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ABSTRACT

This paper presents the findings of a two-phase mixed methods research study that explores the link between experiences of school science of post-16 students and their decisions to take up science for their higher studies. In the first phase, students aged 16–17 ($n = 569$) reflected on the past five years of their school science experience in a quasi-longitudinal approach to determine a typology of experiences. The second phase entailed data collection through interviews of a sample of these students ($n = 55$) to help triangulate and extend findings from the first phase. Students taking up science post-16 reported significantly more positive experiences of school science than students who had decided not to take science further. Of school-related factors influencing experiences of school science curriculum content was the most important followed by being interested and motivated in the subject. There is evidence that interest and motivation in science depend on teacher practice and the perception of science as a difficult subject.

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School experience; science take-up; storyline graph; mixed methods; school-related factors

Introduction

In the U.K., an earlier situation of stagnation in numbers of pupils taking up science past compulsory age (Smith, 2010) has led to a concern that there may not be enough potential scientists particularly engineers in the subsequent decade. The proportion of students taking up science is low particularly in the case of physics in comparison to take-up of other science and non-science subjects (Table 1).

Longitudinal evidence demonstrates that the majority of secondary students are indifferent to science, and even among those who find school science interesting, positive attitudes are not translating into career aspirations in science (ASPIRES, 2003; Sjøberg & Schreiner March, 2010). Many young people still elect to opt out of science once it is no longer compulsory (OECD, 2009). There is much documented evidence for the possible reasons for this loss of interest in science such as the association between the cost of studying and the drop-out rate (Van Langen & Dekker, 2005); the relationship between school selectivity and science uptake (Smithers & Robinson, 2007); the availability of separate sciences at GCSE level (Gill, Vidal Rodeiro, & Bell, 2009); well-qualified and enthusiastic teachers (Smithers & Robinson, 2007); and opportunities to experience science-related careers (Bennett,

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Table 1. Percentage of A-level examination entries in biology, chemistry, physics and mathematics 2009–2015.

Year	Biology	Chemistry	Physics	Mathematics
2009–2010	18.9	14.5	10.1	24.7
2010–2011	19.6	15.4	10.6	26.4
2011–2012	19.9	15.8	11.1	27.3
2012–2013	20.3	16.8	11.5	28.1
2013–2014	20.3	17.1	11.9	28.4
2014–2015	19.4	16.4	11.4	28.6

Source: Department for Education (2015).

Lubben, & Hampden-Thompson, 2013). In addition to this, a large number of studies have identified individual factors influencing decisions to take up science such as gender (Murphy & Whitelegg, 2006), perceived usefulness of the subject (Jenkins & Nelson, 2005), enjoyment (Lyons, 2006) and perceptions of their ability (Vidal Rodeiro, 2007). Rutter, Maughan, Mortimore, and Ouston (1979) in their seminal work on the role of school on children's development highlight that children spend as much as 15,000 hours at school during which schools and teachers have an impact on their development. A few studies have focused on various aspects on student experiences of school science such as curriculum (Osborne, Simon, & Collins, 2003), teacher influence (Urdan & Schoenfelder, 2006; Woolnough, 1994) and school composition factors (Bennett et al., 2013). Literature from other countries highlights that perceptions of school science influence the decision to take science later (Lindahl, 2007; Lyons, 2006; Maltese & Tai, 2010). Despite the different emphases found in the conclusions of these studies reflecting different methodological approaches, population samples and educational settings, the studies reveal a distinct pattern showing that experience of school science has a large influence on students' choice to take science in the future. This study aimed to explore influences on experiences of school science in an English context and differs from other studies in terms of the methodological approach used to gain insight into emerging school factors that may shape the choice of students electing to take science or not in the future.

Theoretical background

The nature of student perceptions of school science is contingent on a number of extrinsic aspects external to the student such as school influences, and intrinsic influences such as gender, self-efficacy and interest, as well as social and cultural influences. All these important influences not only affect school experiences but also the choice to continue with science once it is no longer compulsory. It is acknowledged that the scope for a review of all external and internal influences is not possible in a brief article of this nature, and the following is a theoretical framework without which the study could not be understood. It is part of a larger framework that informed the study including student identity, attainment, age, gender and motivation as well as wider social and cultural influences such as ethnicity, family and peers.

School influences

In their book *Fifteen Thousand Hours* (Rutter et al., 1979), the authors argue that schools have a particular set of values, attitudes and behaviours which become characteristic of the school and influence students' attitude to learning. This point is supported by Bennett et al.'s (2013) claim that composition of student intake, the ethos of the school, school management, the science curriculum on offer and the career advice offered to students are all ways that different schools influence post-16 choices and decisions. In an examination of school management by Smyth and Hannan (2006), they assert that students' choices are already determined to a large extent by streaming policies that restrict choice for less able students. Together these studies provide a framework of school influences to conceptualise the school factors affecting choice of science and to a lesser extent, experience of school science. In addition to these school influences, science curriculum and teacher influence are also extrinsic factors that may affect experience of school science.

Science curriculum

A considerable amount of literature spanning many decades highlights the impact of taught curriculum on students' decision to take science (e.g. Krapp & Prenzel, 2011; Pritchard, 1935; Woolnough, 1994). From 2000 onwards, much has been written particularly about the relevance of the science curriculum to students' lives (e.g. Lord & Jones, 2006) and that students regard the science taught in schools to be overloaded with content and not generally relevant to working life; giving the sense that 'students were being frog-marched across the scientific landscape, from one feature to another, with no time to stand and stare, or absorb what it was that they had just learnt' (Osborne & Collins, 2001, p. 450). Increased emphasis on socio-scientific issues in the science curricular reforms of 2006 was heralded to have a positive impact on post-compulsory participation in science. Millar (2010), however, findings (e.g. Homer & Ryder, 2015) suggest there has been no major impact on the uptake of post-compulsory science courses. Another aspect that may influence uptake of science is the perception that science is a difficult subject. Duckworth and Entwistle (1974) note that physics and chemistry are rated as the most difficult subjects by secondary school students and, more recently, Tripney et al. (2010) find that difficulty of science is the main reason that students elect not to take STEM subjects after GCSE. The perception of science being difficult is entwined with the notion of student self-efficacy and, as Quinn and Lyons (2011) find, there is an increased likelihood that students will make science-related choices if they have high expectations of success in science.

