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WHICH FACTORS ARE IMPORTANT FOR STUDENTS' SCIENCE ASPIRATIONS?

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There is a widespread concern in many countries that relatively few students, especially those from disadvantaged backgrounds, continue to study chemistry and other sciences once it is no longer a requirement for them to do so. More students studying science, including chemistry, is seen as desirable as a means to foster greater quantitative skills, to meet expected demand for more scientists and to address inequalities or differences in the backgrounds of those studying or working in science compared to other areas. This paper uses data from a sample of students attending schools that served disadvantaged neighbourhoods; 4780 students in Year 7 (age 11-12 years) and Year 8 (age 12-13) in England were surveyed in 2015. Predictive modelling highlighted that the students' aspirations to study non-compulsory science in the future, and to study the particular subject of chemistry, were strongly associated with their extrinsic motivation, interest in science and their self-concept beliefs. Some teaching approaches, including making clear the applications of science, engagement in hands-on practical activities and engagement in extra-curricular activities, also had significant, albeit small, effects. The importance of these findings is that it seems that there is much that classroom science teachers can do to boost these factors, whereas factors such as home circumstances and student gender, both of which are widely reported to correlate with science aspirations, are obviously not under the control of classroom teachers.

Keywords: Aspirations, Motivation, Teaching approaches

BACKGROUND AND RATIONALE FOR THE STUDY

Students' intentions to study science once the subject is no longer compulsory continue to be a central concern for science educators in England and many other countries, given varying numbers of students which generally include few from disadvantaged backgrounds (DeWitt, Archer, & Osborne, 2014). Across numerous research studies, students' attitudes towards science, such as their interest in science and perceived utility of science, and their motivational beliefs, such as their confidence in their own abilities, together with their own attainment, have closely associated with their intentions and choices (Bøe & Henriksen, 2015). Teaching approaches and classroom experiences in secondary school have also been found to influence students' interest in science and their other attitudes, but any direct associations with students' choices remain somewhat unclear (Hampden-Thompson & Bennett, 2013).

This research forms part of a project that is exploring and evaluating various interventions aiming to raise aspirations towards science and chemistry, occurring over five years of secondary schooling in England. The presented results report on the first year of the project, before the interventions were implemented, in order to provide a baseline view. Given that there is little existing research explicitly focused on how to raise aspirations in students from disadvantaged backgrounds (compared to research covering more general samples), the research aimed to explore what factors were significantly associated with these students' aspirations. This could then suggest where interventions might plausibly be focused and what educators might plausibly do in order to raise students' aspirations.

METHODS

The sample covered 25 schools in England, located across the East Midlands (9 schools), North West (7 schools), South East (5 schools), and West Midlands (4 schools) of England. On average, 42% of their students were classified as disadvantaged (via eligibility for free school meals, essentially reflecting low family income), compared to a national figure of 28%. Within the schools, 4780 students (2412 in Year 7, 2368 in Year 8) were surveyed.

A questionnaire was used to measure various aspects of students' backgrounds, their attitudes and beliefs concerning science and their learning at school, and various other aspects, all with empirical and/or theoretical relevance to their educational progression and choices (e.g. Bøe & Henriksen, 2015; OECD, 2016). For example, the measurement integrated theorised constructs from the expectancy-value model of motivational choices, such as perceived utility and interest in science, and theorised dimensions of science capital, such as engagement with extra-curricular science. The questionnaire focused on science, with specific items focused on chemistry, given that teaching in Year 7/8 in England mainly focuses on 'science' presented or taught as a whole (rather than biology, chemistry, and physics being taught separately).

Specifically, the survey asked about: students' home and background engagement in extra-curricular science activities, and the amount of encouragement to do so; their experiences of their science lessons, specifically focusing on teachers highlighting the applications or wider relevance of science and on undertaking practical experiments (including student-led activities and so encompassing 'inquiry-based' teaching/learning of science); their perceived value of science to society; their perceived utility / extrinsic motivation in science and their intrinsic interest in science; and their self-concept beliefs of their own abilities in science. Confirmatory factor analysis affirmed the underlying dimensions of each construct; the internal consistency of the constructs was also established via reliability analyses and considering the correlations between different items within the same construct.

Students were also asked about their future aspirations in science and chemistry (e.g. 'I intend to continue to study science/chemistry at an A-level/University or equivalent'; A-levels are examinations taken by students at age 18). The associations between students' reported aspirations and other constructs were considered through correlations and predictive modelling. Predictive modelling essentially reveals the independent association between a predictor and an outcome, while accounting for any other predictors within the model. Given that students within schools share the same environment, teachers, geographical location and potentially other aspects of life or education, multi-level predictive modelling was used to help account for any residual similarities between students within schools.

RESULTS

Correlations between constructs highlighted that the strongest association between science aspirations occurred with extrinsic material gain motivation ($R = .671$, $p < .001$) followed by intrinsic motivation ($R = .537$, $p < .001$) and then students' perceived value of science to society ($R = .467$, $p < .001$). Self-concept also had a positive association with science aspirations ($R = .362$, $p < .001$). Extrinsic material gain motivation measures someone's belief that studying science is valued or essentially undertaken because it will lead to benefits such as a better job; intrinsic motivation measures someone's inherent enjoyment or interest in science; and someone's science self-concept measures their beliefs in their current science abilities.

Multi-level modelling was used to determine which constructs independently explained variation in students' overall science/chemistry aspirations; the 'effect sizes' (ESs) of the predictors are reported as standardised predictive coefficients. Students' aspirations were most strongly predicted by their extrinsic material gain motivation (ES = .461, $p < .001$), their intrinsic motivation (ES = .173, $p < .001$), their self-concept beliefs (ES = .106, $p < .001$), and then various other predictors with significant but smaller effects.

Predictive modelling was then used to clarify how particular classroom variables (potentially under the control of educators) were associated with more specific aspiration outcomes, after controlling for the students' background and extrinsic motivation. For example, accounting for the other predictors, students' participation in science extra-curricular activities was significantly associated with: intending to undertake a science degree at university (ES = .125, $p < .001$); intending to undertake a degree in chemistry (ES = .092, p < .001); intending to choose science at A-Level (ES = .075, p < .001) and intending to choose chemistry at A-Level (ES = .065, p < .001). Students' exposure to science teaching that highlighted the wider applications of science was positively associated with: intending to undertake a degree in chemistry at university (ES = .072, p < .001), intending to undertake a science degree at university (ES = .047, p < .001); and intending to choose science at A-Level (ES = .056, p < .001). Students' exposure to hands-on practical activities was positively associated with: intending to undertake a science degree at university (ES = .040, p < .001); and intending to choose science at A-Level (ES = .038, p < .001).

DISCUSSION

The importance of these findings is that they highlight that there appears to be much that classroom teachers can do to potentially boost students' aspirations.

In common with findings from studies that considered more affluent mathematics and science students (Mujtaba & Reiss, 2014; Sheldrake, 2016), extrinsic material gain motivation was highlighted as being the most important single factor that associated with students' intentions to continue with their science/chemistry studies. Extrinsic material gain motivation reflects students' beliefs about the indirect value of science, such as facilitating various careers (not necessarily within science) and providing students with general skills; educators can conceivably help to explain these benefits of science during the course of their teaching.

Furthermore, providing students with the opportunity to take part in hands-on practical lessons, engagement with science extra-curricular activities and showing how science relates to everyday life were all positively associated with students' aspirations to continue with non-compulsory science and chemistry, over and above students' background and extrinsic motivation. Again, this is encouraging as such factors are largely under the control of classroom teachers whereas factors such as home circumstances and student gender are obviously not.

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