An Innovative Approach to Enhancing Pupil Engagement with Science and Technology

Kieran McGeown, Damian Knipe
St Mary's University College Belfast (United Kingdom)
k.mcgeown@smucb.ac.uk. d.knipe@smucb.ac.uk

Abstract

A report on the review of STEM (Science, Technology, Engineering, Mathematics) published in Northern Ireland has an objective of ensuring the future of STEM education and suggests, "A key factor in enjoying STEM is to increase the level of investigation and experimentation in the classroom. Perhaps the single most recurring theme around curriculum has been the importance of experimentation and practical work in retaining a young person's interest in STEM" (DEL, DE 2009, p124) [1]. The specific focus of this paper is on the findings of a survey on young people's perceptions of science and technology and how they informed the design of two science and technology project activities to be piloted in three Northern Ireland schools. The survey was conducted with 1,125 pupils from 13 post-primary schools in 5 European countries using a questionnaire which was administered to 11-17 year old pupils.

Relevant findings from the survey included: pupils were more interested when working in teams on science and technology projects involving testing and problem-solving; pupils viewed science and technology as a contributor to the understanding of problem-solving and related careers; pupils claimed science and technology helps them to understand the world, improves the environment, benefits society, and makes life comfortable; pupils viewed scientists as creative and hard-working, with many pupils aspiring towards a career in design; and pupils wanted more school trips to science and technology locations related to practical learning and the opportunity to meet experts in science and technology.

One of the pilot project activities designed as a result of the findings from the survey involved the pupils investigating the principles of generating electricity by means of building a model of a hydroelectric turbine. The other pilot project activity facilitated pupils building a micro-robot for the purposes of programming it to complete a specific task. There was a cyclical learning approach taken to the overall pedagogical strategy applied to both project activities. This involved pupils visiting two different locations where a hydroelectric turbine and industrial robots were being utilised for the purposes of increasing the efficient use of resources and generating economic benefits to the local community. The knowledge gained by the pupils during these visits was then fed back into the learning cycle as applied by the teachers in the schools.

1. Introduction

This paper is based on one aspect of a pilot project funded by the European Commission's Lifelong Learning Programme titled 'Stimulating Science and Technology Competences Through Innovative Means For Teaching and Learning' (STIMULA). It reports on the findings of a survey on young people's perceptions of science and technology and how they informed both the design and operation of two pilot science and technology project activities for three schools within Northern Ireland.

The current challenges of the modern world demand that European citizens have the ability to adapt to a rapidly changing scientific and technological environment in their everyday lives. This requires them to have a range of key competences which, when combined, provide personal fulfilment, employability, and a sense of citizenship. The European Commission, when referring to its framework of key competences for lifelong learning, highlights its third key competence as being, "Mathematical competence and basic competences in science and technology" (European Commission 2007, p4) [2]. Studies, such as the Research On Science Education (ROSE) project, focus on the importance of listening to the views of young people. It emphasises that, "one should put more weight on the voice and the views of the learners when curricula are made and when pedagogy is implemented" (Schreiner and Sjøberg 2004, p5) [3]. Similarly, the ROSE project sees young people's attitudes as being a priority when selecting and presenting the contents of science and technology curricula. It implies that, "students' experiences as well as their interest should be attended to in the construction of curricula, in the production of textbooks and other teaching material as well as in the classroom

