

When Technology and Design Education is Inhibited by Mathematics

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Abstract

This paper explores the attitude to Mathematics of B.Ed. (Post-primary) Technology and Design student teachers, in Northern Ireland, and is located within the context of 'STEM' (Science, Technology, Engineering and Mathematics). The aim of the research is to consider whether students' attitude to Mathematics is different when the subject content is presented within or outside their own subject area. Technology and Design provides both 'purpose' and 'utility' to the delivery of Mathematics. Based on the results of an attitudinal questionnaire and focus group interviews it has been concluded that there must be corporate responsibility for the teaching and delivery of Mathematics. Those involved in teaching Mathematics, whether directly or indirectly through a different subject area, must not only be knowledgeable in subject content and its associated pedagogy, but ideally convey a positive attitude towards Mathematics.

Key words

STEM, technology and design, attitudes, mathematics, pedagogy

Introduction

The importance of 'STEM' (Science, Technology, Engineering and Mathematics) subject teaching cannot be overemphasised and has again been brought to the forefront through the recent publications (Department for Education and Science [DfES], 2006; Department for Children, Schools and Family [DfCSF], 2008; Department for Learning and Employment in Northern Ireland/ Department of Education for Northern Ireland [DEL/DENI], 2009). However, interestingly, this particular view is not universally held by all, Natalie Angier writing in the New York Times in October 2010 comments "for readers who heretofore have been spared exposure to this little concatenation of capital letters, or who have, quite understandably, misconstrued its meaning, STEM stands for Science, Technology, Engineering and Mathematics, supposedly the major food groups of a comprehensive science education". However despite such a seemingly negative declaration, there would appear to be a certain 'taken-for-grantedness' in the community that STEM is both logical and reasonable. Accepting the notion that STEM is a generally accepted curriculum construct then Mathematics can be viewed not only as a "vital discipline in itself but it underpins the other STEM subjects of Science, Engineering and Technology" (Smith, 2008:2). The delivery of the

teaching in these subjects is specifically highlighted by the DfES (2006:9) with the comments that 'staff qualified in the subjects they are teaching are likely to generate more STEM-qualified learners, whether measured in terms of GCSE, A-level or vocational qualifications'.

This research, a collaborative project between two tutors, one from Technology and Design and the other from Mathematics, is part of a fuller discussion which considered both the students' competence in numeracy as related to their chosen subject of Technology and Design and their attitude to Mathematics and numeracy. This paper explores the attitude to Mathematics and its implementation through numeracy of B.Ed. (Post-primary) Technology and Design students. The project considers whether the students' attitude to Mathematics and numeracy is different when it is housed within their own preferred subject area of Technology and Design. In the context of this particular study Mathematics serves to inform and enable the delivery of Technology and Design.

The Importance of Technology and Design

The Education Reform Act (1988), ERA, put in place a National Curriculum for England and Wales. Design and Technology, as a subject, formed a central part of that National Curriculum provision (DES/WO, 1989). Following the introduction of the ERA, the Education Reform (NI) Order (1989), ERO, was established. In many respects the ERO reflected the structure and nature of the ERA. Importantly, the Northern Ireland Curriculum followed, which was constructed on the basis of five Areas of Study, including Science and Technology. Within this Area of Study a 'new' and 'compulsory' subject entitled Technology and Design was introduced.

In 1991 a Ministerial Working Group was set up to produce proposals for programmes of study and an Attainment Target for Technology and Design. Indeed the Group indicated that it judged it to be inappropriate to impose any particular definition for Technology or Design. However for the purposes of "its own deliberations" it adopted the following, which we consider to be significant within the context of this study.

"Technology is based on applied science and has a demanding intellectual, creative, philosophical and human content. It is essentially pragmatic in nature since its ultimate measure of success is the satisfaction of

When Technology and Design Education is inhibited by Mathematics

human needs and wants, and identified market opportunities. Technology includes those design activities which strive for technical excellence in terms of function, safety, reliability, quality, efficiency and economy" (Northern Ireland Curriculum Council [NICC], 1991: 6).

Whereas

"Design encompasses thought-action processes which utilise intellectual and physical skills leading to the complete description of a product to satisfy a human need or want, or market opportunity. Design includes the management of these thought-action processes and the generation of the necessary written and graphic material for product manufacture, maintenance and use" (NICC, *ibid*, p6).

