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Should we embed careers education in STEM lessons?

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ABSTRACT

Schools have a particular responsibility to introduce young people to the range of possible options for them after they leave education as few families can provide this. However, in the United Kingdom, careers education is currently not strong in most schools for a number of reasons but principally due to its low status and shifts in government policy and funding. As a result, too many young people make subject choices for post-16 study that they subsequently regret. In particular, fewer young people in the United Kingdom choose post-16 STEM subjects than might do. Yet, STEM (science, technology, engineering and mathematics) graduates are especially valued by employers. We draw on the findings of two research projects, ASPIRES and UPMAP, and argue that one way forward may be to embed careers education in STEM lessons. This can be done in ways that are respectful of and helpful to students. We recommend that an England- or UK-based project to investigate the consequences of embedding careers education in STEM lessons be undertaken.

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Context

Schools have a number of functions but one of the key ones is surely to help young people learn so as to prepare them for their lives once they leave school. In England, as in most other countries, the majority of young people, often after a period of further/higher education that typically lasts a few years, will enter the world of paid employment, whether part-time or full-time. Here, depending on a range of factors including family responsibilities, they will typically spend several decades in a series of jobs.

One might therefore presume that schools would take careers education very seriously. After all, the jobs that one has after leaving school depend to a considerable extent on how well one has done at school and on the subject choices one has made. It is no good hoping to be a doctor if one ends up getting good grades in humanities subjects or poor grades in the sciences. And yet, England has never enjoyed a strong tradition of school careers education and the careers education that is provided has weakened in recent years for a range of reasons but principally due to its low status and shifts in government policy and funding (House of Commons Education Committee, 2013).

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In this paper, we present an argument intended to help redress this situation. We concentrate on STEM (science, technology, engineering and mathematics) subjects in part, as we discuss below, because of a widespread presumption that England needs more people employed in STEM jobs and in part because we draw on the findings of two STEM education projects, one that we were involved in and another funded in the same initiative.

The position of STEM in England

In common with many other countries (e.g. Executive Office of the President of the United States, 2012), successive governments in England have been committed to increasing the number of STEM professionals as they see this as crucial for England to be able to compete in an increasingly competitive global economy (Department for Business, Innovation and Skills, 2009; Truss, 2014). While the number of students choosing to study mathematics or one or more of the various science after the age at which these subjects are no longer compulsory (16 in England) has been rising in recent years, there is still a problem with the relatively low proportion of English students, compared with other countries, who continue with STEM subjects in post-compulsory education (Hodgen, Marks, & Pepper, 2013; Royal Society, 2011).

In large measure, the reason for the low post-16 participation in STEM subjects, relative to other countries, is simply down to the high degree of specialisation that advanced levels in England require (with students typically taking only three subjects in their examinations at age 18 – cf. Hodgen et al., 2013). In addition, there have been a number of pieces of research that have concluded that the low post-16 participation in STEM subjects is at least in part due to the high levels of disaffection of many students taking mathematics and science courses at age 11–16, a phenomenon that is not restricted to England (Bøe, Henriksen, Lyons, & Schreiner, 2011; Brown, Brown, & Bibby, 2008; Gilbert et al., 2006; Nardi & Steward, 2003). While satisfaction on its own is not enough to result in students choosing STEM subjects post-16, it is hardly surprising that dissatisfaction is associated with students being more likely not to continue with STEM subjects post-16. Furthermore, it is known that at least some students make decisions about their post-16 subject choices earlier in their school careers (e.g. at age 11–14 or even at the end of primary at age 10–11) that has sometimes been thought (e.g. Tai, Liu, Maltese, & Fan, 2006).

