Student identity, aspiration and the exchange-value of physics

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Chapter 6: Student identity, aspiration and the exchange-value of physics

Billy Wong
University of Reading, UK

Introduction

In English schools, the subject physics is the least popular of the traditional sciences. Despite an upward trend in uptake in the last 10 years, biology and chemistry typically have 50% more students than physics at *A level*, the main post-16 qualification used for university entry (JCQ, 2020a). The comparative lack of physics students has been a national concern in the past decade, contributing to wider debates of the 'leaky science pipeline' (and the 'rigged bingo game', see Archer, 2019), especially for students from underrepresented backgrounds (e.g., girls and some ethnic minorities, see Lykkegaard & Ulriksen, 2019).

In this chapter, the notion of science identity is explored through the concept of *symbolic exchange*, which recognises that our decisions and choice of consumptions are bounded up with status and power. Drawing on sociological theories of social reproduction, the chapter highlights the added value of studying science for school students, especially in physics and amongst high achievers. Empirical data from 42 A level Physics students (aged 16-18) in England inform the discussion, with the focus on student identity and aspirations in physics. This chapter highlights examples of student decisions to study advanced-level physics due to its exchange-value, symbolic identity and the pull factors of physics. The chapter concludes by discussing the potentials of the concept of *symbolic exchange* for research into young people's science and physics trajectory, especially in the context of identity.

Studying A level physics

In England, the study of A level (officially known as the General Certificate of Education Advanced Level) is the most common qualification for students aged between 16 and 18[1].

[1] There are other qualifications available that are more vocational oriented, such as *BTEC diplomas*, with conscious attempts by policymakers to broaden post-GCSE routes, including that of apprenticeships and *T levels* (from September 2020).

Students typically study for three subjects and their outcomes can be used for university admission. High-tier universities typically require students to have an A level grade set of AAB or above. Some degrees also specify or have preferences in particular A level qualifications, such as A level mathematics in the study of a physics degree (although A level physics is rarely a requirement to study for a mathematics degree). As such, A level qualifications are similar to university entrance exams in other parts of the world (e.g., *gaokao* in China; *SAT* or *ACT* in the US), albeit students' degree options may already be restricted by the type of subject qualifications acquired in school, as explained below.

It is compulsory for students in England to study science in primary and secondary schools (between ages 5 to 16), which tend to include the sub-disciplines of biology, chemistry and physics. At *GCSE* – a qualification normally taken by students aged 14–16 – these sciences can be studied as three individual subjects, through what is commonly known as *Triple Science*. The most popular science at GCSE is *Double Award*, which is taken by c. 880,000 students in 2020 (compared to c. 170,000 for *Triple Award*, see JCQ, 2020b), where the sub-disciplines of science are taught together.

Students who take Triple Science are typically high-achieving students and are more likely to be from socially advantaged backgrounds, which raises concerns about the diversity, equality and inclusivity of the subject (Reiss, 2000). Furthermore, school students often have little or no choice in their science education pathways, which are bounded by school structures, policies and priorities (Archer et al., 2017a). For example, some schools – due to external factors such as league tables and school rankings – may restrict which of their students are 'eligible' to study advanced sciences; most likely based on students' academic profile, such as their existing subject choices and attainments (e.g., at GCSE, typically at age 14). An appreciation of the GCSE system is therefore necessary to understand the challenges of students to study post-compulsory physics, especially at A level (ages 16-18).

Most A level subjects, especially the sciences, demand students to have prerequisite knowledge, as evidenced in their relevant grades at GCSE or equivalent. It is common for schools to only recommend (and in practice, limit) students with certain grades to continue at A level (to strengthen the success rate).