Teacher influence

The availability of enthusiastic and well-qualified teachers has been identified as one of the most effective factors that influence young peoples' perceptions of science (e.g. Bevins, Brodie, & Thompson, 2008; Hattie, 2003; Rowe, 2003; Wai Yung, Zhu, Wong, Cheng, & Lo, 2011). In recent years, there has been an increasing amount of research on the ways that teachers influence attainment and interest in the classroom. Osborne and Collins (2001) claim students' interest is engaged and sustained by teachers who make lessons fun either through their methods of presentation of the material or the organisation of the work. This is substantiated by Rowe (2003) who argues that quality of teaching and learning provision are the most important influences on students experiences and outcomes of schooling; a view upheld by Urdan and Schoenfelder (2006) who argue that the way teachers regulate the academic environment including material covered, approaches to learning and communication with students play an important role on student attitude to school. Similarly, in their study on sources of early interest in science, Maltese and Tai (2010) find that the way teachers interact with their students rather than subject content knowledge is an important factor in getting students interested in science.

Individual influences

Individual influences are defined as the characteristics and dispositions that students bring to learning such as interest, effort, values and perceived ability (Ainley, 2004). There is acknowledgment that these dispositions do not act in isolation but are influenced by other constructs such as attitude, gender, self-efficacy, aspirations and identity as well as larger social and cultural influences such as peers and family. The complex interweave of these influences is difficult to unravel when looking at their impact on perceptions and experience of school science.

Gender

In their review of attitudes to science over the past two decades, Barmby, Kind, and Jones (2008) find that males are generally more positive about science than females and with a less negative trend in their development of attitudes. Examining self-efficacy beliefs in both males and females, Bandura, Barbaranelli, Caprara, and Pastorelli (2001) find that female students judge themselves less efficacious for male-dominated occupations even though they are similar in verbal and quantitative ability on standardised tests. Taskinen, Asseburg, and Walter (2008) find that females avoid vocational choices such as being engineers or technicians even if they have the same ability in science as their male counterparts. This combination of attitude towards science and perception of their own abilities and qualifications are relevant factors when females choose whether to take science or not; if they have a negative attitude to science as well as a flawed perception of their ability, they may decide that science is not for them. The implication for this study is that females may have report a more negative experience of school science which may lead to less likelihood of post-compulsory participation.

Self-efficacy

Bandura (1986) defines self-efficacy as 'the confidence in an ability to succeed'. Schunk (2000) and other researchers (e.g. Bandura 1986; Wigfield & Eccles, 2000; Schunk & Pajares, 2002) have noted that self-efficacy influences choice of activity, persistence and effort and therefore will have some effect on attitudes to and decisions to take up particular subjects. A review of the literature on interest generation by Renninger and Hidi (2011) finds that individuals who think they cannot pursue an occupation will not have an interest in pursuing it. In addition, Quinn and Lyons (2011) find that students are more likely to make science-related choices if they have high expectations of success in science. Elsewhere, Bøe, Henriksen, Lyons, and Schreiner (2011) propose that expectation of success is influenced by perception of difficulty of the subject as well as the students' self-image in relation to this subject; this is supported by Bennett et al. (2013) who find that students who perceive physics as being hard are less likely to take it up. Lindahl (2007) also concludes that attitude to science and self-efficacy both determine science choice.

Interest and motivation

Krapp and Prenzel (2011) argue that interest level and the course of interest development in science subjects depends strongly on the perceived attractiveness of the curriculum's lesson content and on the manner in which scientific knowledge is presented and taught. The implication of this possibility is that interest development in science may be related to experience of school science. Some support for this argument comes from a study (Maltese & Tai, 2010) where 116 science graduates and scientists were asked about the early influences on their choice to take science. Although the majority of respondents (45%) indicate a personal interest in science, a sizeable 40% indicates that initial experience with school or an education-based activity such as science competitions were influential in their choice of science. Renninger (2009) claims that interest develops in relation to available experiences and to how learners perceive, understand and represent these experiences. This point has helps define school science experiences in the context of this study – it is the thoughts, beliefs and feelings about the learning of school science.

Research aims

A number of studies use large sets of national and international data such as the National Pupil Database and Programme for International Student Assessment to explore student attitudes to science but fewer studies have used students' reflections of their school science experiences in order to establish how school experiences shape future choice of science. This study was set up address this gap by looking at student perceptions of school science experience and subsequent participation in science.

The study was driven by three research questions looking at (a) student experiences of school science, (b) the reasons students decided to study science post-16 when it is no longer compulsory, and (c) the role that school science may play in student decisions to study science or not further. This paper is a report of findings for the first research question, *what do students' say about their experiences of school science?* The two sub-questions linked to this research question were:

(1) Are the experiences of students who choose to take science different to the experiences of students who have chosen not to take science any further?
(2) Which factors or incidents are important in the students' experience of school science?

Methods

Research design

To identify school science experiences that play a role in students' choice to take up science, students from Year 12 (ages 16–17) in the Sixth Forms of five secondary schools in England were asked to complete a short survey questionnaire. The students were identified as two types; those taking science subjects post-16 – the scientists – and those not taking science subjects post-16 – the non-scientists. In the questionnaire, they are asked to highlight their experience of school science over their time at secondary school. From this sample population, 10% were selected for in-depth interviews to help identify events that shaped positive and less positive perceptions of school science.

