How is the STEM agenda put into effect in post-primary schools in Northern Ireland

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Abstract

In this paper I consider the teaching and learning of science, technology, engineering and mathematics (STEM) in schools in Northern Ireland. I suggest that the importance of STEM subject teaching cannot be over emphasised in order to encourage pupils to take an interest in and develop positive attitudes towards STEM subjects from an early age. One of the challenges currently facing Northern Ireland and other countries is the apparent declining interest in and uptake of STEM subjects by pupils in post-primary schools. This study investigates practice in two post-primary schools to identify how STEM subjects can be delivered effectively to provide pupils with the opportunity to learn skills vital for today's economy. I conclude that it is clear that post-primary schools, with the support of the Northern Ireland Government and external bodies, play a major role in promoting STEM subjects to young people.

Introduction

Background

In recent years there has been an increasing emphasis placed on the teaching and learning of science, technology, engineering and mathematics (STEM) in schools in Northern Ireland. The acronym STEM stands for the interdisciplinary relationship that exists between science, technology, engineering and maths. Morrison (2006) argues that this interdisciplinary bridging among discrete disciplines is now treated as an entity, known as STEM. As indicated in the Report of the STEM Review (2009) each one of these subjects is becoming more and more relevant in our classrooms. The importance of STEM subject teaching cannot be over emphasised and has been brought to the forefront in many recent publications. (Department for Education and Science [DfES], 2006; Department for Children, Schools and Family [DfCSF], 2008; Department for Employment and Learning/Department for Education [DEL/DE], 2009) The ultimate goal of STEM education is to encourage pupils to take an interest in and develop positive attitudes towards STEM subjects from an early age. One of the challenges currently facing Northern Ireland and other countries is the apparent declining interest in, and uptake of STEM subjects by pupils in post-primary schools. The Organisation for Economic Co-Operation and Development (OECD) commented that the decline in the uptake in STEM subjects is not unique to Northern Ireland; rather it is equally notably visible in the United States, France and Germany. According to the Report of the STEM Review (2009, p12) "*Young people are increasingly disengaged in STEM subjects.*"

The Northern Ireland Government has highlighted in their documentation that it is now imperative that there is more focus placed on the uptake of STEM subjects, with the intention being to promote economic regeneration to produce a high valued-added economy that is globally competitive. (Report of the STEM Review, 2009) The report argues that the skills developed through STEM subjects are a prerequisite to the development of a prosperous and sustainable economy.

Aims and rationale
The aim of this report is to investigate two post-primary schools to determine what strategies are effective in implementing STEM Education at Key Stage 3 level in Northern Ireland. The study is based on a case study of two local schools in the Western Board. Interviews were held with teachers who are associated with STEM subjects to determine how they deliver the STEM agenda at a school level. The study aimed to identify if the teaching of STEM subjects is delivered effectively in post-primary schools or if there is a failure in providing pupils with the opportunity to learn skills vital for today's economy.

In 2007 the revised curriculum was put into effect in Northern Ireland. The curriculum included a clear focus on developing numeracy and literacy skills. There was also an explicit focus on science and technology. This new curriculum gave educators more freedom to take part in STEM related learning with their pupils. The Entitlement Framework now provides pupils with increased choice in the range of courses available to young people aged 14 and above. According to Pitt (2009, p37), STEM allows pupils to learn in a different way than they previously did in curriculum based subjects. He states "The boundaries between the components of STEM become blurred and learners are encouraged to develop transferable skills and knowledge and the metacognitive skills that enable this transfer to be used creatively."

The review will look into how two schools view STEM education and the procedures and methods they have in place to deliver the STEM subjects.

There are many different approaches that can be taken in order to effectively deliver the STEM agenda into schools in Northern Ireland. For example, schools could take a silo approach to the teaching of STEM subjects or rather an integrated approach whereby the concepts and practices of science and/or maths are intentionally integrated with the concepts and practices of technology and engineering. At present there is a concern that a silo approach is taken when it comes to the delivery of STEM subjects. The silo approach to STEM education refers to isolated instruction within each individual STEM subject. (Dugger, 2010) Within schools in Northern Ireland teachers of Technology and Design are relied upon to deliver both Technology and Engineering aspects of STEM. There is an intrinsic relationship between these two discipline areas therefore successful integration of the subjects can be achieved. Science and Mathematics however has a tendency to be treated as a silo.