activities" (Sjøberg and Schreiner 2010, p29) [4]. These studies lend support to the focus of this paper.
The types of science and technology activities to be used in schools, as recommended in a report for the Nuffield Foundation on science education in Europe, should ensure that, "the emphasis in science education before 14 should be on engaging students with science and scientific phenomena. Evidence suggests that this is best achieved through opportunities for extended investigative work and 'hands-on' experimentation ..." (Osborne and Dillon 2008, p9) [5]. Further research suggests that young people's interest in science, engineering and technology is influenced by experiences and interactions that are practical and personal. This research reports that it matters, "if pupils experience hands on science classes with experiments and if they get to know SET professions in practice" Dahmen and Thaler 2009, p5) [6]. The National Foundation for Educational Research (NFER) concludes from its research on young people's views on science education that, "hands-on practical activities, when seen to be relevant to and integrated into the theoretical element of lessons, were a particularly appealing element. Higher levels of pupil engagement in science also related to perceptions of its applicability and transferability to 'real-world' situations, including further study (at university level) and employment opportunities" (NFER 2011, p5) [7]. This selection of research findings supports the design of the two project activities.
The report by DEL and DE on the review of STEM suggests that the young people of Northern Ireland have become disengaged from STEM subjects which have been manifested in reduced enrolments in STEM courses. This has been referred to as STEM fatigue and the report claims that evidence exists of such disengagement from the very early years of pupils' education and continuing on throughout their years within formal education. It is against this backdrop that the STIMULA project had an aim to provide innovative pedagogical strategies for the teaching of science and technology that would enhance the learning experiences of pupils. An integral part of this strategy was to ensure, wherever possible, the participation of local industries in order that opportunities would exist for teachers to contextualize the classroom based activity within the world of work. The project activities that are referred to within this paper were designed after having taken due consideration of the outcomes of the survey.

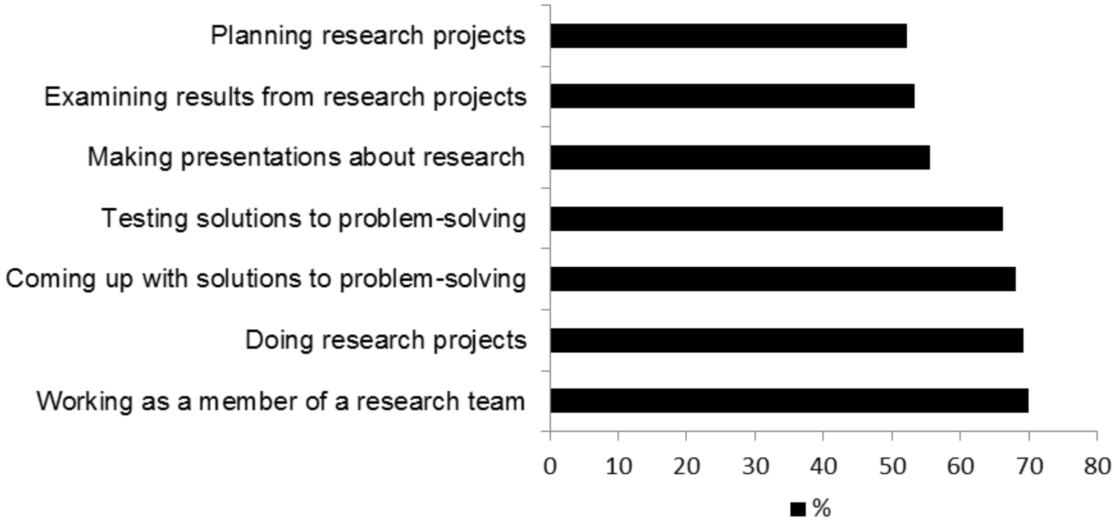
2. Methodology

The methodology involved a questionnaire designed from previous research studies on the perceptions of young people towards science and technology which was available in five languages. Predominantly, it had questions that contained a series of statements which required the respondent to choose from items on a Likert scale. The final draft was piloted with post-primary pupils outside of the chosen sample, after which amendments were made to accommodate a better understanding on the part of the pupils to ensure their time was used efficiently. The questionnaire was then distributed to 1,125 pupils in fifty-one post-primary classrooms from thirteen schools in five countries, using a random stratified sampling technique (Wilkinson and Birmingham 2003) [8]. The sampling ensured schools were in close proximity to the researchers' individual work institutions and that male and female pupils were approximately evenly represented. A letter introducing the survey and explaining the purposes of the questionnaire was sent to the principals of the schools along with a consent letter for parents of the pupils selected (Cohen, Manion and Morrison 2011) [9]. Once consent was obtained from the parents, the researchers visited the schools and further consent letters were issued to the pupils. The questionnaire was then distributed with the same set of procedures and instructions read out by each of the researchers in the five countries.