Participants

The data collection took place in England in 2011–2012. The subjects for this study were 594 secondary mainstream (non-fee paying) school students aged 16–17 years who had chosen A-level subjects as part of the first year of their A-level studies (Year 12). The 273 females and 321 males were from 5 co-educational secondary schools in England. Each school followed similar A-level curriculum structure where Year 12 students elect to take four A-level subjects in their first year. Of these four, one subject, most often the weakest one, is dropped when the students enter the second year of A-level study (Year 13). Each school in the study had been carefully selected to ensure similar science facilities and equipment provision. As the influence of specialist science teachers on science take-up as well as the relationship between number of students taking free school meals (FSM) and school achievement is well documented (e.g. Gorard & See, 2009; Mensah & Kiernan, 2010; Royal Society, 2008), it was ensured that the schools selected for survey and interviews had specialist science teachers teaching science in upper and lower school and that the number of FSM students is comparable in each school. The average number of FSM students is 5% in the five schools – well below the 1% national average for that particular year (Department for Education 2012).

Data collection

The data for the study were collected in two phases; the first phase involved a short survey questionnaire incorporating the storyline method and the second phase involved in-depth interviews.

Survey questionnaires

The storyline method was devised by Gergen and Gergen (1986) to evaluate college students' feelings of well-being and later used in narrative research studies of trainee teachers (Beijaard, van Driel, & Verloop, 1999; Nilsson & van Driel 2010). In this study, the storyline method was adapted from an interview tool used in the above studies to a survey tool for eliciting students' perceptions about experiences and events during secondary school science. With this tool, students would be able to describe their past experiences of school science by using a scale measuring positive, neutral and negative perceptions for each of the school years starting from Year 6 (ages 10–11) in primary school until Year 11 (ages 15–16) in secondary school (see Shirazi 2016 for details). The points indicated for each individual school year were assumed to be events or critical incidents in the students' experiences of school science. Students completing the storyline graph were able to comment on the high and low points of their experiences and describe the underpinning critical events. In addition, they were asked to indicate the factors that they felt were relevant in their choice to take science or not. The data from the surveys provided insight of the aspects that students felt were important in their experiences of school science and formed the factors that influenced their choice to take science or not once it was no longer compulsory. Survey questionnaires were distributed to each of the participating schools at the start of the second school term in January and the majority received by March of the same year.

Interviews

The second phase of the research study involved semi-structured interviews of a sample of students who completed the survey questionnaire to enable rich narrative descriptions of student experiences to provide insight into their experiences of science and the factors that influenced them to choose science or not post-16. From the completed storyline graphs in the survey forms, initially, students were grouped according to sex and then in two broad categories – *scientists* – students taking one or more science subject and *non-scientists* – students who had opted not to take any science subjects at post-compulsory level. These students were then grouped according to one of four trajectory types (see Figure 1 and Table 2), the aim being to select scientists and non-scientists from each trajectory type for interview. Although there is risk of selection bias in this method of purposive sampling, it is an unavoidable step in order to interview a comparable sample of male and female scientists and non-scientists with each trajectory type.

The individual interviews ($n = 55$) were carried out in schools during a normal school day thereby ensuring a natural environment for students. Although originally starting as a purposive sample, at some schools, arrangements to interview the chosen student failed to take place due to student absence or unavailability. In this case, the school would offer a replacement student who had completed the survey questionnaire to interview. This had an effect on my planned data collection as I was left with an uneven balance of students comprising of fewer female scientists. The interview schedule consisted of a 25-minute

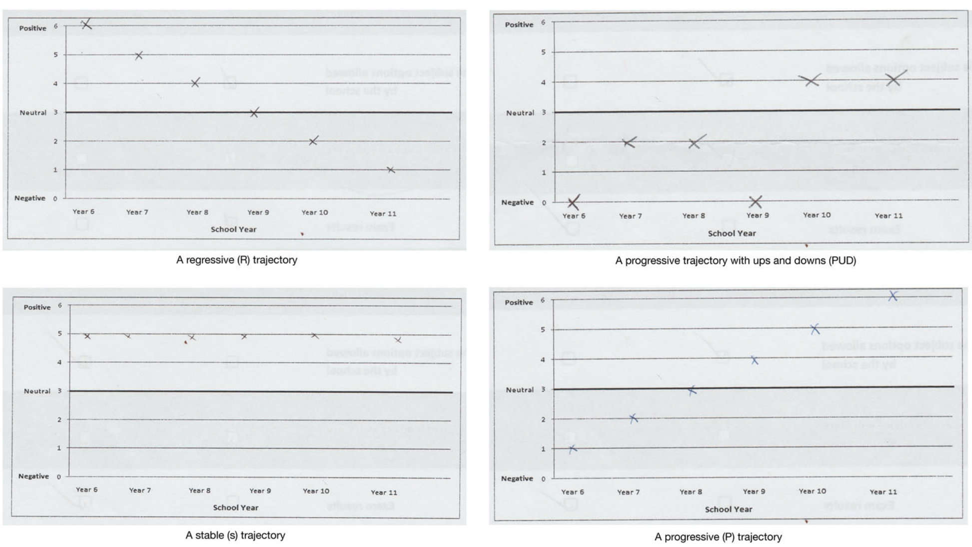

Figure 1. An example of the four trajectories from the storyline graphs.

Table 2. Themes emerging from the coding categories.