To emphasise the intimate connection between 'technology' and 'design' the Working Group suggested that the subject should be considered as 'Technology and Design' a single entity and that there should be one attainment target associated with it, namely, Technology and Design Capability.

Indeed the single attainment target 'Technology and Design Capability' was an attempt to reflect the holistic nature of the subject and accordingly the Working Party reported the need to "develop and apply in parallel:

- scientific knowledge and understanding;
- a range of intellectual skills;
- a range of physical skills;
- a range of communication skills;
- an awareness of the implications of technology and design on the community, economy and environment." (NICC, 1991:18).

The creation of an Area of Study, within the Northern Ireland Curriculum, known as Science and Technology which encompasses the traditional science subjects and Technology and Design is in itself significant and important. The value of Technology and Design is significant and immense. Technology and Design, as a subject, in the Northern Ireland Curriculum offers students an opportunity to identify and solve real problems by designing and making products or systems in a wide range of contexts.

Technology and Design – its value

There are many positive reasons for the compulsory introduction of Technology and Design into the school curriculum. Political pressure for the placement of the subject into the curriculum rests on two arguments: educational and economic (Donnelly, 1992; Eggleston, 1993; McCormick, 1993; Yeomans, 1998; Barlex, 2000;

Stein et al, 2000; Davies, 2003).

Technology and Design – its educational value

Medway (1989), Williams (1998), Hennessy and Murphy (1999), and Wright (2001) all articulated the educational value of including Technology in the curriculum; this really focuses upon the inherent value of the subject for its own sake. Barlex (2000), for example, argues that the subject can make a significant contribution to the development of many different but nonetheless highly desirable educational goals typically greater autonomy; increased creativity; the chance to participate in 'real' problem-solving activities; and the opportunity to engage in critical reflection. "The sum of the above parts is impressive. The potential for learning and developing attitudes and skills for life is immense" (Barlex, 2000:5). Medway expresses the importance of engagement with Technology in much more stark terms when he suggests that the subject is a worthy area of study because "to be ignorant of it is quite simply not to be fully educated" (Medway, 1989:3).

Three educational aims become apparent in relation to Technology and Design in the curriculum: (i) to create an awareness of Technology itself; (ii) to acquire appropriate conceptual, procedural and strategic knowledge and skills to make it possible and; (iii) to develop technological capability (Gibson, 2008). However, the ultimately educational goal for Technology and Design must be to empower young people to acquire, create and use the knowledge that is needed to deal with the various problem-solving tasks that sit before them, whether such situations be familiar or unfamiliar. Therefore the subject can provide real world contexts for the application of important problem-solving and decision-making strategies (Young, 2002). Custer (1995) argues for educational inclusion of Technology and Design in the curriculum because he suggests that it reflects all-encompassing aspects of life in our modern world. Such aspects involve the assortment of technologies involved, the various methodologies employed and a range of skills necessary to ensure effective delivery. Furthermore the educational inclusion of Technology and Design in the curriculum can encourage individuals to be practically analytical of Technology itself and of the changes advocated by it. Furthermore Hennessy and Murphy (1999) highlight an educational goal that is of particular significance. They argue that Technology and Design has the potential to provide students with real world problem-solving opportunities that demand engagement in co-operative and collaborative engagement with others, this view is also supported by Hendley and Lyle (1995). Furthermore it could be argued that as well as the pupils learning to work together in groups (learning to collaborate) they have the

When Technology and Design Education is inhibited by Mathematics

potential to actually learn more effectively and efficiently through group work (learning through collaboration).

Not surprisingly, the educational goals for Technology, as outlined in the literature, are closely reflected in the official documentation which legislates for the inclusion of the subject, Technology and Design, within the Northern Ireland Curriculum.

“Technology and Design contributes to the whole curriculum by providing opportunities for pupils to develop:

- technological literacy;
- an awareness of the effects which Technology and Design have on the world;
- a range of intellectual and physical skills;
- logical and systematic thinking;
- an understanding of technological devices and to employ them;
- the ability to identify, examine and resolve practical problems;
- a range of interpersonal skills” (NICC, 1991:7).