3. Results

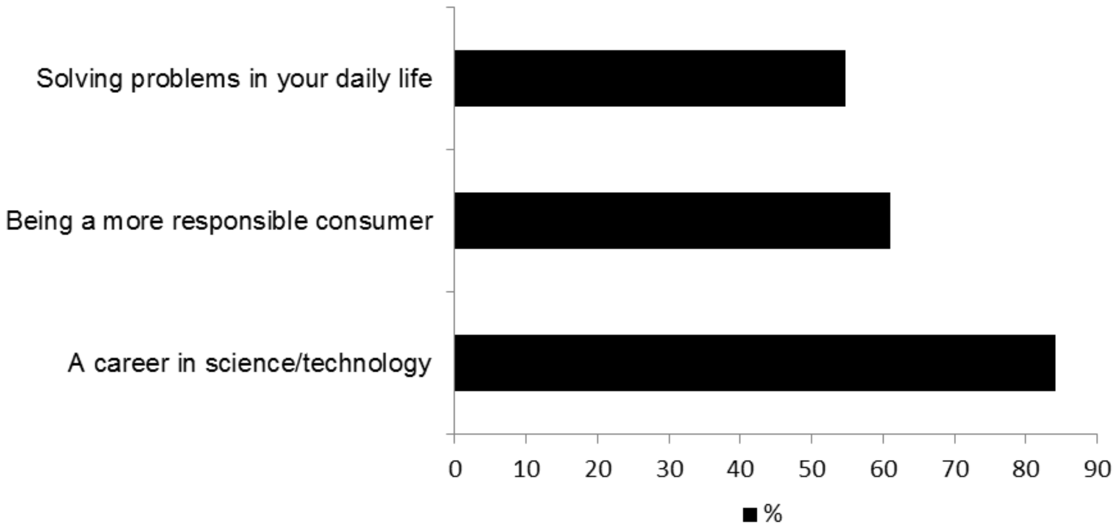
The following results are descriptive in nature and informed the design of the two pilot project activities.
The pupils were asked about their level of interest in a range of science and technology activities. Fig.1 shows those activities deemed the most popular. They included: working as a member of a research team (70%); doing research projects (69%); coming up with solutions to problem-solving (68%); testing solutions to problem-solving (66%); making presentations about research (56%); examining results from research projects (53%); and planning research projects (52%).

Fig. 1. Percentage of pupils who are interested in the following science and technology activities



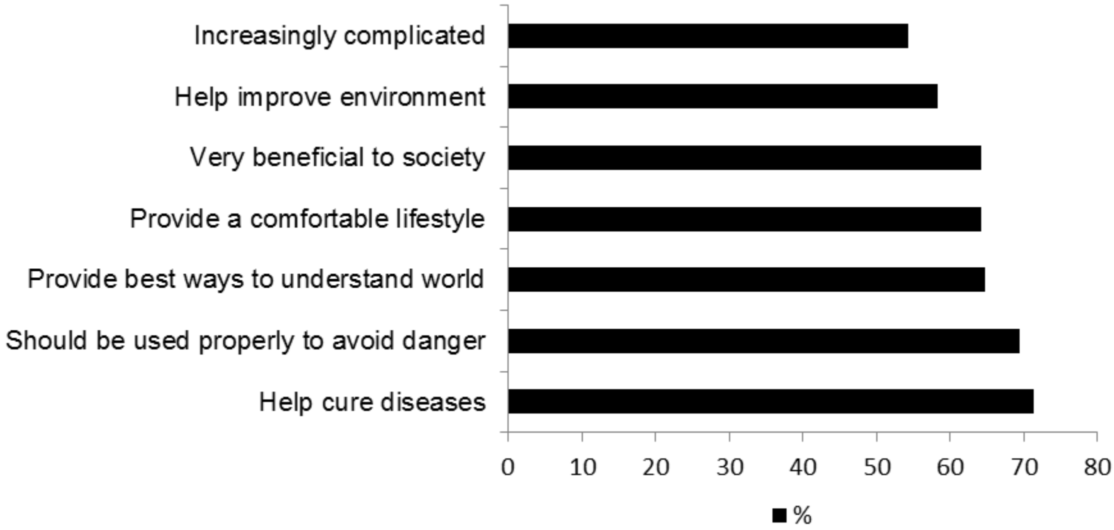
Pupils were also asked about their views on whether or not learning about science and technology improved their understanding of certain issues. Fig.2 indicates the majority of pupils believed that learning about science and technology improved their understanding of: a career in science and technology (84%); being a more responsible consumer (61%); and solving problems in their daily lives (55%).