Defining each aspect of STEM
Defining each aspect of STEM can prove to be difficult however it is necessary to understand each element individually before envisaging it in its entirety.

Science
  Science has a significant role in fulfilling the aims and objectives set out in the Northern Ireland Curriculum; to help pupils prepare for life and work as individuals, as contributors to society and contributors to the economy and environment. Moyer and Everett (2012, p3) define science as "*both knowledge of how the natural world works as well as the practices we employ to determine those understandings*".

Technology
 Mc Cormick (1990, p45) notes that "*the nature of technology is not easy to pin down and the definitions that exist do not give much guidance as to what activities it includes.*" Due to this uncertainty, the term technology causes problems and in turn can cause issues for educators of the subject.

The Northern Ireland Curriculum is constructed on the basis of five Areas of Study, including Science and Technology. It is within this area of study that the subject Technology and Design was introduced. "*Technology is based on applied science and has demanding intellectual, creative, philosophical and human content. It is essentially pragmatic in nature since its ultimate measure of success is the satisfaction of 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 1991, p6)

According to Gibson (2011) Technology and Design, as a subject in the Northern Ireland Curriculum, offers pupils an opportunity to solve real problems by designing and creating systems or products.

Engineering

Like technology, engineering can also be difficult to define. Harrison (2011, p18) 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*." Engineering therefore possesses many similarities to technology as they are both practical in nature and are associated with product design. According to Maoveni (2011), engineering involves the application of physical and chemical laws and mathematics to design and develop and manufacture products and services. This reinforces the idea that an intrinsic link does exist among the STEM disciplines.

Mathematics

Mathematics holds a very significant position in both the Northern Ireland Curriculum and within STEM. Maths is one of the statutory subjects within the curriculum and is "*fundamental to life in the sense that its unique language and forms of notation help to calculate, estimate and problem-solve*" (Northern Ireland Curriculum). Smith (2008) believes maths is a vital discipline in itself and it offers support to the other STEM subjects by providing them with a common language that connects and distinguishes them. Although Maths does have an important role to play in STEM Education it is also an important subject in its own right and must therefore hold its identity in the curriculum.

The view of the Northern Ireland Government on STEM

The Review of STEM was commissioned by the DEL and the DE and formally began in June 2007. Following on from this the Report of the STEM Review was published in 2009. The vision outlined in the Report was to "*empower future generations through science, technology, engineering and mathematics to grow a dynamic, innovative economy*."

The government has long identified STEM Education as a major priority at both school and Higher Education level. The Report of the STEM Review considers the education system in the context of a STEM artery and in doing so identifies the limitations and losses at each stage in the artery. It was made evident in the report that there was a continual decline in interest in STEM subjects beginning in the latter years of primary education. Since commissioning the Report of the STEM Review the government has taken great strides to effectively reduce these limitations and assist schools in their delivery of STEM subjects.

The Department of Education Northern Ireland (DENI) published "Success through STEM" in 2010. This was in response to the Report of the STEM Review. The document highlights the actions taken by the Government to promote STEM in schools in Northern Ireland. Within this document there are 4 main imperatives. This first imperative is that businesses must take the lead in promoting STEM and the second is that key constraints in the STEM artery must be alleviated. This is then followed by the need for increased flexibility in the provision of STEM education and finally the government must improve and increase its support for STEM.

In recent years numerous STEM related organisations, such as Sentinus, have surfaced and play an important role in the support and development of STEM Education in Northern Ireland. The work of STEM organisations builds on the government's ongoing strategies for developing a strong supply of engineers, scientists and mathematicians. The Department of Education supports the work of Sentinus and provides them with funding in order to assist their work with schools and colleges in Northern Ireland. Sentinus delivers STEM related projects for young people aged 7-21. All of their projects require hands on approach. In addition to this they provide a vast range of resources for teachers to enhance teaching and learning in each of the subjects areas, with particular relevance to a real world context.