Clearly the stated educational goal for the subject, “to enable all pupils to become confident and responsible in solving real life problems, striving for creative solutions, independent learning, produce excellence and social consciousness” (NICC, 1991:15), is an important issue.

Technology – its economic value

Secondly, there are a number of economic reasons for the inclusion of Technology and Design within the curriculum with most of these focusing on the preparation of young people for the world of work. In this situation the subject is considered to have inherent vocational value, for example it has the potential to produce a technologically trained workforce (see Eggleston, 1993; Yeomans, 1998; McRobbie et al., 2000). It would appear to be the intention of the Government that the presence of Technology and Design in the curriculum would promote positive attitudes towards industry and aid the process of economic regeneration (Hendley and Lyle, 1996). This is further expounded in the most recent STEM reports (DfES, 2006; DEL/DENI, 2009). According to Williams and Williams (1997) Technology was introduced to meet the needs of an increasingly technologically-based society, because as Eggleston suggests an inability to operate effectively in this area could result in “marginal employment or potential unemployment” (1993:59). In addition, according to Hansen (1995) commenting on technology education from a German perspective, Technology is part of the process of preparing young people for effective citizenship. According to Barnett a young person’s ability or inability to deal with technology in the future could lead to what he

describes as “technological utopia or technologized doom” (1994:55).

Technology and Design, it is argued is an important area of study because the potential future prosperity of the country and ultimately the quality of life of its citizens depend upon it. Yeomans supports “the introduction and expansion of Design and Technology [by suggesting that it would] be a thoroughly good thing which would help to bring about the transformation of British industry and culture which was needed for economic regeneration” (1998:298), the same could be argued for Technology and Design. Yeomans was considering the utilisation of the General National Vocational Qualifications (GNVQ) as a means of vocationalising the Design and Technology curriculum in England and Wales. A newer and extended version of this particular qualification (the vocational GCSE) is offered within some of the larger non-grammar schools in Northern Ireland. The introduction of Technology and Design was according to Davies (2003:158) “one of the government’s central tools for industrial renewal” and hence the compulsory inclusion of the subject in the curriculum. It was suggested that the promotion of Technology and Design in our schools would help to improve the status and the attractiveness of industry in the minds of young people (see Eggleston, 1993; McCormick, 1993; Solomon, 1995; Yeomans, 1998; McRobbie et al, 2000). The proposals of the Working Group concurred with these views, arguing the potential economic benefits of compulsory inclusion of Technology and Design into the curriculum.

Mathematics used to support Technology and Design

The subject focuses upon the four key strands of design, communicating, design and manufacture, and energy and control. In this context Technology and Design, as prescribed by the Northern Ireland Council for Curriculum, Examinations and Assessment [NICCEA] (2006), is an excellent example of the cross curricular learning. Technology and Design is a purposeful and valuable subject in its own right and it is also a subject which enables the meaningful delivery of other subjects to be placed into real-world contexts. In a situation where there is full integration of the two subject areas, namely Technology and Design with Mathematics then the Mathematics can be taught within a context that is relevant to everyday living. The Mathematics has ‘purpose and focus’ through the medium of Technology and Design (Ainley, Pratt and Hansen, 2006:29). An example of this would be the important building block of the capacitor and resistor combination used for many timers and oscillators. Here students may be required to interpret a voltage/time graph or comprehend and manipulate the equation ‘Time

When Technology and Design Education is inhibited by Mathematics

constant = $C \times R'$ where C is the capacitance and R is the resistance. Within 'Mechanical Systems' Mathematics is fully integrated within the work on gears, using the calculation of 'Velocity Ratio' and in practice this will involve the combination of several gears thus increasing the Mathematics. Furthermore, typically, within 'Pneumatic Systems' there is the requirement to calculate the force and speed generated by a cylinder. In this context the determination of force and speed involves calculations that require the use of cylinder force, air pressure supply, piston area and cylinder efficiency. In addition this requires a knowledge and understanding of dimensional units to be used. As student teachers of Technology and Design not only do students have to be able to undertake such calculations and manipulations themselves they must also be able to explain such concepts in a correct and meaningful manner to the pupils in their classrooms.

