Methods

Four approaches were used in compiling this research summary:

1. Two electronic bibliographic databases (Google Scholar and University of Birmingham elibrary) were searched for references to: 'science/STEM and subject choice'; 'science/STEM and career choice/awareness'; 'science/STEM and careers interventions' and 'science/STEM and aspirations'.
2. A recent research review paper on education about STEM careers (Archer, 2011) which accessed high-quality, international research evidence from the fields of science and mathematics education was used as a source for references not located in other searches.
3. Sources identified in the briefing paper (Palmer, 2012) including key websites and reference sources used not identified by 1 and 2.
4. Less than 50 sources were cited by Archer (2011). Consequently, direct approaches by email were made to ASPIRES team members (x2), the STEM Subject Choice and Careers (x1) and STEM Careers Awareness (x1) projects and Wikid curriculum developer (x1), enquiring about research evidence on the impact of their work on STEM career awareness, attitudes or curriculum choice and the role of practical work in particular.

Introduction

STEM qualifications can lead to a wide variety of well paid careers inside and outside science. Even so, it seems that not all young people, especially those from disadvantaged backgrounds and some minority ethnic backgrounds, are aware of this. The Department for Children, Schools and Families (DCSF), now Department for Education (DfE), developed the STEM Cohesion Programme consisting of eleven Action Programmes. One of these Action Programmes sought to make young people aware of the careers open to them through the study of science and maths. It set out to provide students with the support needed to make informed choices for further study and careers in STEM (DfE, 2012). The NFER (2011) evaluation of the programme showed teachers reported improved student awareness of STEM-related opportunities and activities. However, while students (year 9) showed increasing interest and engagement in STEM, fewer were aspiring to a STEM career. One suggestion from this evaluation was for a more continuous focus on STEM in schools, with a broader range of sources for extension and enrichment activities (p vii).

The Science in the workplace theme for the Practical Work for Learning project could be seen as timely, therefore, in providing innovative resources for practical work with a science in the workplace theme. Few of the materials emerging from the STEM Action Programme offered such opportunities.

The key findings of the research

- Explicit teaching about STEM-related career opportunities should be incorporated into Key Stage 3 lessons (Archer et al, 2011, p1)
- Even those students who enjoy science and do well can decide from an early age that science is 'not for me' (Archer et al, 2011, p1)
- There is a critical period between the ages of 10 and 14 in which we should engage students in forming positive attitudes towards science (ASPIRES, 2012)
- Pupils' experience of science in the classroom has been shown to be the main factor affecting their decisions to take science further or not (Munro and Elsom, 2000)
- (There is a) pressing need to integrate an awareness of STEM careers into the mainstream school curriculum (Archer, 2011)
- Interest and attachment to a science-related career are formed early in life, often by the end of primary education (Schoon et al, 2007)
- School experiences are crucial in attracting young people to a career in science (Schoon et al, 2007)
- There is an urgent need for the science education community to work with families, particularly those from more socially disadvantaged backgrounds, to help increase their access to science-related knowledge, resources and social capital (ASPIRES, 2012)
- Support should be given to schools to help integrate awareness of the variety of careers accessible through science into everyday science teaching (ASPIRES, 2012)
- The involvement of practical work in lessons is the most significant factor in promoting positive attitudes toward science (Parkinson, Hendley, Tanner and Staples, 1998)
- One of the most robust predictors of the high results in Finland were frequent use in science teaching of teacher demonstrations (and) practical work (Lavonen, J. and Laaksonen, S., 2009)
- Pupils enjoy subjects where the teaching and learning is active, participatory and has practical applications (Hutchinson, Stagg and Bentley, 2009)

Research synopsis

There has been a range of recent initiatives aiming to provide students with information and guidance about STEM careers. These include the STEM Subject Choice and Careers Project, Futuremorph and A Career in Science?

Within the STEM Action Programme was the STEM Subject Choice and Careers Project, a collaboration between Sheffield Hallam University, Babcock and the University of Warwick. The project developed a range of resources to enhance STEM Careers Awareness for teachers and students (Barnes et al., 2010). While few of the resources developed involve

practical activities, they are story-led and set in STEM work contexts. Some also challenge students to reflect on what is involved in STEM-linked jobs.

The Science Council (2012) have developed the Futuremorph website with input from teachers. This provides extensive information and resources about STEM careers and is mainly video-driven. Although there are links to the Nuffield practical websites they are incidental, not central, to the STEM career-linked information. For example, the page on electrical and electronic engineering links to a practical physics experiment 'Characteristics of a semiconductor diode'. While this experiment develops skills and knowledge relevant to electrical and electronic engineers, it does not inform students about exactly what this career involves.

Duberley and Cohen (2012) have developed the website 'A Career in Science?' which has career stories and career routes sections along with questions to help clarify career interest. There are no links to practical work and the literacy level needed to engage with the materials is above KS3.

