International Journal of Educational Research 85 (2017) 167–183

Contents lists available at ScienceDirect

International Journal of Educational Research

journal homepage: www.elsevier.com/locate/ijedures

# Science teaching and students' attitudes and aspirations: The importance of conveying the applications and relevance of science

Richard Sheldrake*, Tamjid Mujtaba, Michael J. Reiss

*UCL Institute of Education, University College London, 20 Bedford Way, London WC1H 0AL, United Kingdom*

ARTICLE INFO

*Keywords:*
Aspirations
Attitudes
Intentions
Motivation
PISA
STEM

ABSTRACT

More people studying and working within science are desired in numerous countries, although it remains less clear how educators can help. Analysis considered nationally-representative samples of students in England, aged 15 (Year 11), from 2006 and 2015. On both occasions, accounting for students' background and other views, students' perceived utility of science most strongly and positively associated with their science-related career aspirations, while students' reports of encountering different teaching approaches had smaller or no associations. Conveying the wider applications of science to students was the only teaching approach to consistently and positively associate with students' utility and other attitudes. Developing students' attitudes, and hence their aspirations, through highlighting the applications and relevance of science to everyday life may be beneficial.

## 1. Introduction

Understanding students' aspirations to study and work within science continues to be a central concern for science educators in England and other countries (EACEA, 2011; NSTC, 2013; Royal Society, 2014). More students studying science-related subjects have been desired as a means to foster greater quantitative skills, to meet an expected demand for increased numbers of science-related professionals, and to address under-representation and promote equity (CASE, 2014; OECD, 2015; Royal Society, 2008; WISE, 2014).

In England, in common with many other countries, studying science subjects at upper-secondary school is generally necessary to study science courses at university, and studying science at university is generally necessary for a science career. Accordingly, experiences in school may be especially important in facilitating or precluding future careers in science. Primary and secondary education have indeed been found to be important times for developing students' interest in science (Maltese, Melki, & Wiebke, 2014), and students' interest in science and their perceived utility of science (students valuing science through thinking that science leads to various benefits such as fostering their skills and facilitating careers) have been found to be closely associated with their studying and career aspirations (Regan & DeWitt, 2015). Students' attitudes and aspirations to study science reported during secondary school have indeed predicted whether they subsequently gained science-related degrees at university (Maltese & Tai, 2011; Morgan, Gelbgiser, & Weeden, 2013; Tai, Qi Liu, Maltese, & Fan, 2006). However, it remains somewhat unclear what educators can or should do in order to foster attitudes such as interest in science and to promote aspirations towards science, especially with regard to applying particular teaching approaches such as using practical work or debates within classrooms.

Numerous teaching approaches are possible within science education, and historical attention on selecting approaches to increase attainment, and/or on approaches that are assumed to reflect what scientists do, has increasingly expanded to also consider how teaching may influence students' attitudes (Osborne and Dillon, 2008; Savelsbergh et al., 2016). Students' classroom experiences in

* Corresponding author.
*E-mail address:* rsheldrake@ioe.ac.uk (R. Sheldrake).

http://dx.doi.org/10.1016/j.ijer.2017.08.002
Received 7 February 2017; Received in revised form 24 July 2017; Accepted 3 August 2017
Available online 30 August 2017

secondary school have been found to associate with their interest in science, for example, but any direct associations between specific teaching approaches and students' aspirations remains somewhat unclear (Abrahams, 2009; Hampden-Thompson & Bennett, 2013; Wang, 2012).

Accordingly, the research presented here focused on revealing the associations between students' reports of encountering different teaching approaches and students' reported science-related career aspirations, while accounting for students' different background characteristics. In more detail, the research considered associations between teaching approaches and theorised antecedents of aspirations (including students' interest and perceived utility), and then considered what factors (including teaching approaches, interest, utility, and other factors) actually associated with students' reported aspirations, in order to gain greater practical insight. The analysis considered nationally-representative samples of students (aged 15) from the Programme for International Student Assessment (PISA) from 2006 and from 2015 in order to consider the consistency of any findings to enhance the overall insight. The analysis focused on students in England in order to maximise its local contextual relevance.