The operation of Technology and Design requires the management and manipulation of numeracy i.e. the cross curricular skill of 'Using Mathematics' and provides the purpose of the Mathematics in the mind of the student (Ainley, Pratt and Hansen, 2006:29). Numeracy and its execution in a realistic sense is "the ability to apply appropriate mathematical skills and knowledge in familiar and unfamiliar contexts and in a range of settings throughout life, including the workplace (DENI, 2011). It involves the development of an understanding of key mathematical concepts and their interconnectedness, the utility of the Mathematics (p.30) e.g. true mathematical error in measuring and rounding, appropriate reasoning and problem-solving skills as found in finding maximum bearing loads, proficient and appropriate use of methods and procedures e.g. the numerical calculations associated with adding resistors in parallel or active participation in the exploration of mathematical ideas and models. Ainley et al (2006:33) propose that 'opportunities to understand utility can only be provided through purposeful tasks' and we perceive Technology and Design as an excellent subject area in which to do this.

This paper makes the working assumption that those involved in teaching Mathematics, whether directly or through a different subject area such as Technology and Design, must not only be knowledgeable in the subject's mathematical content and its associated pedagogy, but ideally should also convey a positive attitude towards Mathematics. The work suggests that challenging a negative attitude to Mathematics is a necessary part of preparing future teachers of subject areas containing mathematical content. It is hoped that in constructing 'attitude profiles for Mathematics' for the Technology and Design students, based on these research results, that the

tutors within Technology and Design will have a constructive tool in informing their teaching approach and course development.

Conceptual Framework

In the recent publication 'Shape the future directory' (Nuffield Foundation, 2008:6) the 'Principles of Curriculum Enhancement and Enrichment of STEM' have the words motivation, enthusiasm and attitudes permeating through the curricular aspects of their documentation. Smith (2008:1) comments that 'good Mathematics Education requires professional teachers...to teach our young people about the subject in a passionate yet systematic manner'. Attitude to Mathematics as defined by Zan and Di Martino (2007) is a multi-dimensional variable with cognitive, affective and behavioural aspects to it. Various definitions of attitude are available including those of Oppenheim (1992), Lalljee, Brown and Ginsburg (1984) and Ernest (2000) but the common elements of these recognise that attitude is learned and in the absence of intervention the response is consistent.

Brown, McNamara, Hanley and Jones (1999:301) discuss the transition from 'school learner of Mathematics to school teacher of Mathematics'. They use the term 'mathematical baggage' to describe how the "mathematical understanding of such students is, in the first instance, embedded in a strongly affective account of their own mathematical experience in school, where Mathematics was often seen as difficult and threatening." (p.299). The students on whom this research project is based have not chosen to study mathematics but have selected a subject area with strong mathematical content which they will have to teach. Therefore the element of attitude to Mathematics must be addressed through their selected course. Ball (1988, p.40) recognises that attitude problems are a potential impediment to teaching Mathematics and supports teacher education programmes that consciously attempt to constructively change attitude. Ball expresses this view by suggesting that when this does not occur "teacher intervention is often a weak intervention – why teachers...are most likely to teach Mathematics just as they were taught at school".

The important role that attitude towards Mathematics plays in the classroom practitioner's work has been well established by researchers such as Thompson (1984), Ernest (1988), Ball (1990) and Fernandes (1995). Ernest (1989) discussed how a negative attitude can manifest itself and the powerful impact that this can play in establishing the ethos and atmosphere in which Mathematics is taught. This attitude may materialise in the presence, or absence, of enthusiasm and confidence in

When Technology and Design Education is inhibited by Mathematics

teaching the subject. The concern would be that the students undertaking this Technology and Design course would allow their attitude to Mathematics to influence how they teach the mathematical elements within their chosen subject area.

Ma and Kishor (1997:27) considered a complex definition which included the 'belief that Mathematics is useful or useless', a significant factor for teachers and students of a subject with a strong mathematical base. They suggest that 'children learn more effectively when they are interested in what they learn and that they will achieve better in Mathematics if they like Mathematics'. Therefore the subject area of Technology and Design holds tremendous opportunities to accurately and enthusiastically use and teach Mathematics and in this way Technology and Design is developing and enhancing the mathematical experience of pupils in the classroom.