The DE has also commissioned a programme of professional development for teachers to promote and support STEM in the primary and post-primary sectors within the revised curriculum. The development of a STEM Continuing Professional Development (CPD) framework ensures the provision of professional development opportunities for teachers designed to promote effective STEM teaching.

It is important to recognise that businesses and employers have a crucial role in promoting STEM and improving the attractiveness of the subjects. As the Report of the STEM Review notes, "*If the private sector here does not take steps to improve remuneration for STEM employment, it will be difficult to present a credible promotion of the benefits of STEM careers within the private sector, to parents and pupils alike*".

What Educational Research has to say about STEM

According to Gibson (2012) the decision by pupils to study STEM subjects is partly influenced by teachers who deliver them. It is important therefore that the teachers are fully equipped with the knowledge to contextualise their subject and make it relevant to the learner. (Report of the STEM Review, 2009) Gibson (2012, p18) states "*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.*"

 According to Pitt "*STEM as an educational concept is problematic. There is little consensus as to what it is, how it can be taught in schools, whether it needs to be taught as a discrete subject, whether it should be an approach to teaching the component subjects, what progression in STEM education is and how STEM learning can be assessed.*" (2009, p41)

As the Royal Society (2007) noted, in order to facilitate this form of useful interaction between the STEM subjects a 'top down' approach must be must be avoided. Teachers must be willing to communicate with each other and recognise that interactions between the subjects will result in enhanced learning opportunities for their pupils. Barlex (2007, p8) believes that STEM links in schools must be "*grass root*" driven whereby there must be partnerships between teachers which "*thrive on dialogue, risk taking and a shared vision.*"

"*A number of Technology Education researchers also see STEM as providing a career pathway to an engineering profession.*"(Dearing and Daugherty, 2004; Wicklein, 2006)

Research methods

The objective of this section is to discuss the research method and methodology that has been employed for the purpose of this study. This section includes research design, research questions and the ethical considerations which must be taken into account when completing the study.

Research Design
Cohen and Manion (2007, p81) highlight that in any research project it is important to translate a "*very general research aim or purpose into specific, concrete questions to which specific, concrete answers can be given.*" Research by Moore (1987) has emphasised that having a clear objective provides the basis for the design of any project, for the selection of the most appropriate methods and for the management of the project once it has begun. It is important therefore to carefully plan and design a research strategy whereby the final results will be of great relevance to the research questions. Cohen and Manion (2007, p78) also draw attention to the idea that "*there is no single blueprint for planning research*" and thus suggest that research design must be directed by the concept of "*fitness for purpose*".
The use of appropriate methods of research data collection and analysis of data is of vital importance to achieve the goals of research. Accurate data collection affects the validity and the reliability of research and greatly enhances the value of research. Walliman (2005, p244) notes that, "*The research methods must be appropriate to the objectives of the study. A wrong choice of the data on the research can have serious effects on the validity of the conclusions.*" It is therefore important to select the research instrument which will ensure the objectives of the study are fulfilled. According to Bell (2005, p120) "*The instrument is merely the tool to enable you to gather data, and it is the important to select the best tool for the job.*"

Due to the limited time scale of this study the project was conducted by the use of qualitative methods. This study took the form of a case study on two post primary schools in the Western Education and Library Board (WELB). The aim was to gather valid and reliable data that could be analysed and evaluated relating to the strategies currently put in place by post primary schools to promote the STEM agenda at Key Stage 3 level. Teachers involved in STEM related subjects were involved in the interviewing process.

Research Questions
Blaxter et al. (2001, p34) suggest that small scale research should contain a maximum of three research questions. Therefore due to the small nature of this study the research will be underpinned by the following research questions:

- What STEM strategies are presently employed for effective teaching of STEM subjects?
- How are these strategies deemed to be effective?
- In what way(s) are the teaching and learning of STEM subjects enhanced in schools?

