programme of training and the different opportunities that are available. Seeing it in reality and talking to different people you learn a lot more than you ever could by reading about it in a book. Seeing faces and hearing personal stories that people have gone through; it brings home more how this could progress*" (Student 1 – Male). In this respect the student teachers are now better informed about the work that goes on in industry; having seen typical engineering type activities taking place in the 'real world'. It is important for Technology and Design students to have an understanding and knowledge of what engineering and technology are if they are to be effective practitioners in the classroom. The placement did increase student awareness in this area, this is important as they seek to deliver Technology and Engineering, both GCSE subjects in Northern Ireland. The student teacher of today is the aspiring classroom practitioner of tomorrow and therefore it is important that they be given opportunities to develop appropriate knowledge, understanding and skills in context.

The students had the opportunity to observe processes taking place, to ask questions and to gain insight. One student reported "*my subject knowledge behind it has increased so much, I could literally go into a school and if someone were to ask my sir what sort of work, I'm thinking about a career in this you can go away and say, well what section, what area do you like, do you like design you like electronics...things like that?*" (Student 9 – Male). In addition the students gained professionally because they acquired an increased awareness of engineering, technology and industry and therefore are more able to act as ambassadors, in this area, for their pupils. One female student reported that as a result of the placement "*I can actually go when I'm in schools and say to the pupils; you know that's out there. I could probably take them to see what they think of it and then they could benefit from it*" (Student 2 – Female). Students are able describe something more accurately when they have had the opportunity to witness it first-hand; the placement provided, albeit briefly, such an opportunity. One student suggested "*If they [industry] can show me the importance of what they do and the processes that they do and then I can convert that in my own teaching with the pupils; that's going to help them [industry] in the future*" (Student 8 – Male). The STEM Report (2009) highlights the need for teachers to act as ambassadors for this area and the placement provides steps in this direction. Students, as a result of their placement, have a greater confidence to promote engineering and technology as a career, this was reinforced by statements such as the placement "*gives you a better insight in to the kinds of work people could be doing when they leave school and the different ways in which they can get into that workplace*" (Student 3 – Male). Perceptions can be a powerful influence on what someone will do, it is important the student teachers of Technology and Design are able to convey a positive message, to their pupils, about engineering, technology and industry because as Hasna & Clake (2009) remind us perceptions are formed at an early age.

Conclusion

The limitations of this project are recognised and accepted, the placement was limited in terms of duration and as a result of it being based on one industrial location. In a one-week placement it is only possible to become acquainted with so much material, a longer period would allow for a greater understanding to be gained but this could be the subject of further research. In addition the possibility of engagement with more than one industry would be a welcomed addition. These results are based on experiences gained in one industrial setting, rather than across a number of placements – "*I would say not one industrial placement, I'd say over the course of the week two maybe three and, just to give a wide range because there are some places, there were a couple of placements there that had a whole lot of processes; mine had casting and machining*" (Student 1 – Male). However, recognising the limitations of the placement exercise, there are still significant advantages to be gained from such an activity. A change of attitude or an increased awareness, no matter how limited, is still a move in the right direction. Wilson et al (1996:33) make similar comments when they report that "the majority of teachers, may still be disadvantaged when it comes to preparing students for a workplace ethos; knowledge and ethics of which they are largely unfamiliar...if teachers are to make a valid contribution to the personal and social development of their students, they must keep abreast of changes in the labour market". On the basis of the work undertaken and an analysis of the feedback received the potential for greater learning exists. But given the background and the experience of the students concerned the placement activity was worthwhile and proved to be of value. Whilst this study focussed on a small-scale study for student teachers of Technology and Design in Northern Ireland, the potential for transferability to other subject areas is worthy of consideration. Indeed there is merit in considering how an activity of this nature could be more fully embedded, if not throughout the entirety of the course for student teachers of Technology and Design then most certainly, at an earlier stage in the programme. It is possible that the outcome of such an activity and the potential of change in attitudes to, and perceptions of, engineering, technology and industry may not be evident for some time. It is only as the student teacher in the university graduates to become the classroom practitioner that they will begin to influence the pupils in their classes. But if nothing else, the seed has been sown and student awareness of engineering and technology has been heightened.

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