Given that physics (and chemistry and biology) only exist as an individual subject at GCSE under Triple Science, the pool of potential A level science students is already smaller, although students with a strong outcome in GCSE Double Science may also be eligible. In any case, A level physics seems to attract the fewest of students in the traditional sciences. In 1976, over 40,000 students took A level physics and the numbers peaked at over 53,000 in 1982. By 2007, there were fewer than 24,000 students and a gradual upward pattern then emerged and by 2014, the figures were just over 32,000 (Wong, 2016b). In 2020, student numbers have risen to 38,000 (compared to 65,000 for biology, 56,000 for chemistry and 94,000 for mathematics, see JCQ, 2020a), which is still the least popular traditional sciences at A level.

Over the years, researchers have investigated the reasons for the low participation rate of physics in post-compulsory education, especially for females (Hazari et al., 2010; Sax et al., 2016). Girls constitute just one in five A level physics student, whilst there are often balanced if not more girls in the study of biology and chemistry than boys (JCQ, 2020a). Concerns about lack of girls in physics has been studied extensively, especially by the UK's Institute of Physics and their reports under the 'Gender Balance' research theme (e.g., IOP, 2013, 2015; Murphy & Whitelegg, 2006). These studies and others highlight a range of challenges experienced by girls in physics, including the environment of physics as overly masculine, gender stereotypes and the subject being seen as difficult, unrelatable and 'not for me'. Girls in single-sex schools, however, are 2.5 times more likely to study A level physics than girls in co-educational schools (IOP, 2011), which further highlights the issue of gender in school structures and systems as barriers for further physics education.

Research from the *ASPIRES2* project reported that A level physics student are most likely to have done Triple Science at GCSE, be a high achiever/in the 'top set' in science (and mathematics), have high levels of cultural and science capital and have family members working in science (Archer et al., 2017b; Francis et al., 2017). Existing studies suggest that the key reasons for students to choose to study A level physics was due to their experience of enjoyment of the subject, perceived usefulness of the subject for future aspirations and the assumed intellectual identity afforded by the difficulty of physics (DeWitt, Archer, & Moote, 2018; Gill & Bell, 2013; Mutjuba & Reiss, 2016).

As with most subjects, an intrinsic interest in the discipline is central to support and reinforce motivation and enthusiasm for study and learning (Mutjuba & Reiss, 2014). For physics, such interest can extend to extrinsic factors, especially the added value of the discipline. For example, the inclusion of physics as one of 'facilitating subjects' for university application (Russell Group, 2018) has meant that the qualification of A level physics has an added value for entry into higher education (although a broader range of subjects were recommended in their relaunched 'informed choices' website, see informedchoices.ac.uk). Popular stereotypes and perceptions of science and scientists as people of high intelligence can also appeal to particular individuals (DeWitt, Archer & Osborne, 2013; Wong, 2012), even though such identities can also promote discourses of science as 'not for people like me'.

At A level, students tend to study fewer subjects as preparation for specialism, especially at university. This chapter focuses on students who are studying A level physics. The decision to study A-level physics is likely to reflect students' aspirations and identities, especially their intrinsic and extrinsic motivations. More specifically, I am interested in the symbolic/exchange values afforded by physics, which I argue is important for understanding the concept of science identity.

Science identity, capital and symbolic exchange

My approach to *science identity* is informed by sociological theories and literature, where identity as a concept is understood as a social construction. Informed by key writers such as Stuart Hall (1990) and Judith Butler (1990), identity is conceptualised as something fluid, relational, 'always in process' and entangled within complex relations of power (e.g., structural inequalities of gender, class and 'race'/ethnicity). In other words, identity can be thought of as a continuous project that constitutes an ongoing process of negotiation within multifaceted structural and agentic relationships. For individuals, our identities are therefore developed and performed in negotiations with dominant identity discourses (Lawler, 2007). In science education research, the lens of identity can offer us an insight into the nuances of science participations and science aspirations, especially the symbolic values and identities for studying advanced sciences such as physics.

