

Allison J. Gonsalves
Anna T. Danielsson *Editors*

Physics Education and Gender

Identity as an Analytic Lens for Research



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Editors

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Chapter 1

Introduction: Why Do We Need Identity in Physics Education Research?



Allison J. Gonsalves and Anna T. Danielsson

An extreme culture of objectivity: a culture of no culture, which longs passionately for a world without loose ends, without temperament, gender, nationalism or other sources of disorder—for a world outside human space and time. (Traweek 1988, p. 162)

This is how anthropologist Sharon Traweek characterised physics culture, in her landmark book “Beamtimes and Lifetimes”—an account of the world of high energy physicists based on extensive field studies in laboratories in Japan and in the U.S. The “culture of no culture”, Traweek argues, renders social categories of “physicist and physics community and physics culture” non-existent. Similarly, philosopher Sandra Harding has claimed that the abstractness and the formality of physics need to be understood as “distinctive cultural features, not the absence of all culture” (Harding 1998, p. 61). However, getting sight of the cultural production of physics can be difficult and it is thus perhaps not surprising that when dealing with the issue of ‘women in physics’, that the gaze has more often been turned to the women than the physics. As such, over several decades, studies have documented differences between men and women in achievement or participation, or seeking social or psychological explanations for differences in physics engagement. This dualistic understanding of gender and its consequences for physics learning, engagement and educational research has long been challenged theoretically, but only recently have new perspectives on gender and physics been taken up in the field of physics education research. Feminist scholar Evelyn Fox Keller has suggested that binary understandings of gender and science render a situation where “any scientist who is not a man walks a path bounded on one side by inauthenticity and on the

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other by subversion” (Keller 1985, p.174). Responding to this, a recent epistemological shift in research on gender and physics education is turning our gaze away from documenting differences and rather moving towards understanding how gendered identities are constructed in physics learning and practice. For the past decade, we (Allison and Anna) have been researching students’ experiences in physics education, and we have been exploring various uses of identity to understand these. We have seen shifts in how researchers approach explorations of gender in physics, and wish to document these new developments here, in this edited volume. The focus of this book will thus be on extending our theoretical understandings of identity to explore the construction of gender in the teaching and learning of physics, in and beyond the field of physics education research (PER).

1.1 Physics Education Research (PER)

PER is a research field that deals with the teaching and learning of physics, and is typically is considered a sub-field of physics rather than of education (Beichner 2009; Heron and Meltzer 2005). The field of PER is primarily concerned with university level teaching and learning of physics, even though some research groups reach across the whole spectrum of physics education from primary to university (e.g. University of Maryland). PER researchers tend to have a background in physics and it has been argued that it is appropriate for physicists to research university level physics education as they are the ones familiar with the complexities of university level physics coursework and the ones teaching such classes (Beichner 2009). At times, PER researchers have brought research methods from their investigations of the physical world with them into PER (Heron and Meltzer 2005). Research dealing with gender issues is a notable area of concern in PER—an interest motivated by the continued under-representation of women within the discipline. Recently, Scherr (2016) reviewed 400 articles from the past 10 years of publications in *Physical Review Physics Education Research*, and found that about 7% of those were concerned with issues of gender, and of those, 80% were focussed on performance gaps. Very few (3%) of the articles Scherr reviewed focussed on issues related to race, class, sexuality, disability or other social identities. However, a recent focused collection on “Gender in Physics” in *Physical Review of Physics Education Research* presented an emerging focus on identity work in physics learning. In particular were articles encouraging PER scholars to move away from binary models of gender that tend to focus on differences between men and women (e.g., Traxler et al. 2016), and rather to examine how identity might be a useful lens for understanding physics experiences (e.g., Gonsalves, Danielsson and Pettersson 2016). The use of identity frameworks in gender research is already well-established in science education research (e.g., Brickhouse 2001; Carlone and Johnson 2007), so we begin this book from the position that PER scholarship focused on gender issues may benefit from this promising orientation.