### 1.1. Science aspirations and choices

The numbers of students studying science-related subjects at upper-secondary school and at university in England have historically varied, and have often been lower than other subjects and imbalanced with respect to students' gender and home backgrounds (Homer, Ryder, & Banner, 2014; Royal Society, 2006, 2008; Smith, 2011). These differences in studying choices have often been explained by students' different attitudes and beliefs (DeWitt, Archer, & Osborne, 2014; Mujtaba & Reiss, 2014). Essentially, various aspects of students' lives, such as their parents' beliefs (DeWitt et al., 2011) and classroom experiences (Wang, 2012), may influence their attitudes about science, which may then primarily influence their aspirations.

Considered in review across multiple studies, students' interest in science and their perceived utility of science have most strongly associated with their studying and career aspirations, to greater extents than other attitudes, measures of their attainment, and various other indicators related to their homes and backgrounds (Bøe & Henriksen, 2015; Regan and DeWitt, 2015; Tripney et al., 2010). Recent research in England has reaffirmed the relevance of interest and utility to students' prospective aspirations towards studying and working in science, together with further factors including the personal value of science to their identities, their current confidence, their confidence in their future attainment, and influences from their parents (DeWitt & Archer, 2015; Mujtaba & Reiss, 2014; Sheldrake, 2016). Similarly, students in England have retrospectively reported that their studying choices have followed from their interest, perceived utility, and confidence (Bates, Pollard, Usher, & Oakley, 2009; Jensen & Henriksen, 2015; Mellors-Bourne, Connor, & Jackson, 2011; Vidal Rodeiro, 2007). Studies undertaken outside of England, such as in the United States of America (e.g. Maltese and Tai, 2011; Tai et al., 2006) and in continental European countries (e.g. Bøe & Henriksen, 2013; Bøe, 2012), have revealed broadly similar findings, especially regarding the importance of students' interest and perceived utility.

It remains unclear whether any one factor is the most influential, however. Studies highlighting that students cited interest as the primary reason for their choices (Bates et al., 2009; Mellors-Bourne et al., 2011), for example, may contrast with studies that highlighted the primary importance of students' perceived utility of science (Mujtaba & Reiss, 2014; Vidal Rodeiro, 2007). Any number of methodological differences may be relevant, given that studies have variously considered students' prospective studying aspirations (e.g. Mujtaba & Reiss, 2014) or their retrospective recollections about their choices (e.g. Jensen & Henriksen, 2015). While many studies have been large in scale, and broadly generalizable to students across England given particular attainment characteristics (e.g. DeWitt et al., 2014; Mujtaba and Reiss, 2014), they have not necessarily considered precisely nationally-representative samples.

Overall, while students' attitudes towards science have been found to associate with their aspirations, greater clarity would be beneficial, especially as to whether any teaching approaches also associate with students' aspirations and/or with any attitudes that may in turn associate with aspirations. In general, it remains less clear as to what might associate with (and hence potentially influence) students' interest in science and perceived utility of science.

### 1.2. Teaching approaches

Students' studying and career aspirations have been found to be difficult to directly change (Archer, DeWitt, & Dillon, 2014). Pragmatically, in order to increase the numbers of students aspiring towards science careers, educators could instead attempt to foster students' attitudes, such as their perceived utility of science, and/or apply various different teaching and learning approaches or activities in order to inspire or engage students.

Various interventions have explicitly focused on fostering students' attitudes towards science (Rosenzweig & Wigfield, 2016). Numerous approaches have been applied to help increase students' interest in science, such as emphasising the relevance of science and explaining the experiences and work of scientists (Bernacki, Nokes-Malach, Richey, & Belenky, 2016; Hong & Lin-Siegler, 2012; Hulleman & Harackiewicz, 2009). Similarly, promoting the relevance and utility of science to students and their parents has been found to associate with higher science interest and attainment in students, and with students selecting courses in science (Harackiewicz, Rozek, Hulleman, & Hyde, 2012; Rozek, Hyde, Svoboda, Hulleman, & Harackiewicz, 2015). In general terms, educators may be able to explain science careers or the wider applications of science in various ways, perhaps during and/or to supplement other teaching approaches or activities.

Various teaching approaches have been historically applied or recommended within science education. Practical work (often experimental laboratory work) remains valued within science education, for example, due to practical work being assumed to reflect the empirical nature of science, but other justifications and contrasting views are possible (Abrahams & Reiss, 2012; Hodson, 1993;