'STEM' includes technology and engineering as well as science and mathematics. In the United Kingdom, there is virtually no engineering taught before the age of 16, unless one considers electronics within physics to be an example of engineering. The situation with regards to technology is more complicated. Design and technology exists as a subject taken quite widely at GCSE (the examination typically taken at age 16 after two years of study). In 2015, there were 204,788 student entries for GCSE design and technology and 1021 for other technology subjects, compared to 6909 for engineering, 761,230 for mathematics and 819,965 for one or more of the sciences (Joint Council for Qualifications, 2016).

In this paper, we concentrate on changes that might be made in 11–16 education to increase the uptake of post-16 STEM subjects. However, let us make three preliminary points. First, it is not the case that we feel all students should choose STEM subjects; that would be absurd. Our presumption, rather, is that changes might increase the number of students choosing post-16 STEM subjects and that such students would, on average, be glad subsequently that they had made such choices. Second, we use the phrase 'STEM careers' below without getting into a detailed consideration about precisely what is meant by the term. It is obvious that an engineer is in a STEM career and a concert pianist is not but there are many intermediate categories, so that the term 'STEM-related career' is sometimes used in the literature. Third, while some of the changes we recommend are indeed curriculum changes – in that they refer to changes to what is taught – others are to do with the relationships that teachers have with their students and with their pedagogy.

The ASPIRES and UPMAP projects

Given the widespread concerns in the early 2000s about science and mathematics education in England, the Economic and Social Research Council (ESRC) with other funders ran the TISME (Targeted Research Initiative on Science and Mathematics Education) programme from 2008 to 2014 in which five research projects were funded (http://www.esrc.ac.uk/research/major-investments/TISME.aspx); two are particularly relevant to this paper: APSIRES and UPMAP.

The ASPIRES project explored science aspirations and engagement among 10–14 year olds (Archer et al., 2013). Its theoretical framing is primarily sociological, making extensive use, as discussed below, of Bourdieu's concept of 'capital'. It comprised a quantitative online survey of the cohort and repeat (longitudinal) interviews with a selected sub-sample of students and their parents. Survey and interview data were collected at three time points: phase 1 was conducted at the end of primary school (age 10/11, Year 6), phase 2 in the second year of secondary school (age 12/13, Year 8) and phase 3 when students were in Year 9 (age 13/14).

The three ASPIRES surveys collected a range of demographic and attitudinal data. Topics included: aspirations in science; attitudes towards school science; self-concept in science; images of scientists; participation in science-related activities outside of school; parental expectations; parental school involvement; parental attitudes towards science; and peer attitudes towards school and towards school science. The majority of questions used a Likert-type scale to elicit attitudinal responses.

In phase 1, the survey was completed by 9319 students in England, who were recruited from 279 primary schools. Interviews were conducted with 92 children and 78 of their parents, who were drawn from 11 schools. Students came from a broad range of socioeconomic classes and ethnic backgrounds. By the time of phase, 34,600 students from 147 schools completed the questionnaire, of whom 1043 had also completed the survey in phase 1. Eighty-three students and 65 parents were re-interviewed. Those students attended 41 secondary schools.

The ASPIRES project showed that very few young people (approximately 15%) aspire to become a scientist. This percentage remains stable as students age from 10 to 14 years, is markedly lower than aspirations for many other careers (almost 60% aspire to have a job in business) and is despite the fact that most young people report liking school science, report positive views of scientists and say that their parents think it is important for them to learn science. Families exert a considerable influence on students' aspirations. This influence operates in many ways, but a key factor affecting the likelihood of a student aspiring to a science-related career by the age of 14 is the amount of 'science capital' a family has (Archer et al., 2013). Science capital is a term that derives from Bourdieu's notion of cultural capital. For Bourdieu (1977), cultural capital is gained mostly through social learning and constitutes people's symbolic and informational resources for action. What the ASPIRES project did was to focus on science capital as a resource that enables individuals to feel comfortable about science and to desire to access it. Of course, individuals vary greatly in their science capital. If you are a young person and your parents and other family members have never taken you to a science museum, have no interest in watching science programmes on TV and have never bought you a book about science, let alone a chemistry set or microscope, chances are you score low on any measure of science capital.