	Exemplar comments included in the coding categories	
Themes	Low points	High points
Teachers/ teaching	Bad teachers, ineffective teachers, did not like teacher, named teachers, poor teaching, not enough help provided, did not like teaching style, absent teachers	Good teacher, liked teacher, fun teacher, named teachers, good teaching
Curriculum content	Too much science content, did not like topics, repetitive, limited topics, too much information, topics not interesting, too simple, no challenge, learning facts, slow, no depth, too much theory. Not enough practicals	Exciting topics, new topics, more detail, engaging topics, interesting topics, more depth new things, challenging. Lots of practicals, named practicals, fun practicals
Perception of science	Huge workload, hard, increased stress, learning for SATS/tests/exam pressure, not confident, not good at it, did not understand, confusing, difficult, too complex, too serious, exam-focus	Easy, understood science, no exams, less focus on exams, started to understand, confident
Interest/ enjoyment	Science is boring, not interested, science was not interesting, not fun, not bothered, did not like science, was bored	Enjoyed it, exciting, fun, enjoyable, preferred the course/subject, liked science
Classroom environment	Disruption from others, disruptive classes	Liked classes, more time to learn
Attainment	Poor grades, got low grades, in low set, moved down a set, did not try hard, did not concentrate	Got good grades, in a higher set, moved to higher group, more dedicated to it, wanted to do well, worked hard.

long interview with introductory comments aimed to put the student at ease followed by open-ended questions that were asked in any order. The general categories of questions designed for the interview are:

Questions about context: to gain a general picture of their ideas about what school science is; for example, what do you think is meant by school science? What science subjects are you studying?

Questions about value of science: to understand how students look at the value of science; for example, in your opinion what is the value of science/should everyone at school learn about science?

Questions about school experience: to probe in detail the students' experiences of school science; for example, did you enjoy school science/tell me about your storyline graph/did you feel the same way about all three sciences?

Questions about subject choices: to gain insight into the reasons why students chose or dropped different subjects; for example, how did you come to choose the subjects that you are taking now?

Data analysis

Quantitative data from the questionnaires were analysed for measures of central tendency and the findings reported using descriptive statistical methods. Chi-square analyses were used to test for statistical significance between factors that students identified as influential in their decision to take science. In addition, single factor ANOVA was used to find any statistical difference between graph trajectories and science A-level take-up.

Audio recordings of the interviews were transcribed and nodes identified within NVIVO software. The nodes were arranged into coding categories and through taxonomic analysis (Onwuegbuzie, Leech, & Collins, 2012) organised into themes.

Qualitative data from the survey questionnaires were analysed through a thematic analysis approach described by Braun and Clarke (2006). Inductive analysis of the themes led to a number of initial codes that were arranged into thematic maps. Refining of the thematic maps led to six clearly defined themes arising from the coding categories (Table 2).

Findings

Storyline graph trajectories

An assumption based on the trajectories of storyline graphs was that these reflected students' experience of school science. Thus, the shape of the trajectories would tell the story of each individual student's experience of school science – an upwards trajectory indicated an overall positive experience and a downward trajectory would indicate a less positive experience. Although there were many variations of storyline graphs from the survey questionnaires, it was reasonably clear that they could be categorised into the four types of storyline trajectories (see Figure 1) suggested by Nilsson and van Driel (2011). The types are briefly described in Table 3 to indicate the decisions taken to match each trajectory to a type.

The survey data were grouped according to student type (scientist or non-scientist) and categorised according to trajectory type. Slightly more than a third of the whole sample had progressive trajectories and slightly less than a third had negative trajectories. Of the remaining third, a greater proportion had variable trajectories indicating a variable experience of school science while a smaller proportion had experience that did not vary throughout their time at school (Table 4).

The pattern of trajectories for the two different types of students – scientists and non-scientists – showed that scientists had more progressive (P) trajectories (44%) than non-scientists (27%) while the number of non-scientists with regressive (R) trajectories (41%) was higher compared to scientists with R trajectories (22%). Testing for significance with a Chi-square test revealed a significant difference between scientists and non-scientists with P and R graphs ($p < .001$). In other words, significantly more scientists had P trajectories compared to non-scientists and significantly more non-scientists had R trajectories than scientists with R trajectories.

Data from the storyline graph also provided insights into the patterns across individual years at school. Table 5 details the two different types of student (scientist/non-scientist) and their experiences of school science in individual years at secondary school.

Table 3. A typology of storyline graph trajectories.

Type of trajectory	Brief description
Progressive (P)	The trajectory goes upwards with no downward trends. P trajectories are indicative of a positive school experience of science.
Regressive (R)	There is an overall downward trend in the trajectory. There may be a point or two going upwards but the general direction is downwards. R trajectories indicate a less positive school experience.
Progressive with ups and downs (PUD)	The trajectory shows ups and downs over the years but ends at the same position or in a more positive position than at the start of the graph. This trajectory indicates a more varied school experience of science with both highs and lows but generally an upwards trend.
Stable (S)	A straight line indicative of a constantly similar experience of school science throughout the five years at school. The line can indicate a positive, negative or neutral experience.

Table 4. Student type according to storyline graph typology.

	Student types		
Graph types	Scientists $N = 274$	Non-scientists $N = 283$	All students $N = 568$
P	122 (44%)	77 (27%)	199 (35%)
PUD	62 (23%)	56 (20%)	118 (21%)
S	29 (11%)	45 (16%)	74 (13%)
R	59 (22%)	118 (41%)	177 (31%)

The average points for the storyline graphs showed that scientists' experiences followed a more positive trajectory compared to non-scientists (Figure 2). Scientists started off with a more positive experience of science and there was an increasingly positive experience after Year 9 with a surge in positive experience by Year 11. In comparison, non-scientists' perceptions at the beginning of secondary school were slightly less positive than the scientists' and stayed that way throughout their secondary school years. Graphical representation (see below) indicated that school science experience on average did not fall below neutral; showing that most students surveyed in this study generally had a neutral to positive experience of school science; however, individual graphs indicated a variable trend and this is discussed elsewhere (see Shirazi 2016).