The concept of science identity, including identifications with science, has gain popularity in the last decade or so. Notably, Carlone and Johnson (2007) posited that a sustainable science identity within the classroom would require recognition by self as well as by others, such as teachers and peers (Hazari, Brewe, Goertzen, & Hodapp, 2017; Hazari, Cass, & Beattie, 2015). Consistent with Hall and Butler, an identity in science – or science identity – would therefore require approval, recognition and acknowledgement from members of the immediate environment, otherwise the claim to such identity is unsustainable and temporary. With a stronger focus on individual agency, Calabrese Barton et al. (2013) also explored the concept of *identity work* to tease out the complex ways in which students navigate their identities across different science learning contexts (e.g., inside or outside the classroom, in pairs, groups or whole-class discussions). Here, identity work focuses on the processes of identity formation and how individuals construct their sense of selves within different learning spaces (Carlone, Haun-Frank & Webb, 2011).

In understanding young people's science aspirations, the concept of science identity is also prominent, especially in appreciating the extent to which careers in or from science are considered as feasible, plausible and desirable for 'people like me' (Archer & DeWitt, 2017; Wong, 2015). For instance, people in science are often stereotyped as intelligent but socially inept in popular media (Chimba & Kitzinger, 2010), as exemplified in CBS's popular American sitcom *The Big Bang Theory*. The work of scientists is typically presented as intensive and laborious, with long working hours and minimal social life (Masnick, Valenti, Cox, & Osmanm, 2010). The portrayal of scientists in science-fiction movies such as the classic trilogy, *Back to the Future*, strikes a high resemblance to Albert Einstein, one of the most recognisable scientists of our time. Einstein's image as a white old man with a distinctive hairstyle dressed in long laboratory coat is arguably synonymous with being a scientist. Such ingrained images and ideas have, for a long time, reinforced a particular (and mostly exclusive) identity of science for prospective scientists and science students.

An identity in science can therefore be quite particular and peculiar, in the sense that people who associate with science, such as a science student, a science enthusiast or a science professional, can also attract stereotypes about who they are (i.e., their identity), be it positive and negative. In schools, students who study or aspire to study more advanced level sciences may find the study of science attractive because it symbolises intelligence (Wong, 2012), especially since students who are good at science are popularly regarded by their peers as clever and brainy (DeWitt, Archer & Osborne, 2012). Here, an identity in science can be paralleled with a symbolic identity because of what associations with science can also represent, such as intelligence. These students, which I have previously termed as *science extrinsic* students (Wong, 2016a), would be interested in science such as GCSE Triple Science and A-level physics, biology and chemistry because these qualifications are recognised to have an added value, especially for university entry applications, even if their own interests or aspirations in science are minimal. Similarly, students may avoid or reject an identification with science due to the very same intellectual stereotype, which can include descriptors such as nerds, geeks and boffins, and consider these characteristics to be inconsistent with the identities that students wish to embody or be recognised (e.g., 'interesting, but not for me', see Archer et al., 2010). It is therefore important to consider the symbolic and additional meanings of what associations with science can mean for different students as part of our understandings of their science identities.

Underlying these student choices and identifications with sciences, there seems to be value in delving into the *semiotics of science education*, and more specifically, the symbolic/exchange value of studying science. I therefore suggest that in thinking about science identity, or an identity in science, it is important to consider the exchange value of science, especially in the context of science aspirations. Jean Baudrillard (1981), who extends Karl Marx's writing in the sociology of capitalism and consumption, extensively discusses the concept of *symbolic exchange* (or *exchange value*, as advocated by Bourdieu, 1977, see below). In short, Baudrillard argued for the importance of recognising the exchange value of a commodity as much as the use value, which is the directly applicable or obvious purpose of the commodity. Exchange value constitutes the symbolic and added value of the commodity, especially what it means to have acquired such commodity. An example could be buying a t-shirt – the use value is to provide warmth and something to wear, and the exchange value refers to what is means to buy/wear that t-shirt, be it the brand, the design, the materials or the production process (e.g., ethical or sustainable). An expensive or branded t-shirt may signify that the owner is wealthy or fashionable, although it could also be received negatively, such as pretentious or materialistic. Individuals, with their own values and resources, will interact with brands in ways that reflect their own identity. The idea of exchange value is applicable for most commodities, such as cars, smartphones and various lifestyle choices (and therefore *taste*), which invites us to consider the thinking tools of Pierre Bourdieu (1977, 1984) and his theory of practice.