A semi-structured approach will be taken when conducting interviews to allow some control over the type of information acquired. In such an interview, a set of prepared questions acts as a guide for the researcher. Although the researcher will ensure that these key questions are asked of all persons interviewed, the semi-structured format also enables the researcher to ask additional questions where appropriate. Ely et al. (1991, p66) suggests that "*Open-ended questions can unearth valuable information that tight questions do not allow.*" The use of qualitative methods presents the best opportunity to achieve a clear and detailed picture of the opinions of teachers directly involved in STEM subjects in each of the schools. The participant is asked to talk openly and freely about whatever he or she has deemed to be important and is thus encouraged to elaborate and initiate the conversation in alternative directions. Invaluable data such as this is not readily available as figures.

Ethical Issues
It is imperative that any research project takes account of ethical considerations. This is a matter which requires thorough planning, consideration and attention to detail from the offset. Blaxter et al. (1996, p196) provides a useful summary of the key elements of ethical practices in research:

Research ethics is about being clear about the nature of the agreement you have entered into with your research subjects or contacts. Ethical research involves getting the informed consent of those you are going to interview, question, observe or take materials from. It involves reaching agreements about the use of this data, and how its analysis will be reported and disseminated.

The Ethical Guidelines for Educational Research (British Educational Research Association, 2011) advise that educational researchers operate within an ethic of respect for those involved in the research they are undertaking. This applies to those who are both active and passive participants of the study.

This research took the form of a qualitative case study that involved looking at two post primary schools in Northern Ireland. Due to the nature of the research, i.e. a case study based around a school setting, it was essential to obtain access to the schools. Pullen and Gray (2006) believe that access depends on trust and suggests that all researchers should aim for "informed consent". Permission was first granted by the Principal of both schools to allow their school to be involved in the research study. Furthermore a letter sent to participants involved in the interviews ensured that the participants were aware of the nature and purpose of the study prior to the research being carried out. It is at this stage that the participants were also made aware of why their information is necessary, how the information will be used and to whom it will be reported. This gave the participants the opportunity to make an informed choice as to whether they wanted to take part in this study.

Participation is always voluntary and any individual has the right to withdraw from the study at any stage in the process. Participants should be informed that they have the right to withdraw at any time without any reasonable explanation. Walliman (2005, p347) indicates that:
There could be many reasons why a participant may stop taking part in the research: misunderstanding of the research, unwanted implications that appeared, discomfort or embarrassment, or just too much bother.

An additional issue which must be taken into consideration within any research project is confidentiality. Protecting the privacy of all participants is essential and data should be shared only with those originally agreed with by the participants.

Data analysis
This section presents the findings obtained from research by setting out the results of the interviews which were carried out for the purpose of this study. As previously stated the aim of the study was to illustrate the strategies currently put in place to promote the STEM agenda in post primary schools in Northern Ireland. Two schools were examined to provide case studies based on teachers' experiences with and attitude towards STEM education and the strategies employed by schools to promote STEM based learning. Evidence used to form these case studies came from interviews with members of staff from two post primary schools in the WELB, who are directly involved in the teaching of STEM subjects, along with an interview with the Coordinator of the Fermanagh Learning Community.

Links with industries
Participants from both schools were first presented with the question "What STEM strategies are presently employed for effective teaching of STEM subjects?" According to the respondents a strategy deemed to be particularly successful is the recent increase in links with industries, particularly companies in the local area. This close connection with industry seemed to be particularly relevant for School 1. Teacher 'A' (Technology) stated, "We have found that planned visits to industries in the local area play an important role in promoting STEM subjects to our pupils.

The visits changed the pupils' perceptions of and awareness towards engineering and provide them with real life experiences that no classroom lesson could achieve." In addition to this, it was noted by Teacher 'B' (Science) that many of the pupils have a "preconceived idea" of what industry involves. However visits to local companies make them more aware of the vast range in opportunities available through engineering and STEM based subjects.

Participants from School 2 also held the idea of links with industry in high regard. Teacher 'A' (Technology) considered links with businesses and industries to be crucial to the promotion of the STEM agenda stating that "Businesses have the power to promote and develop and clear career path and link between STEM based subjects and the working environment." However it was noted by Teacher 'B' (Science) that "It is great when pupils get the chance to visit industries in the locality but it just does not happen enough. It is becoming increasingly problematic taking pupils out of school mainly due to time constraints, money and health and issues."