Fig. 2. Percentage of pupils who feel that learning about science and technology improves their understanding of the following



Pupils' opinions, displayed in Fig.3, on various pros and cons relating to science and technology indicated that they either agreed or strongly agreed that science and technology: help cure diseases (71%); need to be used properly to avoid danger (69%); provide the best ways to understand the world (65%); provide a comfortable lifestyle (64%); are very beneficial to society (64%); help to improve the environment (58%); and are increasingly complicated (54%).

Fig. 3. Percentage of pupils who report the following pros and cons of science and technology



Pupils were asked about which careers would interest them in the future. From a list provided, Fig.4 shows those careers that interested most of the pupils. They included: designer (45%); doctor (40%); sports person (40%); business person (37%); engineer (32%); and inventor (31%). Pupils were asked about their views towards those who have a career in science and technology. The results in Fig.5 indicate that the majority of pupils either agreed or strongly agreed that those working in science and technology were typically hard-working (70%) and creative (60%), and only small numbers of pupils viewed them as being typically boring (9%), strange (11%), old (14%), nerdy (14%), working alone (14%) and men (18%).

Fig. 4. Percentage of pupils who are interested in the following future careers

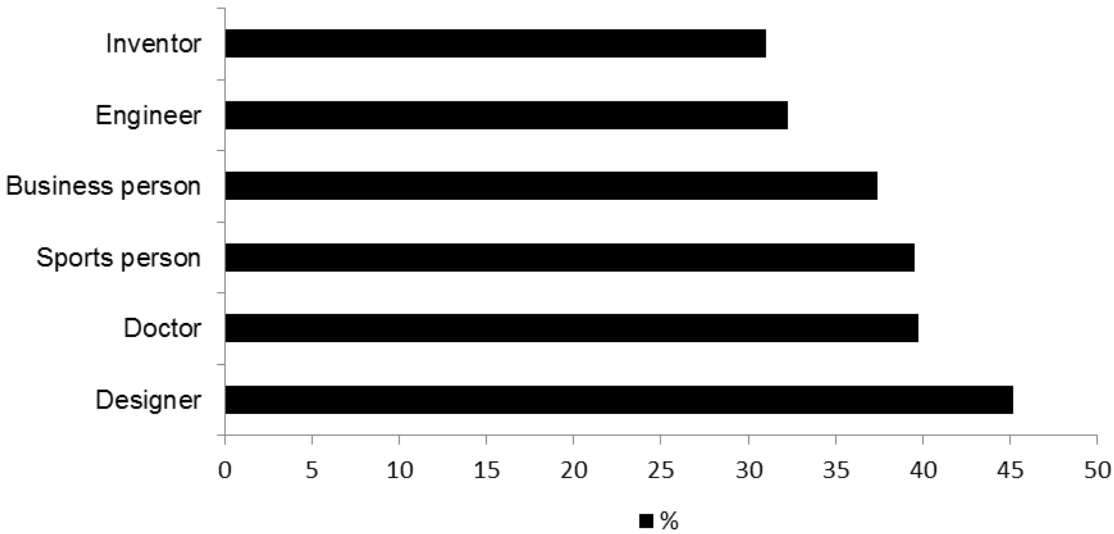
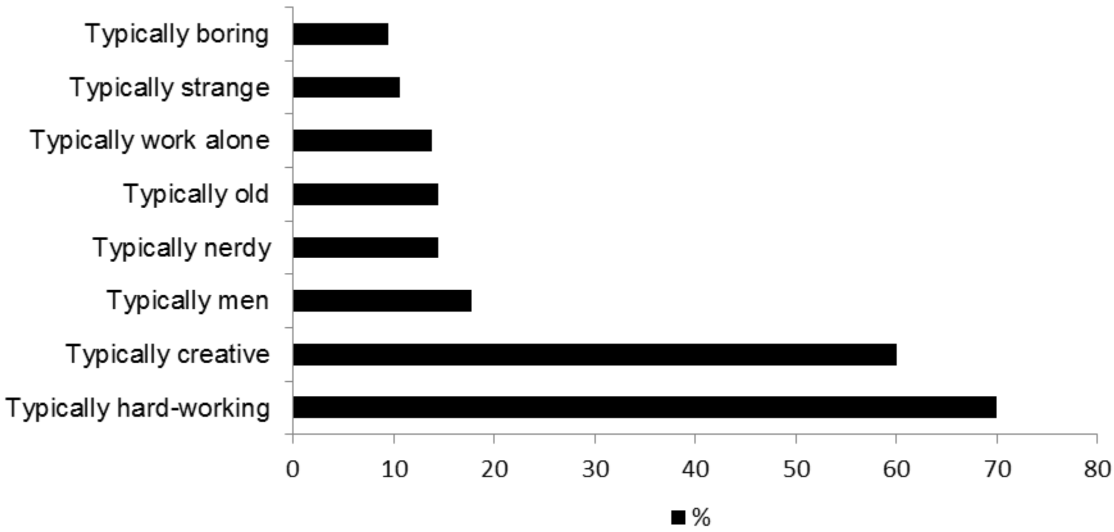