In brief, Bourdieu's work arguably builds and refines on the ideas of Marx, with a focus on the social reproduction of inequalities, by socioeconomic background, through the intergenerational transmission and embodiment of dispositions (*habitus*) and resources (*capital*) that ensures the privileged maintains their privileges across societies (*field*) and generations. In particular, Bourdieu's (1986) theory of *capital* is in alignment with Baudrillard's *symbolic exchange*, although Bourdieu also conceptualised capital with respect to economic, social and cultural dimensions. Most importantly, Bourdieu considered capital as *exchangeable resources*, where possession of one capital can lead to another, including symbolic capital, which is understood as 'the acquisition of a reputation for competence and an image of respectability and honourability' (Bourdieu, 1984, p. 291).

In science education research, Bourdieu's concepts are increasingly popular, especially with the concept of *science capital* (Archer et al., 2015; Wong, 2016b) that considers the breadth and depth of science-related resources that individuals, especially young people, can access and deploy in support of their science trajectories. Students with high levels of science capital are more likely to identify with science (through expressions of science careers aspirations and high attainment) than those with medium or low science capital (see also Du & Wong, 2019 in the Chinese context). Recalling that capital is all exchangeable resources, capital that are related to science (i.e., science capital) will also have symbolic values.

With this in mind, the consideration of *symbolic exchange* within the lens of science identity has the potential to make an important contribution to the understanding of the aspirations and decisions that young people make about their science pathways, especially in the study of advanced sciences such as A level physics. For instance, what is it about A level physics that appeals to students? Why kind of science identities do A level physics students embody?

The study

This chapter draws on data collected in 2018 for an evaluation research interested in the ways that contemporary A level physics students would like to be supported in their learning of physics, in and out of school. Supported by the Institute of Physics (IOP) – a UK-based professional body and learned society for physics, the project explored the views, experiences and ideas that these young physicists have about their science pathways, including aspirations toward advanced science education and future careers. The evaluation itself focused on the IOP's membership system and engagement strategy to support A level physics students.

Empirical data comprised of 42 A level physics students from two major English cities (London and Manchester), who participated in seven focus groups. The method of focus group was utilised to promote discussions and interactions between participants to highlight, debate and reflect on similar and different views, expectations and aspirations about A level physics and beyond (Krueger & Casey, 2014). In other words, the emphasis here is less on the individual, but their collective views and opinions. Through purposeful sampling, students were recruited using the IOP's local network of schools, where a call for participant was emailed and distributed to A level physics students through physics teachers or the school. Interested students were then informed of the date, time and location of the research. The research was conducted at local community centres that are reachable by public transport. Student participants travelled to these respective sites with their travel costs reimbursed.

Whilst recruitment was passive in that participants would actively sign up to take part, the recruitment process was mindful of the importance to include a diverse range of students to appreciate different views and perspectives, rather than a proportional representation of existing figures for A level students, given it is a male-dominated subject. Of the 42 focus group students, an equal number of girls (n=21) and boys (n=21) were participants, which was coincidental despite an awareness on gender balance. Students came from 11 different schools, including one private girls-only school to boost the number of girls in the study (n=12). Our students are ethnically diverse, with 12 self-identified as White, six as Black, nine as Asian, five as Middle Eastern, four as Chinese and six as mixed or with multiple ethnicities. Based on their GCSE or equivalent grades, the A level physics students recruited in this study are considered as high achievers. The vast majority of our students had studied GCSE Triple Science, with a handful who completed the more popular (but less demanding) Double Science.