The Coordinator of the Fermanagh Learning Community shed further light on the opportunities available to schools in the local area in relation to links with industries. In recent years there has been an opportunity for teachers of STEM subjects to participate in a STEM related industrial placement for a period of one week. This project is Government funded and a substitute teacher is provided to cover classes. None of the participants interviewed have availed themselves of this opportunity. This is largely due to the fact that principals are reluctant to release their staff for this length of time as it sacrifices valuable teaching time and in turn may jeopardise grades.

Career Guidance
Another STEM strategy employed by both schools was the inclusion of career talks and careers guidance to promote the uptake of STEM subjects. One point raised by Teacher 'C' (Maths), School 1, was that "Studying science and maths unlocks a vast range of employment opportunities for young people. As an educator it is vital that we provide our pupils with the best opportunities available and thus career guidance is essential prior to the selection of GCSE subjects." It was also noted by Teacher 'B' (Science), School 1, that pupils must have an "awareness of career paths" when selecting their subject choices. School 1 has sought to raise awareness of STEM careers through Parent/Teacher evenings. During these events visual aids such as display boards and posters are used as well as the attendance of STEM Ambassadors and employees from local industry. According to Teacher 'C' (Maths) "STEM Ambassadors are a great asset in supporting STEM and provide both pupils and parents with invaluable careers advice and information in all STEM related areas." Teacher 'A' (Technology) in this school recalled the success of previous events such as these. He stated that "STEM career events have proved to be a great success among parents and pupils alike. The enthusiasm and motivation of STEM Ambassadors turns them into role models for the young people."

As part of the Governments STEM strategy, money was made available to schools to promote STEM to parents. However according to the Coordinator of the FLC the Government lack any real long term strategy for this money was only made available recently. "Obviously it is great that there is now money available to promote STEM to parents but as of yet we are unaware whether there will be any money available next year or what area of STEM that money will be allocated towards." He believes that the Government should have a more stringent strategy in place which would allow schools to plan and incorporate the STEM agenda into their curriculum. Teacher A (Technology) and Teacher B (Science) in both schools believed that greater funding should be allocated to promote STEM.

The science department in School 2 has developed a STEM Development Plan which coincides with their curriculum based teaching and learning. In order to meet the success criteria of the

Development Plan the department must "incorporate STEM Careers into science teaching and learning resources" and "construct a STEM career notice board in each of the science laboratories." (Teacher 'B'- Science) The teachers in the school offer STEM related career guidance to pupils at both Key Stage 3 and Key Stage 4 level. Similar to School 1, School 2 arranges for guest speakers to come into the school to deliver talks on STEM careers. According to Teacher 'A' (Technology) "Guest speakers more than often come from STEM related backgrounds and greatly complement existing STEM strategies within the school."

Active Participation
Teachers from both schools identified that active participation in STEM related activities or events kept the pupils interested and motivated.

In recent years School 1 has got actively involved in the BT Young Scientist Award. Teachers and pupils alike invest a lot of time and energy in preparing for this event and the "hard grafting paid off" (Teacher 'B'- Science) given that they have reached the final stage on two consecutive occasions, and achieved a highly commended award in 2010. According to Teacher 'A' (Technology), the BT Young Scientist Award provides a "stimulating environment for students and teachers to interact across science, technology, engineering and maths in a fun and inspirational way that emphasises the relevance of these topics to everyday life." Teacher 'C' (Maths) also discussed the schools involvement stating "Every year the pupils are eager to build on the success of the previous year. This has now become a significant event in our calendar for our Year 10 pupils."

Active participation was also a key strategy employed by School 2 to promote the teaching and learning of STEM subjects. "We have participated in Sentinus programmes such as the Robotics Roadshow and a number of pupils got the opportunity to visit the W5 Interactive Discovery Centre in Belfast." (Teacher 'A'- Technology) According to the Coordinator of the FLC STEM excursions such as visiting the W5 are promoted through cross community partnerships with other schools. Money is made available for cross community projects to take place. It became apparent however that although this strategy has proven to be an effective method in arousing interest in STEM education among the pupils it has its limitations. Some of the limitations were highlighted by Teacher 'C' (Maths) "Trips to places such as the W5 are a fabulous way to engage pupils in STEM however teachers are finding it increasingly difficult to sacrifice valuable teaching time. There is pressure on the teacher to adhere rigidly to the national curriculum. " According to Teacher 'B' (Science) "There should be a more flexibility within the curriculum. Too much academic content focuses time and energy on examination preparation." The Coordinator of the FLC stated "One of the main challenges facing STEM in post primary schools is that schools are susceptible to sticking to a rigid curriculum where there is more focus put on achieving grades."