1.2 Repositioning Gender Research in PER

The relationship between gender and science is a pressing issue not simply because women have been historically excluded from science, but because of the deep interpenetration between our cultural construction of gender, and our naming of science. The same cultural tradition that names rational, objective, and transcendent as male, and irrational, subjective, and immanent as female, also, and simultaneously, names the scientific mind as male, and material nature as female...Modern science is constituted around a set of exclusionary oppositions, in which that which is named feminine is excluded, and that which is excluded—be it feeling, subjectivity, or nature—is named female. Actual human beings are of course never fully bound by stereotypes, and some men and some women—and some scientists—will always go beyond them. But at the same time, stereotypes are never idle. (Fox Keller 1987, p. 279).

Since the 1980s, work of feminist theorists like Evelyn Fox Keller have compelled us to learn to count past two, that is, to challenge the dualisms that produce and reproduce men and women as different, and position them as naturally or unnaturally inclined towards masculinized subjects like physics. In the same period, empirical studies of physics cultures (such as Sharon Traweek's seminal anthropological work) also began to unveil how binary notions of gender are produced in physics. In 1990, Judith Butler gave us a language to begin to trouble the binary categories around which gender is constituted. The work presented in this book takes as a starting point that gender, like identity, is performative and fluid. Butler suggests that identity work involves a negotiation around subject positions (possible identities) that are simultaneously imposed and taken up. Applying various frameworks, all to some extent based in a fundamental notion of gender and identity as performative, the authors in this book approach gender not as a static trait that one possesses, but rather as something that is constructed between individuals in various social settings (like physics classrooms or labs). Thus, what it means to perform a feminine or masculine identity in these spaces can be context specific, and recognized differently in various situations. This approach to understanding gender in PER demands asking different questions about learning. For example, rather than asking "how do men and women learn these concepts differently?" we may ask "how are ideas about masculinity and femininity produced in these settings?" and then "how do people navigate these understandings in order to be recognized as competent in physics?"

This relational approach to gender demands that we also take into account identity and identity work. In past decades, identity has become a central theoretical concept in many disciplines, particularly science education. As this book will detail, identity frameworks have much to offer our understanding of gender in physics education research, yet identity has been undertheorized and underutilized in relation to physics learning. Frameworks that highlight identity work in physics can be used to explore how gender interacts with constructs like power, privilege, agency, discourse, positionality and inequity and how these are tied up in identity construction and trajectories into and out of physics. For instance, in her 2001 *Journal of Research in Science Teaching* article, Nancy Brickhouse argues that "in

order to understand learning in science, we need to know much more than whether students have acquired particular scientific understandings. We need to know how students engage in science and how this is related to who they are and who they want to be.” (p. 286) and advocates for the usefulness of a perspective on science education that consider learning as identity formation. From this perspective, identity is perceived as something we do rather than something we are (Carlone and Johnson 2007). Following Brickhouse’s influential work, this perspective on science education has been developed by scholars such as Angela Calabrese Barton (e.g., Calabrese Barton 1998) Heidi Carlone and Angela Johnson (e.g., Carlone and Johnson 2007), and Louise Archer (e.g., Archer et al. 2012), and colleagues. Building on the theoretical work of Dorothy Holland, James Gee, Pierre Bourdieu, and Judith Butler, these science education researchers are studying gender by examining identity work. This important work has gained significant purchase in science education research communities, and the recent focussed collection of PRST-PER suggests that the PER community is taking notice. By applying these performative perspectives of gender and identity to physics learning, we can begin to see that not all identity or gender performances are equally feasible. In physics learning environments ‘who’ can be recognised as a certain ‘what’ can be limited by situational and structural constraints (including the body of the individual). As argued by Gonsalves et al. (2016) such a perspective ‘helps us look more carefully at the complexities of gendered experiences in physics environments, rather than simply asking questions about what women need to succeed in physics’ (p. 3).