The UPMAP (Understanding Participation rates in post-16 Mathematics And Physics) project (Mujtaba & Reiss, 2014; Mujtaba, Reiss, & Hodgson, 2014) was designed to determine the factors that made it more likely that students would continue with mathematics and/or physics after age 16. It had three strands. In strand 1, 'Mapping trajectories of engagement and disenchantment', student questionnaires were designed to include items from established psychological constructs alongside validated subject-specific conceptual tasks so that possible relationships between performance, confidence and intrinsic and extrinsic factors could be explored in each subject (i.e. mathematics and physics) and across the two subjects. Mindful of criticisms (e.g. Blalock et al., 2008) that science attitude surveys typically possess weak psychometric properties, a high proportion of the items for the student questionnaire were taken from well-validated constructs in the psychology literature that it seemed reasonable to hypothesise might be related to participation / intention to participate in mathematics and/or physics post-16 (Reiss et al., 2011). A total of approximately 23,000 students completed these questionnaires in either year 8 or 10 and approximately 7000 of these students completed them two years later. There were also teacher questionnaires to obtain data about the mathematics and science departments in the 141 UK project schools.

Strand 2, 'Investigating subjectivities and school culture', entailed working with 12 of the strand 1 schools in more depth. In each of these schools, interviews were undertaken with six students when they were 15, 16 and 17 years old (when the students might or might not still be in formal education). Semi-structured interviewing was used to explore such issues as: student views of the role of parents and other significant adults, peers, teachers and out-of-school experiences on subject choice; student understandings of the nature of mathematics and physics and, as a comparison, English; student views of their abilities in mathematics, physics and English and their relationships to the subjects.

Strand 3, 'Documenting the reasons for Higher Education choices', involved working with 51 first year undergraduates under the age of 21 across four Higher Education Institutions. Half these students had started undergraduate courses in accountancy, mathematics, engineering or physics, and half had started other degrees yet had qualifications that would have allowed them to start accountancy, mathematics, engineering or physics courses. Narrative interviewing (Hollway & Jefferson, 2000) was used to explore with the interviewees their experiences of and feelings about their education, their family and occasions on which they felt they had made a decision about their future, using a theoretical framing focused on identity formation that has been used elsewhere in mathematics education research (e.g. Black, Mendick, & Solomon, 2009).

The UPMAP project showed that young people are more likely to continue with mathematics and/or physics after the age of 16: (1) if they have been encouraged to do so by a key adult (usually in their family or at their school); (2) if they believe that they will gain from studying the subject in terms of job satisfaction and/or material rewards; (3) if they manifest conceptual understanding in the subject(s) and (4) if they have been well taught (Mujtaba et al., 2012). For example, the strongest factor about which schools can do something (as opposed to student gender) that predicted whether year 10 students would actually study physics at advanced level (year 12) was the extent to which students felt that studying physics would help them materially; this factor was even more important than their attainment in physics, which was the second strongest factor. The third strongest factor was the advice/pressure they reported receiving to study post-16 physics, which differed markedly, on average, between boys and girls, from both their homes and their schools. The findings for mathematics were similar.

It needs to be acknowledged that both the ASPIRES and the UPMAP studies are correlational, rather than based on interventions. The connections and explanatory factors are therefore associational only. Later in this article, we discuss what work has been done, is being done and needs to done to research the effectiveness of intervention studies.

The implications for STEM careers education

Both the ASPIRES and the UPMAP projects suggest that relatively modest changes to school practices might help increase the proportion of young people taking STEM subjects post-16. One implication of the widespread lack of science capital among families is that most young people and parents are not aware that science can lead to diverse post-16 routes. The widespread view – that science qualifications lead primarily to a job as a scientist, science teacher or doctor – is contributing to many young people seeing post-16 science qualifications as 'not relevant for me'. Those young people who are aware of the transferability of science qualifications are more likely to aspire to STEM careers and/or plan to study science post-16. Some evidence for the likely benefits of embedded STEM careers education comes from CareerStart, a randomised control trial study in US middle grades of a school intervention designed to advance the occupational relevance of what students are being taught in the core subjects. On-going evaluation shows a significant treatment effect for performance in mathematics (Woolley, Rose, Orthner, Akos, & Jones-Sanpei, 2013).