Active participation in STEM events is not limited to pupils. All six teachers discussed their own personal development in relation to the STEM agenda. The Department of Education now places a focus on providing professional development to primary and post primary teachers to support STEM teaching. Teachers from both schools attend STEM related courses which are organised by the WELB. Teacher 'C' (Maths) however believes that "More needs to be done to support teachers of STEM. There needs to be a better framework whereby teachers are kept updated on STEM developments in order to promote the best practices in respect of the curriculum, pedagogy and assessment." Teachers from School 2 also "liaise with relevant external agencies to enhance STEM Awareness." (Teacher 'B'-Science) Department staff from science, technology and maths has liaised effectively with Careers Education, Information, Advice and Guidance (CEIAG) staff regarding the delivery of STEM across the departments. Other external agencies include the Department of Environment (DoE), Waterways Ireland, Water Treatment Works and Environmental Health.

Collaboration

Collaboration among departments surfaced quite regularly among the participants. The inclusion of a STEM Development Plan and a STEM Action Plan in School 2 set out solid foundations for collaboration among the three STEM departments. All teachers involved in STEM related subjects were involved in developing the plans and in turn were responsible for ensuring the aims and targets set out in the plan were achieved. Teacher 'B' (Science) is responsible for scheduling STEM meetings within the school, with representatives from all STEM departments attending. "Reviews meetings are scheduled annually. During these meetings we reflect on the strategies which have been effective in delivering and promoting the STEM agenda and discuss areas of improvement. From this we devise a new action plan for the year to follow." (Teacher 'B'-Science)   When asked 'How do you promote other STEM subjects within you own subject area' Teacher 'C' (Technology) responded, "Links are made to other STEM subjects through teaching and learning programmes. This is primarily set out in the Scheme of Work. Many of the skills acquired in maths can have cross curricular links with other subject areas, particularly science and technology". Furthermore, this point was backed up by Teacher 'A' (Technology) who stated "Transferable skills from Mathematics are often utilised in a science and technology context." "Work covered in Technology and Maths is aligned with topics delivered in science to assure continuity. For example, here in the science department we teach pupils about the flow of electricity and this has cross curricular links with technology where pupils get the opportunity to participate in electronic projects as well as theory learning."

The results from School 1 did not display the same level of collaboration among teachers. Teacher 'A' (Technology) stated that "During the year we have meetings with other subject leaders regarding STEM but this is often informal and after school hours." The participants were also asked 'Do you work in close connection with teachers of STEM subjects?' It was established that due to the small nature of the school there was always "close contact between departments" (Teacher 'B'-Science) however when collaborating with other members of staff regarding STEM it revolved largely around the teaching of numeracy skills. "Many common approaches to the teaching and learning of STEM revolve around maths as it is a core subject at Key Stage 3 Level."

Summary of Results

The interviews carried out enabled the development of case studies, illustrating the experiences and opinions of teachers on strategies they currently employ to promote the STEM agenda in their school. All six participants taught a STEM related subject and therefore were key figures in the schools STEM strategy. As this was a research project, these interviews provided an insight into the research questions and aims set out at the beginning of the project.

On analysis of the results there were a number of key themes which surfaced among the candidates. These included the connection schools have with local industries, career guidance available to pupils, pupil participation in STEM related activities and collaboration among teachers of STEM subjects. Although the delivery of strategies varied there was a certain level of consistency in terms of the approaches taken by teachers to provide pupils with STEM based learning.