The Science Aspirations and Career Choice: Age 10-14 project (ASPIRES) based at King's College London suggests that the presentation of 'cold' and formal, relatively abstract, information on its own is not sufficient to change patterns of educational choice, especially in working-class learners. This is just the type of resource that is offered by the websites reviewed in the three preceding paragraphs.

There is a science curriculum (Wikid), developed for 11-14 year olds by the team at Sheffield Hallam University (upd8, 2012), which places students in 18 very different STEM career contexts. The materials centre on practical activities and investigations which require students to engage with data and secondary information garnered from a range of different STEM-related workers. All the contexts used in these activities refer to people who use the STEM ideas or the people who discovered them, but the messages about STEM careers and opportunities offered by studying science and maths are not explicit.

The ASPIRES project is working with teachers to develop pedagogical strategies for teaching about careers in science at KS3. To date, any materials linked to this phase of the project are not in the public domain. There is a linked longitudinal research study of the factors affecting aspirations and engagement with science in KS3 students. Findings from this study (Archer, 2011) show that '*there is a disconnect between interest and aspirations…that even those who enjoy science and do well, can decide from an early age that science is 'not for me'* (p1). The study suggests that, as a consequence of this, '*more needs to be done to make science a 'conceivable' career option for a broader range of pupils'* (p1). Archer (*op cit*) suggests that incorporating explicit teaching about STEM-related career opportunities into Key Stage 3 lessons is one approach to addressing this need.

The Key Stage 3 focus appears critical as views are formed early (Archer, 2010). Murphy and Beggs (2005) suggest that most young people's science aspirations and views of science are formed during the primary years and have solidified by the age of 14, leaving the idea that 'science is 'not for me' very difficult to change.

The need for the '*science education community to work with families* (author emphasis) *particularly those from more socially disadvantaged backgrounds, to help increase their access to science-related knowledge, resources and social capital'* is stressed by the ASPIRES

project. The team also emphasise the need to increase public awareness of the variety of careers accessible through science and suggest that support be given to schools to help integrate this sort of awareness into everyday science teaching. Many studies report parents as the most influential factor in careers information and choice (Hutchinson, Stagg and Bentley, 2009; Millward et al, 2006; Pollard et al, 2003; Park, Khan and Patrina, 2009). These studies show, in addition, that the influence of parents is more important than that of teachers and friends.

Hutchinson and Bentley (2011), in summarising the key factors influencing subject choice, included parents, the extended family and interest in and enjoyment of the subject. Family was by far the most likely to be consulted (87%) along with subject teachers (59%) and careers teachers (56%). Such findings highlight the need for STEM teachers to be well informed.

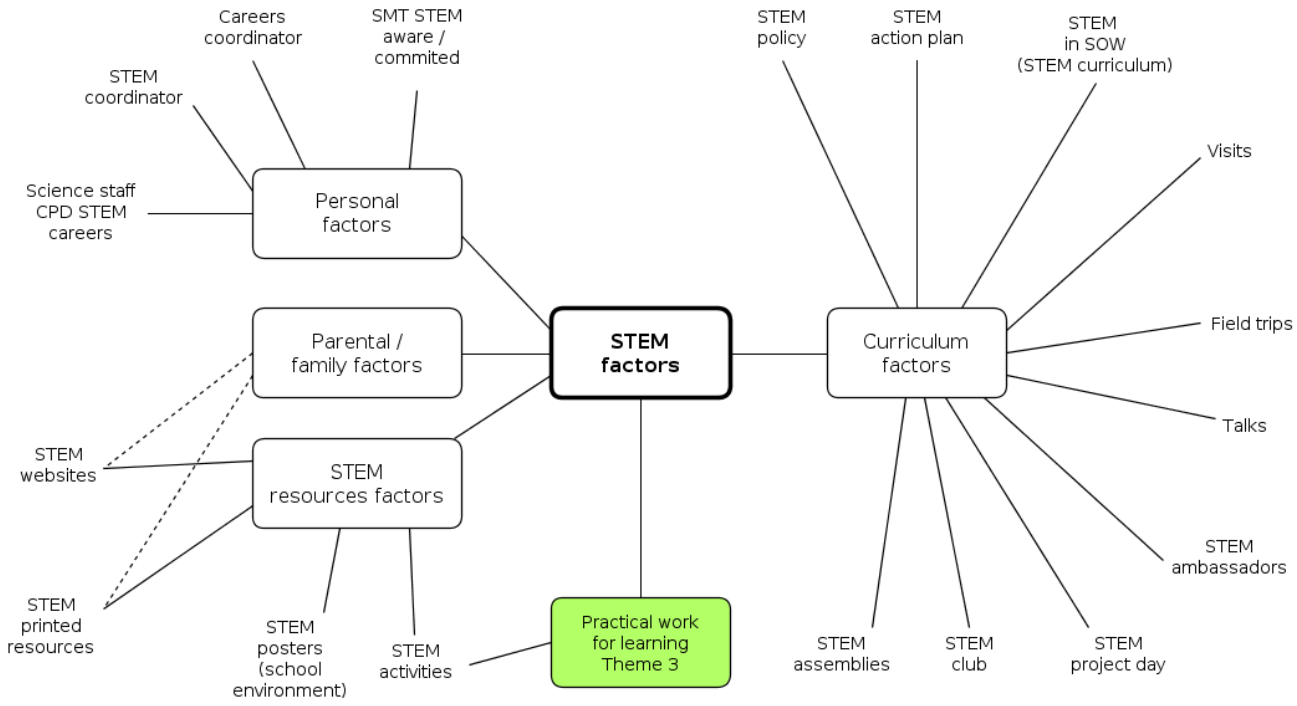
DeWitt *et al*. (2011) report that students' aspirations in science are most strongly predicted by parental attitudes to science and school and that students from an Asian ethnic background appear to exhibit highly positive attitudes towards science when compared with White British students.