Accordingly, we present, explain and defend eight propositions that follow from the ASPIRES and UPMAP projects and focus, though not exclusively, on embedding careers education in STEM lessons.

STEM careers education should be embedded within STEM subjects to a far greater extent than is presently the case. Whatever the arguments about whether careers education should take place within school subjects or not, the reality is that, as discussed above, much non-subject-specific school careers education is weak. Furthermore, careers teachers rarely have a background in STEM and there is a danger that the education they provide about STEM subjects can be out-of-date or stereotyped.

What do we mean by 'embedded STEM careers education'? At its simplest, this entails teachers of STEM lessons using materials and pedagogic practices to communicate to students how STEM subject are used in the world of work. This does not require major changes from what happens today – though the changes would be more substantial for mathematics than for the other STEM subjects. In science lessons, there has been a long tradition of textbooks and other resources showing science in action in the world of work, e.g. Tomkins, Reiss, and Morris (1992) and the many SATIS (Science and Technology in Society) materials produced from 1984 (SATIS revisited, 2015). Indeed, certain courses, notably in England the various Salters-funded courses that use contexts and the several applied science courses for 14–16 year-olds, lay particular stress on the utility of science (cf. Ryder & Banner, 2011). In mathematics lessons, there is a very strong tradition of attempting to demonstrate the utility of what is being taught but, interestingly enough, this is more often everyday utility (e.g. mathematics for everyday finance) rather than the use of mathematics in STEM careers.

Such careers education needs to respect the autonomy of learners rather than being indoctrinatory. Careers education is often characterised as having three aspects: information, advice and guidance. It is the first of these that is appropriate for STEM teachers to embed in their lessons. There is nothing wrong with, for example, a mathematics teacher being enthusiastic about how mathematics is used in weather forecasting; quite the opposite. But it would be inappropriate for a mathematics teacher to try to steer students toward a career in meteorology, actuary, accounting, economics, engineering or whatever. Education is about inspiring students but it is not about narrowing their career options (Watts, Law, Killeen, Kidd, & Hawthorn, 1996); quite the reverse – it entails helping them to understand the implications of their subject choices and ultimately respecting their decisions.

Students do not need to be convinced that STEM careers are important; they need to be confident that they could have such careers. A key finding from the ASPIRES study is that the common rhetoric that students are not that interested in science is not the case. A high proportion of the sample, throughout the 10–14 year age range, stated that they were interested in science and that they believed that scientists were doing important work; they just did not want to be scientists themselves. Digging a bit deeper, there were a number of reasons for this. Over 80% of the students who were surveyed agreed with the statement that 'scientists are brainy'. The problem with this is that students are then likely to think that science is not for them; it is for a small number of very intelligent others. This problem is perhaps likely to be exacerbated both by the fact that in STEM subjects students are more likely than in other subjects to be told that they have got certain things wrong and by the fact that STEM GCSEs are harder than those in almost all other subjects (Coe, Searle, Barmby, Jones, & Higgins, 2006).

The ASPIRES study also found that gender issues are important. Girls were less likely than boys to aspire to science careers, even though a higher percentage of girls than boys rated science as their favourite subject. For the 12–13 year old students, 12% of girls aspired to become scientists whereas one and a half times as many, 18%, of the boys did.