School 1 recognises the role local industries play in developing pupil interest in STEM. The school creates opportunities for pupils to interact with STEM related businesses and companies in the local area. Such visits give pupils an invaluable opportunity to observe engineering and industry in a real world context. They also allow pupils to define more clearly what engineering and technology really is and how skills developed through STEM based learning can be adapted into the work place. As indicated earlier, pupils have a preconceived idea of what engineering involves and this notion is often dispelled by the industrial experience. School 1 also places a great emphasis on career guidance with particular relevance to STEM careers. As part of this strategy to encourage pupils to

take up STEM related subjects the school has also reached out to parents. During organised events such as Parent/Teachers evenings, guest speakers and STEM Ambassadors are present to interact with and inform both parents and pupils on the added value STEM subjects can give to pupils. The school involvement in the BT Young Scientist Award has proved to be a great success among the staff and pupils and all three teachers concurred that actively participating in events such as this stimulate pupils interest and enthusiasm in STEM. The study of results displays a somewhat lack of collaboration among staff members in relation to the STEM strategies within the school. It was established from the interviews that little communication actually took place between departments in terms of developing cross curricular links with other STEM subjects.

School 2 also stressed the importance of creating links with industries in the local area as they have the potential to show pupils the connection between STEM based subjects and the working environment. It became apparent however that there are a number of issues which hinder them from reaping the benefits of this strategy. These include time constraints, funding and also issues with health and safety. School 2 acknowledges the importance of active participation. They have attended Sentinus events such as the Robotics Road show and more recently the W5 Interactive Discovery Centre. They brought to light the fact that opportunities such as these are not always readily available due to the nature of the curriculum. There is a significant amount of pressure among teachers to achieve grades and therefore it is difficult sacrificing time for STEM related outings. Within the school environment however there is a considerable amount of time and preparation put into a school STEM strategy. Members from all STEM departments come together to discuss the current STEM agenda within the school and construct STEM Development Plans which they strictly adhere to throughout the school terms.

Conclusion

In this section it is important to bring together the various strands of the investigation in order to determine if the aims set out at the beginning of the project were met. In this investigation, the aim was to determine how effective post-primary schools are in implementing STEM Education at Key Stage 3 level in Northern Ireland. It looks at the range of strategies currently employed by two schools to promote STEM education and the procedures and methods they have in place to effectively deliver STEM subjects.

The DE and the DEL within Northern Ireland are trying to challenge the declining interest in and uptake of STEM subjects at both post-primary and higher education level. The natural consequence of this growing disengagement in STEM is that there will not be enough people qualified in STEM subjects to supply our workforce. In 2009 the Government devised a 'Report of the STEM Review' which examined issues related to STEM and likewise recommendations to ensure the future of STEM education. Further to this the Government published 'Success through STEM' in 2010 which highlights the actions taken by the Government to promote STEM. With all this in mind it is important to evaluate how effective schools are in implementing the STEM strategy into post-primary schools in Northern Ireland given that the Government are putting so much emphasis on it.

The findings of this report suggest that there is an awareness of the importance of STEM among post-primary schools in Northern Ireland. Both schools involved in the creation of this report displayed a STEM initiative from all teachers interviewed. This study has shown that STEM staff within post-primary schools has begun to develop their own STEM strategy, unique to their school.

One of the most significant findings to emerge from this study is that school links with industries plays a major role in the each of the schools STEM strategies. This is concurrent with the Governments recommendations on how to successfully deliver STEM. They believe that "Business must take the lead in promoting STEM." (Report of the STEM Review, 2009) It is highlighted in the report that schools need to support this initiative but it is up to businesses to provide this credible

and strategic leadership to achieve goals. Fortunately for the two schools involved businesses and industries in the local area are enthusiastic to get involved.

The study has also brought up controversy in relation to the Government's current STEM strategy. It is clear from Government documents such as the 'Report of the STEM Review' and 'Success through STEM' that the Northern Ireland Government is intent on securing a future for STEM education. However, the results displayed in the data analysis have strongly questioned the validity of their strategy. The results suggest that the Government do not have a long term plan in place; rather they inform schools of funding and strategies for the current year and provide no information of any stages to follow.