Each focus group lasted an hour and a half on average and was audio-recorded, with the data transcribed verbatim and more sensitive details anonymised. All names of students are pseudonyms. The size of each group was between five to seven students and I conducted two girls-only group (FG1, FG2), two boys-only group (FG3, FG7) and three mixed-sex groups (FG4, FG5, FG6). The composition of each focus group was pragmatic and primarily based on the availability of students. Most groups included students from at least two schools, although the two girls-only focus groups were comprised of students from the private school for girls. Participants were prompted to discuss their views and experiences about science, especially their reasons for studying physics at A level and the support available. There were further questions designed to evaluate the IOP's membership system for young physicists, which is not part of this analysis. As an observation, most students in the focus groups were open to share their thoughts about A level physics and their trajectories so far in post-compulsory science education.

Data analysis is informed by a social constructionist perspective which recognises social phenomena as socially constructed and discursively produced (Burr, 2003). Focus group data were managed and organised using the software *NVivo*. Initial codes were created through the identification of relevant themes that emerged in the initial stages of data analysis where there is a 'back and forth' movement between the data and analyses in an iterative process through which the dimensions of concepts and themes were refined or expanded through the comparison of data (Corbin & Strauss, 2014). These codes were subject to an iterative process of gradual coding refinement, with the themes being revised with emerging research data and further coding.

In this chapter, the lens of science identity is used to interpret the data, including the concepts of exchange value and symbolic identity. Here, focus group discussions and narratives of students' views and experiences of science and physics were analysed as potential expressions, indications and performances of identities in science. Furthermore, these interpretations also considered the possibilities of *symbolic exchange* in students' identity and aspirations in science, which shed further light into the extrinsic value of physics. In other words, what are the added meanings of being a physics student?

The exchange value of physics

In English schools, science is usually taught as an overarching subject that encompasses a range of sub-disciplines. Typically, it is not until at GCSE (age 14), via Triple Science, where the individual sciences of biology, chemistry and physics can be studied as distinctive science subjects. Arguably, this stage is where students begin to explore more specialised science identities in school, which is further developed at A level. To appreciate the *symbolic exchange* and complexities of a physics science identity, it is important to explore why students study A level, what aspirations these students have and the extent to which they identify with physics.

From the data, it is no surprise to report that students who chose to study A level physics said they did so because of their interest in the discipline, contrary to other research (Mujtaba and Reiss 2016) which noted the higher importance of extrinsic motivation. As also reported by DeWitt, Archer and Moote (2018), fascinations with the scientific discoveries, concepts and applications of physical science are echoed by many students when asked about the reasons for their choice of study:

> *I really enjoy physics because everything that I've ever done and, it sounds cheesy … has been a direct influence of physics. So, I'm drinking a cup of coffee now, and when I poured it, it was too hot. But thanks to thermodynamics, now it's fantastic to drink. (Nathan, 17, White male, FG7)*

> *I feel like physics explains life, in a sense. I feel like it's more than just a subject. Physics is literally everything around us, and that's the best part. You look at something and, oh my gosh, this is staying down or using Newton's Laws, all that stuff. It's just so binding, and follow everything, and it somehow connects to everything. (Lydia, 17, Black female, FG5)*

Existing studies agree that the capacity of young people to appreciate science and physics in their everyday lives is likely to increase and strengthen their scientific interest, aspirations and even school attainment (Archer & DeWitt, 2017; Archer et al., 2020; Godec, King & Archer, 2017). Whilst these intrinsic interests are critical, the appeal of A level physics extends beyond the content of the discipline, with ample evidence to infer that the study of physics is also recognised by students to have added, or exchange, value.

Careers 'from' physics

Our students clearly recognise that A level physics is a 'facilitating subject' (Russell Group, 2018) that would be particularly useful for university application and future careers, even though few have expressed an interest in a physics career (DeWitt et al., 2018). Instead, most wanted a career *from* physics (Wong, 2015), especially in engineering.