The non-overlapping SE bars from Year 7 onwards indicated a significant difference between the perceptions of scientists and non-scientists at the 95% confidence interval levels at these years at secondary school. On average, from Year 7 onwards, scientists had an increasingly positive trend in their perceptions of school science while non-scientists had a slightly lower but stable trend in their perceptions showing that for a large number of scientists, the experience of school science becomes increasingly more positive from Year 8 while it remains more or less similar to previous years' experience for non-scientists.

Important factors affecting school experience

Having established the varying experiences of school science between the two types of students, qualitative analyses of both survey and interview data provided an insight into the important factors that comprised school science experience for these students. When drawing storyline graphs, students were invited to describe their reasons for at least one high and one low point of their school experience which lead to emergence of six key themes (Table 6).

Analysis of the interview responses showed similar key influences narrated by students when describing their school experiences of science detailed below.

Table 5. Experiences of school science in each individual year at secondary school.

	Year 6 Age 10–11	Year 7 Age 11–12	Year 8 Age 12–13	Year 9 Age 13–14	Year 10 Age 14–15	Year 11 Age 15–16
Scientists $N = 274$						
Mean	3.7	3.7	3.7	3.8	4.0	4.6
SD	1.5	1.3	1.3	1.4	1.6	1.7
Non-scientists $N = 283$						
Mean	3.3	3.3	3.2	3.1	3.1	3.1
SD	1.6	1.5	1.4	1.3	1.4	1.3

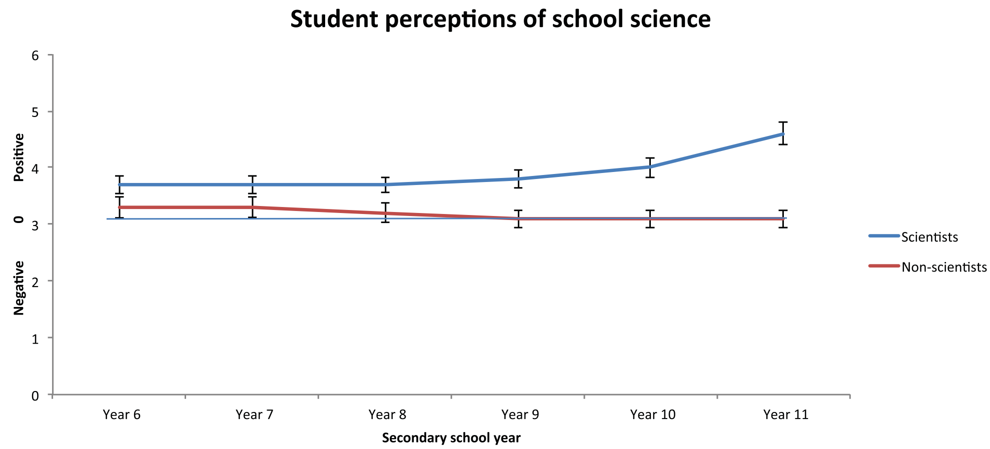

Figure 2. Average trajectories of scientists and non-scientists.

Teacher personality and teaching style are one of the top three factors

It is acknowledged that teachers and teaching are potentially quite distinct factors but survey and interview responses highlighted the complex relationship between teaching methods and teacher personality; for example, 'if you like a teacher as a person, whatever he is teaching you are going to like it more no matter what'. For students in this study, a combination of teacher personality and their teaching method contributed experience of school science for students:

> I think he was the best teacher we ever had; he was really good. He had a way of teaching that was [pause] you always enjoyed his lessons and he was always really funny and he kind of messed around with you. If someone came in late he would say go on to the front and dance like a chicken. We learnt more in year 9 then any of the other years, we'd still learnt a lot from him but you couldn't notice how much you were learning because he was so much (fun) the way he went about it. It was enjoyable (and) it was my favourite subject in year 9. (Female, non-scientist)

> I had a really good teacher; even the dull lessons weren't that dull. (Male, non-scientist)

The combination of good humour and teaching is a recurring theme narrated by many students. Another student who had been had been taught in France in her earlier years and moved to England later was able to highlight some differences in science teaching:

> In year 10 I really started to enjoy it (science) because I really understood everything and the way of teaching was really different. It's a lot more enthusiastic and they give you a lot more mental images and a lot more stories and they give you actions to learn; it might be more

Table 6. Student high and low points arranged by significance.

Reasons for high points	No of survey responses ($n = 485$)	Reasons for low points	No of survey responses ($n = 506$)
Curriculum content	180 (37%)	Lack of interest / enjoyment	140 (28%)
Interest/enjoyment	106 (22%)	Teachers/ teaching	109 (22%)
Teachers/teaching	103 (21%)	Curriculum content	95 (19%)
Perception of science	41 (9%)	Perception of science	86 (17%)
Attainment	31 (6%)	Classroom environment	42 (8%)
Classroom environment	15 (3%)	Attainment	22 (4%)

> childlike but it is more interesting and subconsciously you learn what is being taught to you. Whereas in France you copy off the board and the experiments are done for you. (Female, non-scientist)

A combination of enthusiasm coupled with a rich teaching narrative helped the student to become interested in science and cast a positive influence on her school science experience in Britain.