The UPMAP study found complementary gender findings. For instance, boys were more likely to respond positively towards physics-specific constructs in the survey than were girls. Girls (regardless of their intention to participate in physics) were less likely than boys to report being encouraged to study physics post-16 by teachers, by family and by friends. Despite this, there was a subset of girls still intending to study physics post-16. These girls had higher physics extrinsic motivation (a factor we discuss in more detail in the section that follows), more positive perceptions of physics teachers and lessons, greater competitiveness and a tendency to be less extrovert (Mujtaba & Reiss, 2013).

A prime reason why students study STEM subjects after the age of 16 is because they believe such subjects will be useful for them. The ASPIRES study found that most young people and their parents had a narrow view of where science can lead. The widespread view – that science qualifications lead primarily to a job as either a scientist, science teacher or doctor – contributes to many young people seeing post-16 science qualifications as 'not relevant for me'. Importantly, those young people who are aware of the transferability, i.e. of the utility, of science qualifications are more likely to aspire to STEM careers and/or plan to study science post-16.

Again, the ASPIRES findings are complemented by ones from UPMAP. Factor analyses indicated eight physics-specific constructs that correlated with intention to study physics post-16. These are shown in Figure 1, along with the associated effect sizes (Cohen's *d*). As is evident, much the most important factor is 'Physics will help me in the job I want to do in the future'. This is what is meant by 'physics extrinsic motivation'.

Related to this is a finding that social science subjects are thought by most young people to be more achievable, more interesting and more fun (Department for Business, Innovation and Skills, 2014). 'They believe that there is no need to "be a genius", even someone "dumb" or "thick" could study these subjects' (Department for Business, Innovation and Skills, 2014, p. 69).

Another important reason why students study STEM subjects after the age of 16 is because a significant adult – often a parent or teacher – believes that such subjects are worthwhile and they (the students) can succeed at them. In the UPMAP study, our interviews with first year undergraduates who had the qualifications necessary to read physics at university, yet only half of whom were, the other half reading subjects not related to physics or engineering, enabled us to explore why some students but not others were studying physics, engineering or related subjects. What we found, which we had not anticipated, was the central importance of an adult who represented physics to the student (Rodd, Reiss, & Mujtaba, 2013). Such adults were typically science

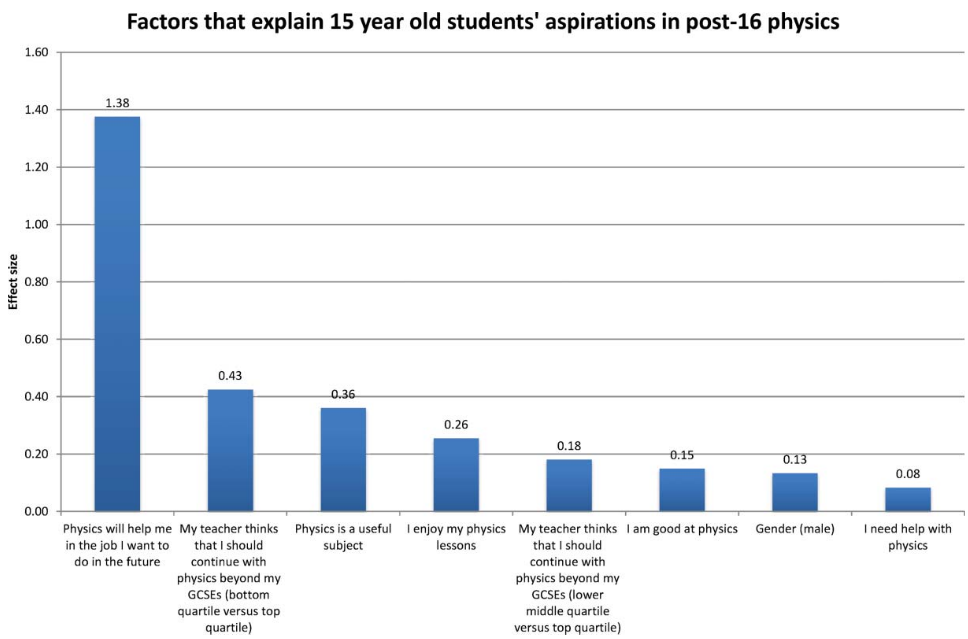

Figure 1. Factors that explain 15 year-old students' aspirations for post-16 physics.