Fig. 5. Percentage of pupils who view the following as representing those with a career in science and technology



An overwhelming majority of 80% of pupils thought their school should provide them with more science and technology trips, with less than half of the pupils reporting being on a visit to various science and technology related locations since starting at their school. There were also 68% of pupils who believed that their school should allow them to do more practical projects related to science and technology. The majority of pupils also indicated that they were interested in carrying out science and technology experiments (75%) and creating science and technology displays (51%).

4. Conclusion

This conclusion outlines how the findings of the survey influenced the design of the two project activities. For the purpose of this paper the researchers are focusing on just two of the project activities piloted in Northern Ireland.

The first activity, labelled ‘Hydroelectric Turbine Project’, was designed for use with Year 10 pupils (13-14 years old) and fulfilled many of the survey findings. The underlying focus of this activity was to enable the pupils to engage with an authentic problem which was to determine how electricity could be generated using water. The pupils worked as part of a team to manufacture a working solution that used both scientific and technological knowledge and skills. The pupils also had to overcome problems to do with refining the design of the hydroelectric turbine in order to maximise the output. The pupils measured the amount of alternating current that was generated by the hydroelectric turbine as a means of testing its efficiency. The pupils were also afforded the opportunity to witness the same knowledge and skills that they had used being put into effect within an industrial setting with the purpose of improving the everyday life of Northern Ireland citizens. The pupils also had discussions with an onsite engineer and technician as well as those involved in the design of the industrial equivalents of this project activity.

The second activity, labelled ‘Microbot Project’, was designed for the purpose of reinforcing learning in the principles of basic robotic control and programming using PICAXE controlled microbots for Year 12 pupils (15-16 years old) and again fulfilled many of the survey findings. A local industrial partner became involved in the project activity in order to contextualise the project work. Pupils were able to appreciate how the use of robots allowed people to be freed up for the purposes of being involved in more productive tasks as well as increasing the efficiency of the industrial operation. The pupils also had discussions with the resident engineer and technician who were able to inform them as to what was required in terms of both maintaining and ensuring the twenty-four hour operation of the robots.

Both of these activities met elements of the Northern Ireland Curriculum at Key Stages 3 and 4 within the learning area of Science and Technology. The hydroelectirc turbine activity developed the following in Key Stage 3 pupils: their knowledge, understanding and skills; their development as individuals; and their understanding of how to be contributors to society, the economy and the environment. The microbot activity enabled the Key Stage 4 pupils to further develop knowledge, understanding and skills as directly related to the specific syllabus they were undertaking in the subject area of Technology and Design.

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