There are a number of important limitations which need to be considered. The most important limitation lies in the fact that the current study has only examined a very small sample of schools and the two schools which were sampled were within close proximity to each other. Due to time constraints it was only possibly to investigate a small number of schools however if further research was to be carried out a larger sample of schools could be studied. The possibility of engagement with schools throughout Northern Ireland would add substantial value to this report.

Further research might explore the perceptions of the pupils on the delivery of STEM subjects in their school. This type of information could prove to be invaluable as pupils are at the forefront of STEM education. They will be able to establish what strategies work best for them and likewise recommend strategies which would be best suited to further engaging pupils in STEM subjects.

In conclusion it is clear that post-primary schools, with the support of the Northern Ireland Government and external bodies, play a major role in promoting STEM subjects to young people. However the level of STEM among schools varies greatly and it is important to encourage schools to reach the peak of STEM education.

References
Barlex, D. (2007) STEM: an important acronym. D&T News (36). Warwickshire, UK: The Design and Technology Association.
Bell, J. (2005) *Doing Your Research Project: A guide for first-time researchers in education, health and social science*, 4th edn., Berkshire: Open University Press/McGraw-Hill Education.
Blaxter, L., Dodd, K. and Tight, M. (1996) How to Research. Buckingham, Open University Press
British Educational Research Association (BERA) (2011) *Ethical Guidelines for Educational Research*, London: British Educational Research Association.
Cohen, L. and Manion, L. (2007) Research methods in education: Rutledge
Dearing, B. & Daugherty, M. (2004) Delivering Engineering content in Technology Education. The Technology Teacher, 63(3), 8-11
Department of Education and Department for Employment and Learning (2009) *Report of the STEM Review*, Belfast.
Department of Employment and Learning Northern Ireland (DELNI) (2011) *Success through STEM*, Belfast: DELNI.
Dugger, W. (2010) 'Evolution of STEM in the United States', pp. 4 [Online]. Available at: *http://www.iteea.org/Resources/PressRoom/AustraliaPaper.pdf* (Accessed: 12th January 2014).
Ely, M., Anzul, M., Friedman, T., Garner, D., & Steinmetz, A.M (1991) *Doing qualitative research: circles within circles*, London: Falmer Press.
Gibson, K. (2012) 'Student Teachers of Technology and Design: Can short periods of STEM-related industrial placement change student perceptions of engineering and technology?' *Design and Technology: An International Journal,* 17(1), pp. 18.

Harrison, M. (2011) 'Supporting the T and E in STEM: 2004-2010', *Design and Technology Education: An International Journal,* 16(1), pp. 18

McCormick, R. (1990) Technology and the National Curriculum: the creation of a 'subject' by committee? *Curriculum Journal*, 1(1), 39-51.

Moaveni, S (2011) *Engineering Fundamentals: An Introduction to Engineering*, 4th edn., USA: Global Engineering.

Morrison, Janice, 2006. TIES STEM education monograph series, attributes of STEM education.

Moore, N. (1987) *How to do research*, 2nd edn., London: Library Association Publishing Ltd.

Moyer, R., Everett, S.A (2012) *Everyday Engineering: Putting the E in STEM Teaching and Learning*, Arlington, VA: NSTA.

Northern Ireland. NICC, (1991) Proposals for Technology and Design in the Northern Ireland Curriculum: Report of the Ministerial Technology and Design Working Group, Belfast: Northern Ireland Curriculum Council.

Pitt, J. (2009) 'Blurring the Boundaries – STEM Education and Education for Sustainable Development', *Design and Technology Education: an International Journal,* 14(1), pp. 37 [Online]. Available at:*http://ojs.lboro.ac.uk/ojs/index.php/DATE/article/view/201/176* (Accessed: 4th November 2013).

Pullen, S., Gray, C. (2006) *Ethics, Law and the Veterinary Nurse*, Philadelphia : Elsevier Butterworth Heinemann.

Smith, A. (2008) *Conference Report Summary,* London: Advisory Committee on Mathematics Education.

Walliman, N. (2005) *Your research project*, 2nd edn., London: SAGE Publications.

Wicklein, R. (2006) 5 Good reasons for engineering design as the focus for technology education. The Technology Teacher, 65(7), 25-29.