One aspect of the SETNET (2007) program is to help promote positive attitudes in pupils towards Science, Technology, Engineering and Mathematics. In this work emphasis is placed on students developing their knowledge, understanding and attainment within and between these four key subjects. The positive and enthusiastic delivery of all aspects of these subjects will be a contributing factor to the programme's success. The teacher's enthusiasm and confidence in delivering Mathematics is a key contributory factor, enabling pupils to learn for themselves and from each other, therefore developing their confidence and inevitably promoting a positive attitude to Mathematics or the mathematical elements within another subject (OfSTED, 2008).

Crawford, Gordon, Nicholas and Prosser (1995) surveyed 300 beginning university students and their approaches to the study of Mathematics. The image of Mathematics that the majority of students had when commencing their course was that it was a necessary set of rules and procedures to be learned by rote. The students participating in this research, undertaking a B.Ed. (Post-primary) in Technology and Design may not have studied Mathematics in the two years prior to entering this degree pathway. They may hold the view that Mathematics is a set of rules and procedures to be learnt by rote. Therefore these students are moving from 'school learner of mathematics to student teacher of Mathematics', (Brown, McNamara, Hanley and Jones, 1999:301) with less than positive and accurate views on the teaching of Mathematics within their chosen subject area. Brown et al (1999:299) describe how the 'mathematical understanding of such students is, in the first instance, embedded in a strongly affective account of their own mathematical experiences in school, where

Mathematics was often seen as difficult and threatening'.

The student teachers of Technology and Design need to be aware of their own attitude to Mathematics before any negative attitudes can be addressed. Their course must then address the development of positive attitudes towards their mathematical teaching within their chosen subject area. This is taking on board the work of Ernest (1989), that teacher educators should include both the cognitive and affective aspects of teaching Mathematics in their course construction. He urges teacher educators to consider the mode of instruction experienced by the pre-service teacher as this will impact on their mathematical learning experience and subsequently on their teaching of the subject. The suspicion is that when the Technology and Design students are teaching the mathematical elements of their subject or providing mathematical remediation to their pupils they will do so as they remember being taught. Yet Technology and Design curriculum content provides an excellent opportunity to present mathematical material in an interesting, useful and enjoyable way in order for positive attitudes towards Mathematics to develop. This is where the teacher's attitude to Mathematics becomes important and where Nardi and Steward (2003) have highlighted that pupils' attitudes and emotions towards Mathematics are linked with the types of activities and work in which the pupils engage in the classroom.

MacNab and Payne (2003) advocated that a teacher's attitude, especially in Mathematics, influences their quality of teaching of the subject. If teachers have a positive attitude and feel confident in their own Mathematical abilities, then effective teaching should take place (Williams, 2008). The teacher's mathematical confidence and attitude will also determine how the mathematical subject material is delivered and whether the emphasis in teaching mathematical content is on 'correct or incorrect answers' and how these are achieved. (Ernest, 2000; Golafshani, 2002)

It is interesting to consider why these student teachers have chosen to undertake a B.Ed. (Post-primary) in Technology and Design but may not have selected to study Mathematics in the two years prior to entering this degree pathway. If their decision is based on their mathematical ability then as Papanastasiou (2000:27) suggests the level of success experienced in Mathematics has been found to affect their attitude towards the subject. Ma and Xu (2003) expressed a similar view on prior mathematical achievement resulting in a change in attitude towards the subject and potentially development at a later stage to Mathematics anxiety.

Boote (2003) acknowledges that teacher educators need

When Technology and Design Education is inhibited by Mathematics

to consider the beliefs and attitudes of the pre-service teacher, but he questions whether the teacher educator is (i) competent to become what he terms a “belief and attitude therapist” (p.258) and (ii) whether the role of the teacher educator should extend beyond providing the teaching skills for their subject area.

However, knowing that the research indicates the existence of negative attitudes towards Mathematics and the influence this can have on the teacher’s classroom practice it would seem intuitively wrong not to address the area of attitude towards the subject in the preparation of a new teacher for the profession.