There is also a gender imbalance reported in the literature with men more likely than women to persist in science career aspirations (Mau, 2011). Interest and attachment to a science related career are formed early in life, often by the end of primary education. School experiences, in particular, are crucial in attracting young people to a career in science (Schoon et al, 2007). Osborne, Simon and Collins (2003), in an extensive literature review, reported the crucial importance of student gender and the quality of teaching.

Hutchinson, Stagg and Bentley, (2009) report that pupils enjoy subjects where the teaching and learning is active, participatory and has practical applications. Others (Munro and Elsom, 2000) have suggested that pupils' experience of science in the classroom is the main factor affecting their decisions to take science further or not. Clearly intrinsic factors such as enjoyment of science have a strong link to the teacher. There is a need to support STEM teachers in showing how the curriculum links to the world outside and to work carried out by scientists. The STEM Subject Choice and Careers Project, (Barnes et al., 2010) developed a range of resources to support STEM careers awareness for teachers. The resources aimed to enable teachers to embed careers activity in the STEM curriculum at KS3, but practical work was not included. Online tools available on the National STEM Centre website enable schools to evaluate and develop their STEM provision, including curriculum enrichment and enhancement, but they offer general principles rather than concrete examples involving practical work.

ASPIRES (2012) refers to the wealth of evidence suggesting that 'one-off' interventions have little long-term or widespread impact on science choices and participation rates and they emphasise the value of more sustained activity to integrate science careers awareness into the mainstream science curriculum.

The Practical Work for Learning project is well placed to make a sustained contribution, and its potential position amongst the various other factors affecting STEM career choices is indicated by the following diagram:



The implications for teaching approaches (including practical work)

There are two firm steers from the research *viz*:

- **intervention needs to happen early (i.e. KS3 if not earlier)** and
- **it needs to involve parents/guardians**

It could be difficult to achieve the latter through practical work, but there are precedents for homework involving practical activities. Social science practical work might be appropriate, such as involving students in collecting (parents'/guardians') opinions on short (science careers) information flyers? The students might produce the flyers to as part of the activity. Such activities fall within Millar's (2004) definition of practical work.

Suggestions for interventions linked to the key findings, which include practical work

It might be useful for the development team to examine examples from the Wikid materials, developed to make careers more explicit. For example, 'In the limelight' is a resource where students become lighting experts who are designing a set for the 'The International Music Awards'. It is based on the real work of the British design agency Universal Everything for the MTV awards show. This activity looks at practical applications of colour mixing and shows students various career routes in the industry.

The brief (Palmer, 2012) suggested contextualising science practical work within applications of science in industry, medicine or research (Wikid has examples of these). It also suggested activities which use practical work to solve authentic problems from science industries. For example, using a scaled down test tube model of an industrial process (e.g. inverting sugar with yeast trapped in alginate beads) and challenging teams of pupils to increase the efficiency of the process (Dunkerton & Lock, 1989).

The Futuremorph website has six career contexts linked to career examples. There is no practical work but the curriculum contexts they use are KS3 topics. Topics include living things, environmental science, energy and motion, natural and man-made materials and Earth and Space. There could be a case for practical work in these contexts and a link to websites other than Nuffield in the Science and the workplace Theme.

Suggestions for the support needed to help teachers engage with the resources

Many sources stress that for successful intervention it is important that STEM teachers are 'clued up'. Recent initiatives have done much to enhance teacher awareness. This project could occupy a novel niche which provided support for teachers in a form that offered a combination of practical work and explicit STEM careers information yet also engaged students' families.

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Websites

A Career in Science?

ASPIRES project

Futuremorph

National STEM Centre

STEM Subject Choices and Careers Project

Tomorrows Engineers