teachers or family members. Here is an example for Benjamin (pseudonym) who was reading physics with theoretical physics:

> I don't know if it's relevant cos it's not to do with education as such but my Grandpa, he helped a lot because when I went to visit him in Spain we went for a walk and he was telling me about the stars and about the earth rotating and it's all these new things, it was like, wow.… I didn't see him often because he's lived in Spain since I was about that age [10 years old]. It was just a couple of one offs put together.… he is a very practical man, very logical and I don't know what he did before he retired, but he obviously has an interest in it [physics]. I don't know if it's as big as mine now, but he definitely enjoyed teaching it to me for no reason whatsoever, he just decided to teach me.

The adult who represented physics did not themselves have to be especially knowledgeable about physics. Rather, they had to communicate (1) that physics was of importance/value; (2) that the student could do well at physics. Interestingly, we found no evidence that competitions, much loved by some organisations in their attempts to persuade school children that physics/engineering is for them, did any good at all. Indeed, in some cases interviewees told us how such competitions had put them off.

Families are the main influence on 10--14 year olds' aspirations. Children from families that are familiar with the world or science are much more likely than their peers to want to study science post-16 and/or work in science careers. The ASPIRES study developed the concept of 'science capital' to help explain how a student's existing resources – notably their family's understanding of, and relationship to, science – can shape the likelihood of them seeing post-compulsory science as a possible and desirable career option. Science capital refers to science-related qualifications, understanding, knowledge (about science and 'how it works'), interest and social contacts (e.g. knowing someone who works in a

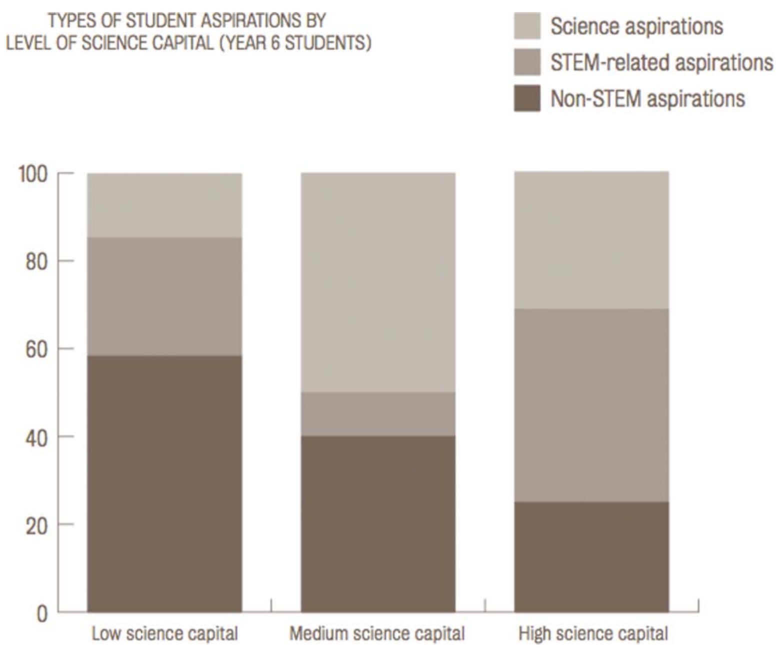

Figure 2. Student science/STEM aspirations as a function of their science capital (Year 6 students; taken from Archer et al., 2013).

science-related job). Students were categorised as having low, medium or high science capital. Figure 2 shows a strong relationship between science capital and the likelihood of a student aspiring to study science.