Methodology

Four groups each containing 10 students who were undertaking a B.Ed. (Post-primary) degree in Technology and Design completed an attitude questionnaire, 5-point Likert style scale, mid-first semester. Group 1 contained students from Year 1 of the course, group 2 from Year 2 etc. The B.Ed. (post-primary) programme contains small numbers of students and 10 was the maximum of the smallest cohort entry and was therefore taken for the sample size.

The questionnaire was composed of 22 statements, adapted from the work of Ernest (2000) which examined attitude to Mathematics, where a value of 1 indicated strong disagreement to a statement and a value of 5 indicated strong agreement with the statement. The statements were presented randomly within the questionnaire so as to avoid bias and were of two types. The first type explored their attitude to Mathematics not within the context of Technology and Design. Type two style statements considered their attitude to the mathematical elements within their work in Technology and Design. Typical type two statements included: “I feel at ease with work in Technology and Design which involves the use of Mathematics.” “I’m fearful that I will make mistakes if I have to use Mathematics in the Technology and Design classroom.” and “I am fairly confident about my ability to use Mathematics within Technology and Design.

The results were analysed for each year group separately in accordance with the recommendations of Eifler, Potthoff and Dinsmore (2004). This allows for the calculation of a mean value from the Likert scores allocated for a given statement. Initially the purpose of the research was not explained to the students so as not to influence the response of the students. After the questionnaires had been completed a number of focus group interviews were conducted in order to further the discussion between students and tutors on emerging issues around

mathematical confidence and attitudes to Mathematics and how it could be addressed to support the students. This paper reports only on the results of the questionnaire.

Discussion of Results

The work in the affective domain in relation to student teacher attitudes to mathematical work within Technology and Design are presented in Table 1. This table presents the statement asked and for each of the four year groups the mean of the relevant Likert statements.

The first two rows in the table might suggest that students’ confidence in Mathematics has become more negative over the four years. However, it should be remembered that the mathematical content within Technology and Design is progressively more difficult through the degree pathway.

Results of this research would appear to suggest a number of interesting and related issues. Firstly, a number of students tend to have a fear of Mathematics. This view is reflected in the scores attributed to such statements as “Sometimes I am fearful of Technology and Design that involves the use of Mathematics”, (3.50, 3.29, 3.6, 3.7) “It makes me nervous to think about tackling Mathematics within Technology and Design” (3.6, 3.36, 3.2, 3.7) and “I feel insecure when undertaking Technology and Design work that involves Mathematics” (3.2, 3.36, 3.7, 3.3). Such an element of negativity regarding a fear in the use of Mathematics must have a significant impact upon a teachers’ own confidence to deal with the subject and in their subsequent use of it in the classroom with pupils. Secondly, students expressed a dislike for Mathematics and any work which overtly involved the use of Mathematics. Such a view is reflected in the high scores attributed to such elements as “Throughout school I have never liked Mathematics” (Year 2 - 3.57 and in Year 4 - 3.9) and “At times I dislike Technology and Design because it involves Mathematics” (3.50, 3.29, 3.6, 3.7). Once again such levels of disdain towards Mathematics as a subject must have an adverse impact upon the delivery of Technology and Design which encompasses the use or the application of Mathematics.

Clearly the attitude of the teacher to Mathematics and the mathematical elements of any course that they deliver are important. A teacher displaying negative, or indeed perceived negative attitudes to Mathematics, will have a potentially significant influence upon the views and perceptions that their pupils will reflect towards Mathematics or any subject that has mathematical content. This research shows that students do have perceptions towards Mathematics and the mathematical content of