The survey questionnaires indicated that almost a quarter of students cited teacher influence as the high point in their school experience of science. Comments revealed that when students like their teacher, it has a positive influence on their experience and enjoyment of school science:

> During year 11 I had a really good teacher and that really made me enjoy it (science) a lot. (Male, non-scientist)

When student use the term 'good teacher(s)', there are a number of constructs that students might mean as 'good'. Here, one emerging construct about a teacher's personality is the teacher being *fun*. This was highlighted when students talked about their teachers' sense of humour as in the case of the teacher who made his students dance like a chicken when they were late or in the case of the biology teacher below:

> The best memory I had of science was in year 8 and we were learning about classification. My teacher was pretending to be a lizard and she got down on the floor and started to crawl … she was so fun and yes, I think that was the best year of science. (Female, scientist)

Another aspect of a 'good' teacher is the ability to be a source of inspiration for the subject they teach. Students like teachers to have not just a mastery of their subject but also enthusiasm in teaching it:

> Passion about the subject … if you see that they're enjoying teaching the subject and enjoying teaching you, it encourages you to try a bit harder and make the effort to enjoy it as well. (Male, scientist)

> I think that the way it was taught affected how I did it, because they (physics and maths) are quite hard subjects and you need an enthusiastic person to tell you it to be actually interested in it. (Female, scientist)

Apart from making their subjects interesting, some students felt that 'good' teachers helped their students enjoy science by teaching in a way that helped them understand difficult concepts:

> In year 9 and year 10 I had a teacher [who] made science really interesting and he explained stuff really well and if you didn't understand it he would really go through it really basic form and it was really interesting. (Male, non-scientist)

This understanding of students' needs helped teachers to teach them in a way that related to feelings of success as well as interest and motivation. Having a teacher able to explain science well and in a way that a student could understand helped to increase interest and motivation in the subject:

> I think the teacher at the time, the way he explained everything to me, I think he actually got me interested and that first interest is what pushed it from there. (Male, scientist)

> I had quite a good teacher in Year 11; it was a new teacher from Canada and I really liked him. I liked my lessons with him. That's when I started going to the after-school classes and that really helped me get a C (grade); I really didn't think I would get that. (Female, non-scientist)

In some cases, the experience of having a good teacher was remembered by students a long time after the experience took place. For example, this student talked about the influence of her primary school teacher:

> My primary school teacher has always encouraged me because she was the one who set up my science club even though it was only a couple of days, she was the one who got me all the things and she got me my interest in science. (Female, scientist)

Although this student's storyline graph had a regressive trajectory indicating negative experience of school science, her interview responses showed her primary school teacher was responsible for her interest in science. This finding was not unique, with many students recalling teachers from early years at school that made lasting impression on their school experience.

Teachers' personality or their teaching methods were also the source of negative experience of school science. For example, a student talked about how his teacher influenced his experience of physics:

> In year 8 … having that one teacher (for physics) was really boring and I didn't really get on well with him at all and it kind of put me off it (physics) for life. (Male, scientist)

The poor teacher–student relationship seems to have contributed to the student giving up physics permanently. Although this is an extreme example, generally, there was a correlation between how students perceived a teacher and their lack of interest in that subject. In other words, if a student disliked their teacher, they would generally dislike the subject too. This situation was highlighted in several other interview responses:

> I never really got on with my teacher, so that didn't help and then I didn't like the way it was taught and we never had a good teacher/ pupil relationship. That put me off. (Male, non-scientist)

> I think the teachers I have had has a lot to do with it (decreasing interest in science) because I really don't like my teachers that much … .when I had the two in the last year in year 10 and 11 for GCSEs, I really didn't enjoy it and I don't think they made the lessons very interesting and I think it actually made me dread going to science a little bit. (Female, non-scientist)

Another aspect of teaching that was a recurring theme in both surveys and interviews is teachers' pedagogical style The transmissive pedagogies Lyons (2006) describes in his work that put students off science are also evident in the comments from students in this study:

> Too much note-taking; dislike the dreary way it is taught, hate power points. (Male, non-scientist)

> Subjects were taught quickly and unenthusiastically. (Female, non-scientist)

> My teacher was dull to listen to and I forgot how interesting science was because she made it seem so boring. (Male, non-scientist)

> She (the teacher) never made anything fun or interesting, she would make you sit there and make you listen when she was writing on the board. (Female, non-scientist)

> Just the way they [teachers] go about it really, just flipping through PowerPoint presentations and talking at you, I think you won't enjoy that as much as someone who gets you involved. (Female, non-scientist)

Transmissive methods of teaching cause lack of interest and motivation in science with students shunning extended periods of writing or watching presentations. Closely related to this is the influence of supply teachers and their impact on interest and motivation in science. A recurring theme emerging from the interview responses was negative experience of school science due to teacher absence and supply teachers teaching science. High teacher turnover in some schools caused loss of continuity for the students leading to a less positive experience of school science. Some students with temporary teachers felt it was difficult to keep adjusting to a new teachers' pedagogical style:

> I think it was the teachers that changed so much it just made it quite hard to focus. In English I had the same teacher for pretty much the whole way through and because they know what they have taught you it's just a lot easier to go through things. (Female, non-scientist)

Another aspect highlighted in the survey data and related to the argument above is the tendency of supply teachers to work from textbooks and the lack of experiments when they taught science lessons. These were important influences in narratives of students with negative trajectories.

Science curriculum content plays a very important role in positive experiences of school science

Students in lower secondary school (ages 11–14) were more likely to ascribe boring and uninspiring science curricular content as the reason for their negative experience of school science. They commented about topics being taught at a rushed pace with no chance to revisit or understand concepts at a more leisurely pace:

> Rigid curriculum left no room for any exploration of more interesting points. (Male, non-scientist)

There was also a perception that the science facts needed to be learnt to pass exams were repetitive and dull:

> GCSE science was repetitive and boring – too exam focused in comparison to previous years. (Male, non-scientist)

> [Explaining a decline in opinion of science] I think it was just work load, cause to start off with, when you're in year 6 and year 7, the younger years, there weren't any serious exams, whereas when those years came along, there was a huge work load on us and it sort of changed my opinion on it, it gave me negative outlook on science. (Male, non-scientist)

In addition to this, particular topics were also singled out as being uninspiring:

> In year 9 I didn't like science because I didn't think it was that interesting because it was about food chains … when it goes to the ecosystem, that's the one I don't like. (Female, scientist)

> In year 7, 8 and 9 we learnt more about rocks and stuff, which isn't interesting. (Female, non-scientist)

> I really didn't like it (science) in Year 6 because we kind of went over and over plants and flowers and stuff; so I really hated Year 6. (Female, non-scientist)

A very important factor-related negative experience of school science was a lack of science experiments in early and late school experience. The lack of interesting experiments in secondary school made students feel that science was mainly theory to be learnt for examinations.