Table 1: A level Physics students' primary career aspiration

Careers mentioned	**Girls**	**Boys**	**Total**
Engineering	8	12	20
Medicine	3	0	3
General science	3	0	3
Physics	2	1	3
Finance/Banking	0	2	2
Architecture	1	0	1
Geology	1	0	1
Sports science	0	1	1
Undecided	3	5	8
Total	**21**	**21**	**42**

Table 1 presents the primary career aspirations that were mentioned by our students. Most expressed an interest in a STEM career and just under half (20 out of 42, 48%) explicitly stated engineering as their main career goal (which includes careers in aerospace, bio, civil, mechanical and structural engineering). While our recruitment strategy certainly contributed to the type of students (i.e. A level physics) who self-selected to participate, it is rather concerning that only three students (out of 42, or 7%) appear interested to pursue a career *in* physics, and these students appear to be driven by their intrinsic interests and motivations. Six students also stated a secondary career aspiration, which include working the fields of physics (n=2), general science (n=1), neuro-technology (n=1), radiotherapy (n=1) and economics (n=1). For most of our A level students, their study of physics was understood to be a process or gateway into their desired career pathway:

> *I want to go into engineering or something like that, so obviously you need to do physics. (Abby, 16, White female, FG1)*

> *The basic principles of engineering are based around physics and maths, so physics will be central to everything I want to do in engineering. (Larry, 17, White male, FG7)*

Students with an engineering career aspiration clearly recognised the relevance of A level physics, as well as mathematics, to be essential subjects for a career in engineering, which is unavailable as a school subject. In fact, all but one student (41 out of 42, or 98%) were also studying A level mathematics, which was mentioned by some to be a requirement in their schools in order to study physics (see also Kemp, Berry & Wong, 2018, p. 131). The other popular subjects are A level chemistry and A level further mathematics, which are studied by 19 (or 42%) and 15 (or 36%) of the 42 A level physics students, respectively.

For students with career aspirations in medicine, general science, finance/banking, architecture, geology and sports science, the subject physics is generally considered as a useful or complementary subject. For those with undecided or unknown career aspirations, their reasons for studying A-level physics were due to personal interest, but also because they believed they were 'good' at the subject, especially at GCSE (age 14-16). I return to the symbolic identity of being good, or intelligent, in the next section.

When probed to discuss why few young people appear to find a physics career attractive, it was suggested that the subject itself lacked a strong and distinctive identity. For instance, physics is seen, by some students at least, to be a 'supporting' subject, rather than as a 'mainstream' discipline such as mathematics and engineering. Hannah (16, White British female, FG2) explains that:

> *Even if you do like a physics questions … so much of it is sometimes just maths. [Physics] doesn't seem like it has much of an identity. It is just like, "Oh, this is sort of like maths with a few extra bits".*

In a related vein, a handful of students was also uncertain about the range of career options available for those with a physics specialism:

> *I don't really know what else I'm going to do with physics, other than the subjects I chose … I looked for other professions and there's not that many linked with physics and other subjects. (Mark, 16, Black British male, FG3)*

However, when asked to envision the role of physics in their futures, such as in five or ten years, most students were positive that their knowledge of physics would play a useful part in their professional or personal lives. Here, most students acknowledge that physics is a versatile subject, especially for employment:

> *Physics has a lot, it can open a lot of doors because it can, you can use it in a lot of different kind of areas. (Stephen, 17, White male, FG3)*

> *It opens many doors to you because if you get good grades in physics people see that you have high abilities, like you can cope with anything really. (Maha, 16, Middle Eastern female, FG4)*

Our students appear to appreciate that the study of A level physics has *symbolic exchange* (Baudrillard, 1981), or added value, as the subject can be a pathway into other careers, especially engineering. The study of physics also infers a status or perception as a competent person, which is explored below.