When Technology and Design Education is inhibited by Mathematics

Statement	Year 1	Year 2	Year 3	Year 4
I have always been confident about my ability to do Mathematics.	3.2	2.64	2.7	2.4
I am fairly confident about my ability to use Mathematics within Technology and Design.	2.6	2.71	2.4	2.3
I try to avoid Technology and Design work which involves the use of Mathematics because I am not very good at Mathematics.	3.5	3.5	3.9	3.9
Mathematics is a subject that is easy.	3.4	3.07	3.0	3.0
I am at ease using Mathematics within Technology and Design.	2.70	2.57	2.5	2.4
I feel insecure when undertaking Technology and Design work that involves Mathematics.	3.2	3.36	3.7	3.3
I try to avoid Technology and Design work which involves the use of Mathematics because I do not like working with Mathematics.	3.5	3.5	3.9	3.9
I find Mathematics difficult.	2.7	3.5	3.6	3.6
I am not good at Mathematics.	3.00	3.21	3.0	3.8
I like Technology and Design work which involves the use of Maths.	3.00	2.93	2.9	3.0
Sometimes I am fearful of Technology and Design that involves the use of Mathematics.	3.50	3.29	3.6	3.7
Technology and Design work which involves Mathematics is good.	3.3	2.86	2.9	2.9
I feel confident in my ability to use Mathematics in my Technology and Design work.	2.9	2.79	2.4	2.6
It makes me nervous to think about tackling the Mathematics within Technology and Design.	3.6	3.36	3.2	3.7
I find work within Technology and Design that employs Mathematics difficult.	3.1	3.21	3.0	3.4
I feel that I am reasonably good at Mathematics but I can't apply it to problems.	2.90	3.29	3.1	3.5
I'm concerned that I will make errors when I am using Mathematics in the Technology and Design classroom.	2.90	2.93	3.3	3.5
If I have to undertake any kind of calculation within Technology and Design I will always look for some form of help.	2.90	3.21	3.3	3.6
Throughout school I have never liked Mathematics.	2.60	3.57	3.1	3.9
I find the Mathematics within Technology and Design to be easy.	3.40	3.21	2.7	3.5
At times I dislike Technology and Design because it involves Mathematics.	3.50	3.29	3.6	3.7

Table 1: Results of the work in the affective domain

When Technology and Design Education is inhibited by Mathematics

subjects and such perceptions can be very powerful. Furthermore this research reveals that students' confidence in their own ability to use Mathematics is not as strong as one would imagine given the fact that all students have a grade C or above in GCSE Mathematics. It is of concern that in this survey, the attitude to Mathematics of the students tends to impact upon their attitude to Technology and Design as seen by their responses to the statements 'I try to avoid Technology and Design work which involves the use of Mathematics because I do not like doing Mathematics' (3.5, 3.5, 3.9, 3.9) and 'Technology and Design work which involves Mathematics is good' (3.3, 2.86, 2.9, 3.0). It is disappointing to note that this negative response to the place of Mathematics within their subject area of choice does not seem to improve as they progress through the course. However, it could also be argued that as a student progresses through the course and gains experience teaching their subject on school placement then their understanding of the predominance and position of Mathematics within Technology and Design becomes more realistic. This recognition of the importance of Mathematics within their subject and their role of teaching Mathematics through Technology and Design could in reality be a positive factor.

The students indicated that their concept of Mathematics as a separate entity, as suggested by their responses to the statement 'Mathematics is a subject that is easy' (3.4, 3.07, 3.0, 3.0), was not specifically negative. However, their responses became more negative when the Mathematics was presented within their own subject of Technology and Design (2.6, 2.71, 2.4, 2.3). This was highlighted in their statements that they were reasonably good at Mathematics but that they couldn't apply it to problems. However, there may also be some element of challenge resulting from the transferability of knowledge and skill from one subject area to another. This is significant as the Mathematics within Technology and Design is presented within a totally relevant context of problem solving within everyday living. Their responses to the statements 'I am at ease using Mathematics within Technology and Design' (2.70, 2.57, 2.5, 2.4) and 'I feel confident in my ability to use Mathematics in my Technology and Design work' (2.9, 2.79, 2.4, 2.6) are consistent with their lack of confidence in their mathematical ability. This will impact on their teaching particularly when they are challenged by pupils to explain calculations or remediate a pupil's errors. This would agree with the work of MacNab and Payne (2003:64) who having reviewed the attitude of both B.Ed. (Year 4) and PGCE students concluded that less than half of those surveyed felt confident when working on mathematical tasks and this lack of confidence materialised in their attitude towards teaching the subject. It may have

been interesting in addition to looking at the students' attitude to Mathematics and their attitude to Mathematics within Technology and Design to also consider the attitude to their chosen subject area as a separate entity.