> In year 7 we weren't trusted enough with the other experiments; we were told 'this is how you do it, this is what you will be doing' and then [after] it picks up a bit more. (Male, non-scientist)

> In Year 10 we didn't do that many practicals and the ones we did were more of a demonstration and you was expected to answer questions rather than doing them yourself. (Male, scientist)

Both curricular content and teacher influence also underpin another important factor influencing school experience of science – interest and motivation in science subjects discussed below.

Interest and motivation in the subject were very important factors with both intrinsic and extrinsic factors playing a role

In survey responses, many students made general comments such as 'science was boring' and 'I didn't enjoy science', making it difficult to understand exactly what influenced their discontent. However, a handful of students did attempt to elaborate their responses by mentioning they did not like certain science topics or that what they learnt in school was unrelated to 'real' science. It was student interviews that helped uncover the important relationship between lack of interest in science and the influence of teachers and curriculum:

> I preferred Chemistry and Physics; but Biology I didn't really enjoy it. I was good at it, but I didn't really enjoy it, that could have been because of the teacher at the time. (Male, scientist)

> I just don't think it (physics) is as exciting as biology … I don't enjoy it as much. (Male, scientist)

> I didn't enjoy science that much from Year 7 until Year 9. I think the curriculum was really boring and wasn't interesting at all. (Female, scientist)

Some students related their lack of interest in science due to classroom environment.

> In Year 8 we were put into sets based on results and I didn't do too good; I felt that the group wasn't as focused on science, they (other students) were messing around and I felt I didn't enjoy it as much. (Female, non-scientist)

Perceptions of science as a difficult subject also play a part student experience of science at secondary school

Student comments about the difficulty of science highlighted a subtle nuance between science being 'a challenge' and being 'difficult'. For some students, science in early years was not challenging enough while the later years were too challenging:

> Year 6 science was uninteresting and easy. No challenge. (Female, scientist)

> GCSE science is challenging and difficult. (Male, non-scientist)

> It (science) got really difficult in Year 10. (Female, non-scientist)

The shift from being challenging (a positive experience for the scientists) to becoming difficult (a negative experience for the non-scientists) highlighted the differences in perceptions of difficulty in science for these two groups of students. The survey findings resonated with interview data with students explaining why they found science difficult:

> I found it just so much information to remember (science) and so much information of how stuff worked and how the gases would condense, I couldn't really get my head around it; and I don't like anything I don't understand. (Female, non-scientist)

> I couldn't grasp it (chemistry) as much and when you can't grasp it, you don't enjoy it as much. (Female, non-scientist)

From both survey and interview responses, it was seen that a large number of scientists and non-scientists agreed that science was a challenging and difficult subject. However, in the case of scientists, it seemed they were willing to take up science subjects post-16 even though they found them challenging while non-scientists gave up science at the earliest opportunity because the challenge was too much for them and they would rather take up subjects they perceived as less difficult. This apparent difference in perception led to the notion of success in science and is discussed in more detail below.

Attainment was not as important a factor and was also not an indicator of success in science

In this study, attainment was applied in the narrower concept of the term, that is, pertaining to examination results. Students were encouraged by good grades and these contributed to a positive experience of school science. Interview responses revealed the relationship between interest and attainment in terms of student perception of being good at science and a positive school experience:

> My best year was Year 11; I was so into science for that year. I loved it; Physics was my strong point, and I was really good at science at that point. (Female scientist)

> Throughout Year 7, 8 and 9, all I cared about was playing football so science wasn't on my mind. And during year 10 everyone was doing science so I just got into it and I found things quite fascinating, I was getting good grades and I liked it even more. (Male scientist)

For some students, effort towards a subject was easier if they were interested in it and they realised this increased effort led to better attainment:

> When you are trying to learn it and obviously you have an interest in it, it's going to help you learn it better, rather than being bored I find it interesting and actually do better. (Male scientist)

A number of students who attained good grades and perceived they were good at science were more likely to report their enjoyment of the subject and a positive experience of it at school.

Although gaining good grades in subjects helped provide extrinsic motivation for science, the interviews highlighted that getting good grades did not necessarily equate with being successful in science. Students who felt they had to work hard to gain good grades in science reported that they did not feel successful in science.

Discussion and conclusion

This paper aimed to explore what students thought of their science experiences at secondary school; the factors and incidents that had important impact on their experiences; and if there was a difference in perception of experiences by students who had chosen to take science further (scientists) and those who had not (non-scientists). The key findings and their implications are discussed below.

Student experiences of school science

Using the storyline instrument, quasi-longitudinal data about the high and low points of the school science experience of post-16 students were collected. From the points on the graph, emerging trajectories presented the student's experiences of school science. A typology of trajectories was constructed and related to positive or negative school experiences. Thus, students with an upward trajectory were assumed to have a positive experience of school science while those with a downward trajectory had a less positive experience. The results suggested that on average, school experience of science became increasingly positive for some students (who went on to choose science) as they progressed through secondary school while school experience other students (who later chose not to take science) was only slightly positive throughout their years at secondary school. These findings support and extend existing knowledge about the relationship between different classroom experiences on students' enrolment choices (Lindahl, 2007; Lyons, 2006) by showing that a positive experience of secondary school science may influence students' choice of science. The results showed how student experiences were affected by school-related influences further extending understanding of the role these influences play. The findings suggest that although on average, there is significant difference between the progressive and regressive trajectories of students, the shape of either trajectory is not substantial enough to support the idea that there is progressively negative perception of school science described in literature (e.g. Abrahams, 2009; Haste, 2004) leading to a 'Year 8 dip' in school experiences.