An intelligent identity

Several students, including those with science career aspirations, attributed their impressive GCSE grade in science as a key validation of their academic ability. To put it more bluntly, it appears that some students took A level physics because they can, as evidenced by their previous attainment. These students may be strategic in their subject choices, with rational rather than sentimental decisions, to ensure that their academic trajectories are guided by the probabilities of best possible outcomes:

> *I would never pick a subject that I'd enjoy but I'm not good at, if that makes sense. There's a lot of subjects which I might enjoy, but I just don't get good grades in so I*

wouldn't pick it. When you pick subjects, it's not really what you enjoy. It's what you're good at. (Luke, 16, Black male, FG3)

I did it [A-level physics] because in GCSE [Triple Science] I liked it, and I was good at it, and that's the only reason. (Onnika, 17, Middle Eastern female, FG5)

For students such as Luke, the decision to study A level physics is based on perceptions of their academic ability to perform and achieve (‘*it's not really what you enjoy. It's what you're good at*’). This reason can also be used to explain the comparative lack of A level physics students, who may be dissuaded by the belief that they are not good enough to do physics, especially since physics is popularly regarded as a hard and difficult subject. As such, being good at or achieving high grades in physics can entail a symbolic identity that is unavailable in most other subjects, namely as academically competent or even as clever (DeWitt et al., 2013), especially from peers and even family or community members (Wong, 2012). For example:

Yasmine:	*When we tell people out of school, like family or something they're like, "Wow, you must be really clever because you take maths and physics”.*
Lorraine:	*Like, everyone thinks it must be such a hard subject to take.*
Yasmine:	*Yeah. (FG1)*

For other students, this (mis)recognition from others on physics being a difficult subject can also have a positive influence on their identity, especially as a smart or intelligent person:

Researcher:	*And how does that [physics seen as a hard subject] make you feel?*
Gary:	*Yeah. It makes me feel better.*
Leah:	*Definitely.*
Researcher:	*In what ways?*
Edward:	*Makes you feel smart, like you're doing something that other people really can't do.*
Researcher:	*Does it make everyone else feel smart as well?*

ALL: Yeah. (FG5)

As can be seen, some students recognise and even feed off recognitions from others that the study of A level physics entails intelligence and cleverness. Studying physics offers student a plausible identity as a genius, at least from peers (*'if you take physics, they'll assume you're a genius'*, Markus, 16, White male, FG7), especially from those who have struggled with science and physics themselves. While A level physics students felt the subject physics is less intimidating than it appears, they believe it is one of the harder subjects, and our students generally agree that the symbolic identity afforded by physics as people of high intelligence is an appropriate and attractive identity to embody.

Girls in physics: Has the tide turned?

Across the seven focus groups, our students generally acknowledge the added challenge for girls to persevere in science and physics, citing the socialisations and expectations derived from traditional gendered discourses, including the lack of female role models (Archer et al., 2012, 2013).

The boys-only groups (FG3, FG7) reasoned that fewer girls study physics because '*girls are more into*' biology and chemistry, with science-related career aspirations more likely to be in medicine than in engineering or physics, as the latter is more of '*a boyish thing to do*' and physics '*Nobel prize winners are mostly men*'.

The girls-only groups (FG1, FG2), all from a private school for girls, also recognised the barriers from traditional gendered discourses, although these were interpreted as more historical. Instead, the girls suggest that '*the tide has now turned*' for women in science, driven by a number of local/national initiatives, as well as the international #metoo movement against sexual harassment and assault. The girls said that their school has been actively promoting physics, with an attractive package of support from field visits to attendance of external lectures to specialised resources in school.

Some girls saw the recent emphasis of the STEM sector as a whole to promote and encourage women to participate in the field as a unique opportunity on which they ought to capitalise, with ever more and even exclusive science-related opportunities (e.g., placements/internships) that are only available to girls. It seems that these girls are highly aware of their current (even if temporary) advantage to maximise the opportunities afforded by this 'gender turn' which celebrates and promotes women in STEM, especially the appreciation of female in traditionally male-dominated fields such as physics.