This edited collection expands our understanding of gendered participation in physics from a *binary gender deficit model* (Traxler et al. 2016) to a more complex understanding of gender as performative and intersectional with other social locations (e.g., race, class, dis/ability, etc). The work presented in this book contributes to a growing scholarship using sociocultural frameworks to understand learning and participation in physics, and that seeks to challenge dominant understandings of who does physics and what counts as physics competence. Studying gender in physics education research from a perspective of identity construction allows us to understand participation in physics cultures in new ways. We are able to see how identities shape and are shaped by inclusion and exclusion in physics practices, discourses that dominate physics cultures, and actions that maintain or challenge structures of dominance and subordination in physics education.

1.3 New Perspectives on Gender and Identity in PER

The chapters offered in this book present new perspectives on understanding identity in PER while at the same time constructing a broad picture of the complexity inherent in *doing* physics and *doing* gender. Various perspectives on gender and identity will be explored via commentaries and empirical evidence emerging from a range of participants (in upper secondary settings, and higher education settings),

employing a variety of research methodologies and analytic lenses. Several chapters take up examinations of the discursive practices that construct insider identities in physics. In Chap. 2 Louise Archer, Emily MacLeod and Julie Moote present data from interviews collected over 7 years from girls who had expressed aspirations to study physics. Archer and colleagues draw on concepts from Bourdieu to understand how girls move in, through, and out of physics. The data presented in this chapter, and its theoretical framing, help us to understand the gatekeeping practices present in the field of physics, and how these practices help to ensure the reproduction of the fields' elite status alongside the marginalization of women from the field. Louise Archer, Julie Moote and Emily MacLeod then present different data from the ASPIRES project in Chap. 4, this time with a focus on constructions of masculinity that permit a seamless or normalised trajectory into the study of astrophysics. Archer et al. once again draw on longitudinal data and a Bourdieusian framework to examine how interactions of capital, habitus and field work together to possibilise and normalise a male student's trajectory into becoming a physics student. This framework illuminates how notions of masculinity work with a discursive construction of cleverness that are normalised and demanded in physics, and how these work in positive ways for this student, but may operate to marginalise others.

New to the field of PER are perspectives on how intersectionality (e.g., Crenshaw 1989, 1991) can be taken up theoretically and operationalized in research on physics cultures. In Chap. 4 Angela Johnson provides an introduction to the framing of identity with an intersectional analysis in her chapter that explores intersectional physics identities, in higher education learning environments that seem to work well for women physics majors of colour. Unique to this work is her perspective that identity is not an individual experience, but rather a *feature of a social setting*. This opens up many possibilities for questions about how personal interactions, cultural features and structures in various settings can send messages about what kinds of people belong in those settings. The intersectionality lens Johnson applies here helps us to see how different kinds of people may experience the same setting differently depending on their various social identities and personal characteristics. Similarly, in Chap. 5, Diane Crenshaw Jammula and Felicia Moore Mensah present us with stories of students in physics labs that highlight the intersections of masculinity, femininity and racialized subjectivities, and how the alignment of White, middle class, masculine subjectivities with conventional physics afford male students the confidence to define what counts as physics in laboratory spaces. This chapter presents us with the innovative use of reflective journals as a data collection method, and an insider perspective as the lead author Crenshaw Jammula was also the physics class instructor.

Chapter 6 presents a different perspective on gate-keeping, this time considering the role that physics jokes have in constructing a discursive field that is accessible to some but inaccessible to others. In their chapter, Anders Johansson and Maria Berge explore the discursive construction of physics culture through lecture jokes in university quantum mechanics classes. These researchers draw on ethnographic data to explore questions about how physics lecture jokes may structure possibilities for students to identify with physics and as physicists, by constructing celebrated

subject positions through jokes, which may do the discursive work of positioning students inside or outside of physics.