School-related factors influencing school experiences

Six key themes emerged as the main elements of student school experiences – curriculum content, interest, teachers, perception of science, attainment and classroom environment. This evidence from survey and interview data is in keeping with similar studies exploring factors that interest and engage students in science (e.g. Lyons, 2006; Reiss, 2000). Some findings such as impact of classroom environment and teacher absence are not prominent in the wider research literature and these are aspects that warrant further investigation.

Curriculum content: In establishing the factors that influenced their experiences, a strong discourse emerged about how curriculum content engaged and motivated some students while others became disengaged and bored. Students mentioned enjoyment of new topics in science that were challenging and more detailed than they had experienced in lower secondary level. Some students with regressive trajectories of experience spoke about their dislike for particular science topics such as rocks and plants. However, the most common aspect of the science curriculum commented on was science experiments. There was much evidence to suggest that students believed doing more and varied science experiments at school made science interesting and engaging. A large majority felt that science experiments decreased in quality and quantity as they progressed through secondary school. Some felt the lack of science experiments caused them to disengage from science. A large number of students in this study missed out on doing science experiments because they had supply teachers instead of regular science teachers.

The findings suggest that science curricular content needs to be less repetitive and exam-driven. In 2003, Osborne, Simon and Collins expressed concern that science is seen as a subject of little interest as it is perceived to be a domain that is exclusive and beyond the comprehension of the average individual. The 2006 science curricular reforms in England with emphasis on socio-scientific issues and the scientific literacy were heralded as being more engaging and relevant to students' lives. While there is yet to be decisive evaluation of whether these aspirations have been met, student comments indicated that to them, the current science topics were boring, full of theoretical content and exam-driven; very similar to comments made by students almost two decades ago. However, without a full evaluation of the new curriculum, it cannot be claimed that the curriculum is to blame. What may be the case is that pedagogy has not followed curricular change, evidenced by the number of comments about transmissive pedagogies in science classrooms.

Teachers and teaching: Positive learning experiences of many students in this study emerged where students perceived teachers as enthusiastic and inspiring as well as teaching in a way that is engaging and motivating. It is important that science teachers not just consider subject content knowledge as important but also the way subject content knowledge is taught. A large proportion of students felt that their science teachers relied too much on ICT led lessons (power points and videos) to do the teaching for them. There was a marked preference for student-centred active learning approaches and less 'chalk and talk'. Student responses revealed that varied activities in the classroom, having a teacher with a good sense of humour and an empathy with their students all increased positive experience of school science. Comparatively, when students talked about teachers in their low points of school experience, they made reference to teachers who never make science fun or interesting – a complaint summarised by a student in his survey questionnaire who noted 'the teacher was so boring I forgot how interesting science could be'. Teacher pedagogy was also a reason for mainly low points in student experiences. From several student accounts, there was evidence that activities such as copying work from the board or from textbooks and excessive videos and power points disengaged these students from science. A specific point emerging from the interview responses and one that may be particular to the English context was the effect of classroom environment on students' interest in science. Factors such as disruptive peers and lack of teacher control were felt to have an important impact on their school experiences of science. As one student described the low point in her trajectory, 'science is precise subject. You need to be able to concentrate in class'.

Science experiments: Another important influence on school science experience of science was science experiments. Students expected science lessons to involve some experimental work and in classes where regular practical work was included in the repertoire of teaching approaches, students reported an increased interest in science and a more positive experience. These findings correspond with research that practical lessons generate engagement albeit short-term (Abrahams, 2009) and point out the need for further exploration of the difference between quality and quantity of practical work.

Science as a difficult subject: Perception of science as a difficult subject was an influential factor in negative experiences of school science. Students talked about the difficulty of science and its focus on examinations and how a difficult curriculum contributed to a negative experience because they did not feel confident in their ability to be successful in science. They emphasised a lack of science understanding made them less successful in science assessments and that by attaining poor grades they were moved down sets which made them feel quite negative about school science. Related to this, negative experiences of school science occur where there is greater teacher turnover and frequent teacher absence. It is recommended that science departments reflect on their policy of allocating supply teachers to make sure that early experience of school science is not marred by teacher absence or frequent changes of supply teachers. However, it is also important to note that more mature students are also affected negatively by teacher turnover and therefore it is necessary to have a pool of well-qualified science teachers who can be called upon to fill in a temporary gap in the science department.

Science curriculum teaching needs to be spread evenly throughout the academic year to avoid students feeling overloaded at stress points especially near examination time. The practice of early introduction of General Certificate of Secondary Education (GCSE) science courses – as early as Year 8 (age 12–13) in some schools – also needs to be addressed. Too early an introduction to the science GCSE course leads to students feeling overburdened with difficult and exam-focused science topics. This leads to the perception of science being difficult and has implications both for interest in science as well as success in science. A recommendation is that students are introduced to GCSE science in the latter half of year 9 (age 14) after a thorough grounding in basic science concepts in the preceding years. These basic concepts should be taught creatively and enthusiastically by well-trained teachers who are able to enthuse and inspire their young and impressionable students.

Finally, it is acknowledged here that the research is limited by the nature of self-reporting and that the retrospective nature of the study will have resulted in some re-telling of the students' narratives. The question whether researchers can directly and faithfully capture a fixed and final snapshot of lived experience is one that cannot be answered here. However, the points raised in the discussion above resonate with findings of the different studies indicated in literature review. Insight from this study gives future direction for comparison with secondary schools in countries such as Scotland and Malaysia which are more successful in encouraging relatively high proportions of student participation in post-compulsory science courses.

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