Some of the state-school girls in the mixed focus groups (FG4, FG5 & FG6) also articulated similar views, with one speaking about '*being a girl who is kind of successful in physics … [is a] kind of empowering because it's like you want to prove people wrong*' (Alison, 16, Middle Eastern girl, FG4). Here, the symbolic meaning for girls to be successful in STEM seems to offer these A level physics girls an added sense of pride, through their supported challenge of the dominant and gendered discourses of physics (see also Avraamidou, 2020). The study of A level physics therefore provided some girls with a powerful, meaningful and even noble identity in science/physics.

The symbols of an identity in science

In this chapter, I have explored the reasons behind why students study A level physics, with a focus on science identity and the concept of *symbolic exchange* (Baudrillard, 1981). The student identities of those who study advanced physics are not just those of *any* student, but specifically physics students, which, when interpreted through the lens of *symbolic exchange*, encompasses extrinsic and external meanings and implications. Students who study A level physics are mostly aware of the high exchange value afford by the subject for university applications (Russell Group, 2018), future career options and even a heightened sense of self-belief. Young people may make study choices as a result of intrinsic interest and motivation, but it is evident from the data that these decisions, especially for post-compulsory education, can also be strategic and symbolic. Referring to one of the five 'types' of science participation I identified in a previous study with minority ethnic young people (blinded), students who are *science extrinsic* will continue with their science education as long as the subject is considered to be useful for their future educational and career plans.

The lens of science identity enables us to take a deeper understanding of young people's trajectories in science, by considering the type of person that one wants to become. Studying A level physics (and beyond) is therefore more than just the learning and understanding of physics content and concepts; it is also the recognition and gradual embodiment of the cultures of science and physics. This brings us back to the question of what it means to be a scientist, especially a physicist, for those who are studying post-compulsory physics. Is their choice driven only by scientific curiosity and fascination? Or, is the *symbolic exchange* of A level physics, with the various added valued as already discussed, an important factor of consideration? The evidence suggests both, which means our understanding of science identities, especially for young people, ought to consider what the perceived added value and extrinsic meaning of doing, studying or working in/from science means for the individual, as well as perceptions of them from others (Carlone & Johnson, 2007).

If we wish to promote further access and participation in advanced level physics, either for study or as a career, then perhaps the added values of physics – be it financial or personal prestige (i.e. symbolic) – ought to be marketed more strongly by educators and employers, rather than to wait for future physicists to emerge purely from their own intrinsic interests. Whilst this approach may not be as appealing as those where participation is nurtured and supported through students' scientific interests, it is a pragmatic method that should not be completely dismissed as we must try and explore a range of different ways to initiate the shift in the existing imbalances of physics.

It is also important to appreciate that whilst the symbolic meanings and identities of studying physics can be positive, with various added values, these symbolic identities can be a negative, especially when associated with undesirable traits or values that appear inconsistent with the self-identities of individuals. These could be stereotypes of scientists/physicists as socially inept and eccentric, or the 'chilly climate' of physics (perceived or actual) for girls and/or minority ethnic groups in a traditionally masculine and white field (Aikenhead, 1996; Blickenstaff, 2005). As such, an identity in physics can certainly be exclusive and exclusionary, and so the concept of *symbolic exchange* can be positive with added value, as well as negative and 'subtracted' value, when we consider the symbolic meanings and cultural understandings/interpretations of what an identity in physics can potentially mean.

So, what does this mean for science identity research? By highlighting the importance of exchange value and symbolic identity, future studies informed by the lens of science identity need to ensure that external and extrinsic factors are thoroughly considered when attempts are made to interpret and make sense of the science educational trajectories and career aspirations of young people. Thus, the concept of symbolic exchange should be considered as a part of our understandings into how individuals identify (by self or by others) with science, in recognition of the added meanings of studying or working in science, especially physics.

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