Two contributions to this collection move the field into very new theoretical territory with the introduction of sociomaterialist and critical disability frameworks. In Chap. 7 Marianne Løken and Margareta Serder take up Barad's (1999) notion of 'intra-action' with material objects to understand women's educational choices that lead them towards physics careers. This framing helps us to understand how materials, and students' intra-actions with them may play a role in gendered educational choices. This post-humanist perspective on gender and the material has been well-developed in the field of science and technology studies (e.g., Asberg and Lykke 2010), but is very new in the field of physics education research, and will be of interest especially to those involved in laboratory design and out-of-school-experiences intended to attract diverse youth to physics. Also providing new theoretical perspectives to consider is the work of Adrienne Traxler and Jennifer Blue presented in Chap. 8. Like Johnson, these PER researchers remind the reader that gender is never the 'whole story', but rather only one way to signal 'not-belonging'. Traxler and Blue draw on DisCrit--a recent synthesis of critical disability and critical race theory--and crip theory, which studies the intersection of disability with LGBT identities to consider how we might begin to look beyond exclusively gender-focussed frameworks to understand identity work in physics.

Finally, in Chap. 9 Jaimie Miller-Friedmann presents the trajectories of successful women in physics through a narrative account of the strategies and tactics used by female academics who have had significant success in the field of physics. Miller-Friedmann's analysis demonstrates three significant experiences and identity negotiations that facilitated women's persistence in physics: 1) reliance on the self, 2) social support networks, and 3) the construction of a working class hero identity. This work presents suggestions for recruitment and retention of women in physics.

The book concludes with contributions for practitioners in physics education in higher education and upper secondary levels. Dimitri Dounas-Frazer discusses his positionality as a queer physics professor in higher education contexts and how this positionality informs his views on dualisms that shape social relations in physics. His commentary draws on lessons from the chapters in this volume that caused him to interrogate his professional and personal identities in relation to physics teaching, and pedagogical changes he has made in response to these reflections. Dounas-Frazer describes specific actions he has taken to "take gender seriously" in physics classrooms, including developing "accountability partnerships" with colleagues to support gender- and race-based equity in higher education physics contexts. Similarly, Christopher Gosling—a physics teacher in a secondary school in rural United States—interrogates his own positionality in relation to both physics and his physics students, in response to his reflections on the chapters in this book. Gosling provides his reflections on the chapters most salient to post-secondary physics environments, and highlights themes related to *gendered norms* in classroom practice, *cleverness* as a pre-requisite for success in physics, and gendered assumptions about *interest* in physics. He discusses how these themes have

influenced his own teaching, and provides advice and solutions for practitioners in secondary physics education classrooms.

Studying gender in physics education research from a perspective of identity and identity construction allows us to understand participation in physics cultures in new ways. We can see how identities shape and are shaped by inclusion and exclusion in physics practices, discourses that dominate physics cultures, and actions that maintain or challenge structures of dominance and subordination in physics education. The chapters offered in this book will focus on understanding why researchers in PER can benefit from identity framings and its usefulness in various contexts with various learner or practitioner populations. This scholarship collectively presents us with a broad picture of the complexity inherent in *doing* physics and *doing* gender, in the “culture of no culture”.