Many students have little idea of the doors that will be opened to them if they study STEM subjects after the age of 16. Embedded STEM careers education may help remedy this. The ASPIRES study worked with a group of teachers from selected London schools to develop ways to translate key messages from the research into practice. In particular, it worked with teachers to develop ways of embedding STEM careers information within KS3 science lessons – notably the message that science qualifications can lead to a wide range of careers both in and beyond STEM at graduate and technical levels. Teachers were encouraged to devise their own strategies for adapting existing resources to meet the needs of their particular students. Some schools focused on introducing careers-related material into each curriculum topic, whereas others focused on adapting resources to be used in after-school contexts (Archer, DeWitt, & Dillon, 2014).

The intervention succeeded in broadening students' understandings of the range of jobs that science can lead to or be useful for. However, it did not significantly change students' aspirations or views of science. This indicates that students' aspirations may be resistant to change. At the same time, it should be noted that the intervention was relatively modest both in duration and intensity. The Royal Society of Chemistry is currently funding a five-year intervention to see if students from disadvantaged backgrounds can be helped to be more likely to choose to study chemistry post-16 and, ultimately, at university (UCL Institute of Education, 2015). This study only began in autumn 2014 so it will be some time till we know how successful it is.

Careers education needs to help broaden students' awareness of the transferability of science qualifications for a wide range of careers both in and beyond science, at degree and technical levels. Both the ASPIRES and UPMAP studies concluded that too few students appreciated the transferability of science qualifications for a wide range of jobs, whether such jobs were thought of as scientific or not. We therefore find ourselves in strong agreement with such initiatives as the Science Council's futuremorph (Science Council, 2015) and the various programmes of the Institute of Physics (2015) that stress careers *from* rather than *in* science and maths. Of course, there are other reasons why students might wish to continue with STEM subjects once these are no longer compulsory (in particular because they enjoy them and/or are good at them). Nevertheless, one lesson from both the ASPIRES and UPMAP projects is that many students make their subject choices with career choices in mind.

Discussion and conclusions

Educational aspirations can be theorised in a number of ways. Gorard, See, and Davies (2012) discuss how we can identify and assess the evidence for the causal impact of aspirations, attitudes and behaviours of young people and their parents on educational outcomes such as attainment and post-compulsory participation. In this they build on earlier work of Gorard (e.g. Gorard, 2004) which, in turn, builds on such classic understandings of causality as that provided by John Stuart Mill. Gorard puts particular weight on the importance of interventions, writing that 'For X (a possible cause) and Y (a possible effect) to be in a causal relationship, it must have been demonstrated repeatedly that an intervention to change the strength or appearance of X strongly and clearly changes the strength or appearance of Y' (Gorard et al., 2012, p. 22). Gorard et al. (2012) conclude that parental involvement in their children's education is the factor for which most evidence exists that improving this improves educational outcomes such as attainment and post-compulsory participation in education, followed by individual extrinsic motivation and improving poor behaviour.

Loic Menzies (2013) argued that the focus for schools should be keeping pupils' aspirations on track and that a good way to do this is to work with parents/guardians to build their capacity to support their children's learning. Menzies also concluded that effective intervention strategies were likely to include 'High-quality careers advice, work experience and work-related learning' (p. 3).

Since the completion of the ASPIRES project, there have been a number of developments to do with the application of Bourdieu's concept of 'capital' to STEM education. In science education, Gokpinar and Reiss (2016), developing earlier work by Hart (2012), have attempted to synthesise Bourdieu's concepts of habitus, cultural and social capital and field with Sen's capability approach to develop a model of students' science-related capability development which proposes that the role of outside-school factors is twofold, first, in providing an initial set of science-related resources (i.e. habitus, cultural and social capital), and then in conversion of these resources to science-related capabilities. Williams and Choudry (2016) have explored the extent to which 'mathematical capital' (analogous to science capital) is useful in mathematics education research. They conclude that Bourdieu's concepts are of value but need extending to include the contradictory 'use' and 'exchange' values of mathematics. However, these developments do not detract from the messages of ASPIRES that we explore in this paper for careers education.