The students expressed concern that they would make mathematical errors when explaining Mathematics in the Technology and Design classroom. In many cases this again is down to a lack of confidence in their own ability to use and apply Mathematics; there is an inherent fear factor attached to the subject. This lack of confidence in their own mathematical ability was addressed separately by the authors in developing an online numeracy resource. The role of this resource was to scaffold and support numeracy within Technology and Design (Bell and Gibson, 2009). However, their responses also indicated that when they have to undertake calculations within their chosen subject they are showing sufficient maturity and positivity towards Mathematics that they are seeking mathematical help in some format. The students were prepared to ask for and accept help and support from others including their tutors. The student responses to the statement 'At times I dislike Technology and Design because it involves Mathematics' strongly suggests that the attitudinal concern is with the Mathematics contained in their subject and not Technology and Design itself. The same students displayed a high level of ability in many areas of Technology and Design but had more conceptual difficulty with some of the associated mathematical aspects of it.

Conclusion

Ultimately, Mathematics has both 'purpose' and 'utility' to enhance the delivery of Technology and Design; Technology and Design is a meaningful, important and valuable subject in its own right. This work brings to the fore the question of who and how should the pedagogical issues of teaching Mathematics within a Technology and Design course be addressed. This is particularly important when viewed in the context of the literacy and numeracy strategy published by the Department of Education for Northern Ireland who argue that "teachers as professionals readily recognise their responsibility to ensure that children are afforded an opportunity to excel and fulfil their basic potential and it is self-evident that literacy and numeracy are the basic tools of learning" (DENI (2008:7). While cognisant of the fact that there are many important skills to be developed (for example graphic skills visualisation skills); in Northern Ireland there is a drive, in particular, to increase literacy and numeracy standards. Without the inclusion of this aspect of teaching Mathematics, are students being fully prepared to expose and discuss the common mathematical misconceptions that will arise in the calculations which their future Technology and Design

When Technology and Design Education is inhibited by Mathematics

pupils will be faced with? The use of teacher 'buddy groups' may serve to support using Mathematics through other subject areas. This system allows both planning and teaching of the supporting subject (numeracy) to be specifically addressed by the school numeracy coordinator. It ensures that the conceptual mathematical framework, with the numerical manipulation and calculation, is addressed prior to its use within the 'main subject area'.

The work should cause tutors to contemplate on whether it is sufficient to tackle the mathematical difficulties of the students in the hope that this will increase their confidence and attitude to Mathematics. If student teachers of Technology and Design lack confidence in their mathematical ability and possess a negative attitude towards the subject and its teaching then teacher educators must address this at Initial Teacher Education stage. If not then one of the key concepts underpinning cross-curricular teaching of numeracy is being neglected. Similar issues are raised in the DENI (2008:9) Literacy and Numeracy strategy which suggests that it should be the case for all pupils to "point to the need for targeted and supportive action to support those most at risk of underachievement as well as for action designed to maintain and improve achievement in literacy and numeracy so that all young people can leave school prepared for adulthood and well-placed to interact with and make a positive contribution to society and the economy." Such preparation will be most successful when the teachers in schools involved in delivering the mathematical elements within their subject areas are willing and enthusiastic about this aspect of their teaching. If newly qualified teachers of Technology and Design are entering the classroom with these attitudes then clearly there should be further work done during 'Early Professional Development' (EPD) and 'Continuing Professional Development' (CPD). Recommendation 15 from the Advisory Committee on Mathematics Education (ACME) (2006:24) states that:

The DfES with the Teacher Development Agency (TDA) should set out a requirement for widespread provision of sustained CPD which improves subject knowledge and teachers' own confidence in, and attitude to, the subject (Mathematics)

And more recently Advisory Committee on Mathematics Education [ACME] (2008:2) in discussing the importance of the cross-curricular nature of learning with other STEM subjects commented that 'quality CPD is needed in order for this to be embedded practice'. This work with B.Ed. (Post-primary) students has clearly allowed the students to reflect on their role as the 'Mathematics teacher' and how

it is their responsibility to deliver the mathematical content of the Technology and Design curriculum. This has to be a format of delivery that is 'enthusiastic, inspiring and current' (DfCSF (2008:8)). Having breached the initial barrier of acknowledging that Mathematics teaching is the responsibility of all teachers irrespective of their subject, a sense of collaborative professional learning between tutors and students has been allowed to develop.

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