References

- Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2012). Science aspirations, capital, and family habitus: How families shape children’s engagement and identification with science. *American Educational Research Journal*, 49(5), 881–908.
- Åsberg, C., & Lykke, N. (2010). Feminist technoscience studies. *European Journal of Women’s Studies*, 17(4), 299–305.
- Barad, K. (1999). *Agential realism: Feminist interventions in understanding scientific practices* (pp. 1–11). The science studies reader.
- Beichner, R. J. (2009). An introduction to physics education research. *Getting Started in PER*, 2(1), 1–25.
- Brickhouse, N. W. (2001). Embodying science: A feminist perspective on learning. *Journal of Research in Science Teaching*, 38(3), 282–295.
- Butler, J. (1990). *Gender trouble: Feminism and the subversion of identity*. New York: Routledge.
- Calabrese Barton, A. (1998). Teaching science with homeless children: Pedagogy, representation, and identity. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, 35(4), 379–394.
- Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, 44(8), 1187–1218.
- Crenshaw, K. (1989). Demarginalizing the intersection of race and sex: A Black feminist critique of antidiscrimination doctrine, feminist theory and antiracist politics. In *University of Chicago Legal Forum* (Vol. 140, p. 139).
- Crenshaw, K. (1991). Mapping the margins: Identity politics, intersectionality, and violence against women. *Stanford Law Review*, 43(6), 1241–1299.
- Gonsalves, A. J., Danielsson, A., & Pettersson, H. (2016). Masculinities and experimental practices in physics: The view from three case studies. *Physical Review Physics Education Research*, 12(2), 020120.
- Harding, S. G. (1998). *Is science multicultural?: Postcolonialisms, feminisms, and epistemologies*. Indiana University Press.
- Heron, P. R., & Meltzer, D. E. (2005). The future of physics education research: Intellectual challenges and practical concerns. *American Journal of Physics*, 73, 390–394.
- Keller, E. F. (1985). *Reflections on science and gender*. New Haven/London: Yale University Press.
- Keller, E. F. (1987). On the need to count past two in our thinking about gender and science. *New Ideas in Psychology*, 5(2), 275–287.

- Scherr, R. (2016). Never mind the gap: Gender-related research in physical review physics education research, 2005–2016. *Physical Review Physics Education Research*, 12(2), 020003.
- Traweek, S. (1988). *Beamtimes and lifetimes*. Cambridge: Harvard University Press.
- Traxler, A. L., Cid, X. C., Blue, J., & Barthelemy, R. (2016). Enriching gender in physics education research: A binary past and a complex future. *Physical Review Physics Education Research*, 12(2), 020114.

Chapter 2

Going, Going, Gone: A Feminist Bourdieusian Analysis of Young Women's Trajectories in, Through and Out of Physics, Age 10–19



Louise Archer, Emily MacLeod, and Julie Moote

2.1 The Exclusion of Women and Femininity from Physics

The ‘gender problem’ in physics is a long-standing and widely recognised issue. Women remain under-represented in post-compulsory physics (e.g. Smith 2010a, b, 2011), despite decades of interventions aimed at improving the gender profile of physics (Darke et al. 2002). These differences are not the result of inequalities in female attainment in the subject (Haworth et al. 2008; Smith 2011; Tan et al. 2013; Tytler et al. 2008). Rather, attention has been drawn to the masculine *culture of science* (Harding 1998), and the multiple ways in which this disadvantages and excludes women (Blickenstaff 2005), through explicitly gendered curricula and representations of the subject (e.g. Baker and Leary 1995;) which girls struggle to find relate to (Calabrese et al. 2006; Calabrese Barton et al. 2008; Haussler and Hoffmann 2002), to the gendered biases of teachers (Carlone 2004), and these unconscious understandings people have developed in which physics is seen as being ‘for boys’, such that girls receive less encouragement from others to pursue the subject (Mujtaba and Reiss 2013). Indeed, even those women who pursue the subject at degree level find it hard to reconcile their femininity with a legitimate physics identity (Danielsson 2012; Gonsalves 2014).

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2.2 A Feminist Bourdieusian Conceptual Lens

Despite Bourdieu's relative lack of interest in gender in this work (cf. Bourdieu 2001), feminists have still found his theoretical tools useful and productive, particularly for reconceptualising identity – as simultaneously part of (produced by and incorporating) the social world (Bourdieu 1984, 1990; Bourdieu and Passeron 1972; Bourdieu and Wacquant 1992). As Adkins explains, 'the notion of the subject as not simply engaged with the world, but *in* the world, is one which has great appeal to feminists' (Adkins 2004: 10, emphasis in original). Bourdieu's theory breaks down the Cartesian dualism and provides a framework in which gender can be understood as not just a product of the mind/ consciousness. That is, his work provides a conceptual framework for understanding gender whereby 'mind and body, thought and action, are indissolvable' (Adkins 2004, p. 11).