In the United Kingdom, the withdrawal of the Connexions service – a governmental information, advice, guidance and support service for young people aged 13 to 19 (up to 25 for young people with learning difficulties and/or disabilities) – early on in the 2010–2015 Coalition government has not helped careers education in general or STEM education in particular (see Smith, 2000, 2007). The responsibility for such careers education was passed to schools, but with no concomitant funding.

A very large number of strategies have been attempted to increase post-16 uptake of STEM subjects. To at least a certain extent, the increases in the numbers of students taking mathematics, further mathematics and science advanced levels (Joint Council for Qualifications, 2015) suggest that collectively these have worked (Tomei, Dillon, & Dawson, 2015). However, it is very difficult to apportion success to specific initiatives, given how many there have been: STEM ambassadors (Gartland, 2014); improved continuing professional development for STEM teachers (National Centre for Excellence in the Teaching of Mathematics, 2015; Science Learning Network, 2015); curriculum changes (Homer, Ryder, & Donnelly, 2013), etc.

As has been noted 'decisions to enter "STEM jobs" at the point of, or after, graduation are often part of a longer process of career decision-making by individuals' (Mellors-Bourne, Connor, & Jackson, 2011, p. 2). A considerable amount of work has been undertaken into how individuals make decisions, including ones to do with their careers (e.g. Eccles, 2009; Skatova & Ferguson, 2014). In certain ways, such debates are typical of standard ones to do with structure and agency. Young people do make choices about the school and post-school subjects they take and the jobs they accept, but they make such choices not as free agents but as individuals at least partly constricted by circumstances – some of which are specific to them and others of which are more generic.

With specific reference to STEM subject choices and careers, what is increasingly clear is the importance of the experiences that individuals have, often many years before they make their first explicit choices (ASPIRES and UPMAP references above; Tai et al., 2006). The ASPIRES and UPMAP studies suggest, first, that family background is important – as mediated by 'science capital' – and, second, that students are typically more likely to choose STEM subjects if they believe that they will benefit materially from doing so. These findings are congruent with the results of a randomised controlled trial that showed that when 15–16 year-old students were given information in a one-hour lesson about variation in graduate salaries (depending on subject choice), mathematics take up at A level increased by 10% while biology and art A level take up fell by roughly 25% – in line with the economic consequences of studying these subjects (Davies, Davies, & Qiu, 2014).

In this paper, we claim that one of the conclusions of the ASPIRES and UPMAP projects is that there are good grounds to believe that embedding careers education in STEM lessons should increase the uptake of post-16 STEM subjects. Given the above discussion, and in particular the findings of both the ASPIRES and UPMAP projects that many students make their subject choices with career choices in mind, there seems to be a clear argument for a research project to investigate rigorously the effects of embedding careers education in STEM education. The lessons of Archer et al. (2014) are that such a project needs to be well funded and of several years duration. Useful findings should emerge from the on-going CareerStart and Chemistry for All projects, though the former is US-based and the latter restricted to Chemistry and not specifically focused on embedding careers education in lessons. This suggests that an England- or UK-based project would be of value.

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Tamjid Mujtaba is a research officer at the UCL Institute of Education and works on various projects related to education. Her expertise is in the social sciences, particularly psychology. From 1999 to 2001, she was involved in a study that explored students' attainment and aspirations. From 2001 to 2006, she was involved in two longitudinal studies, evaluating the impact of interventions to raise attainment. From 2006 to 2007, she led on the analytical strategy on a mixed methods project. From 2008 to 2012, she led on the instrument design, analytical strategy and analysis of national student surveys in a study that investigated factors that affect post-16 uptake in mathematics and physics, whilst also working on the qualitative element. Since 2013, she has been working on a number of projects to do with learning and participation in STEM subjects.

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