Drawing on Moi (1991, 1999), Adkins (2004) argues that gender is best conceptualised as part of the general social field, being 'extraordinarily relational, with a chameleon-like flexibility, shifting in importance, value and effects from context to context or from field to field'. In other words, gender is both 'dispersed across the social field and deeply structuring of the social field' (Adkins 2004, p. 6). For feminists, Bourdieu's emphasis on embodiment is also highly congruent with feminist approaches to identity, as epitomised by his conceptualisation of the habitus (the internal framework of socialised dispositions which is both structured by and structuring of experience) as being both an embodiment of the social world (hexis) and a socialised body that shapes the social world.

While feminists have generally found little use for *Masculine Domination* (2001) per se, Bourdieu's sole text focusing on gender, there is a treasure trove of feminist extensions and adaptations of his main ideas. For instance, McNay (1999) extends Bourdieu to understand gender as 'a lived social relation which will always involve conflict, negotiation and tension' (Adkins 2004: 11), in which experience is always relational but not foundational. Lawler (2004) has also provided a feminist Bourdieusian analysis of how gendered and classed identities are conferred on subjects via cultural authorization by the media.

2.3 The Aspires/ Aspires2 Study

For our analysis, we draw on data that were collected as part of the Aspires/ Aspires2 project – a 10 year, mixed methods study of children's science and career aspirations from age 10–19 that was funded by the UK Economic and Social Research Council. Our wider dataset comprises large-scale national surveys of a cohort of students as they progress through primary and secondary schooling, combined with in-depth longitudinal interviews with a subset of young people and their parents (e.g. see Archer et al. 2017). However, for this chapter, we focus on a subset of interviews that were conducted with seven young women: Danielle, Davina, Hannah, Kate,

Table 2.1 Demographic details of the seven young women

Name	Science GCSEs	Science A levels	Post-18 destination	Social class	Ethnicity	Gender identity at age 18
Danielle	Double science	–	Sociology degree	Working-class	White British	Female
Davina	Triple Science	Maths, physics, chemistry	Gap year (with offer for Chemistry degree next year)	Upper middle-class	White British/ European	Female
Hannah	Triple Science	Chemistry, maths, further maths, physics	Physics degree	Upper middle-class	White British/ North American	Female
Kate	Triple Science	Biology, chemistry, physics, maths	Natural sciences degree	Upper-middle-class	White British	Female
Mienie	Triple science	Chemistry, Maths, Physics	Gap year (before taking up offer to do Chemistry degree)	Middle-class	South Asian	Female
Thalia	Triple science	- (<i>started but did not finish physics A level</i>)	Japanese studies degree	Middle-class	White British	Other
Victoria	Triple science	Maths, DT (<i>started but did not finish physics A level</i>)	HE foundation engineering course (with view to do electrical engineering degree following year)	Middle-class	White British	Female

Mienie, Thalia and Victoria (see Table 2.1). These young women were selected from the wider dataset on the basis that by 16 (Year 11, in the English school system), they had all expressed an aspiration to study Advanced level (A level¹) Physics. Interviews were conducted at five time-points; Year 6 (10/11), Year 8 (11/12), Year 9(12/13), Year 11 (14/15), and Year 13 (age 17/18).

As can be seen from Table 2.1, six of the girls went on to study advanced level physics (Davina, Hannah, Kate, Mienie, Thalia and Victoria) but the seventh, Danielle, was dissuaded by her school from taking the subject. Four of the young women successfully completed physics A level (Davina, Hannah, Kate and Mienie) but two were deselected from the course by their school part way through their studies (Thalia and Victoria). Only one young woman (Hannah) went on to study for a physics degree, although five of the seven young women pursued other science/STEM-related routes post-18. Using our analytic lens, we now explore the young

¹ Advanced Level / A level examinations are the 'gold standard' post-compulsory academic qualifications that are studied over 2 years with final examinations taken at age 18. A levels are the most usual qualifications that provide entry to university degree courses.

women's accounts in more detail to try to understand the processes at work which facilitate, or prevent, their physics trajectories.

2.4 Impossible Female Physicists – Girls Denied Entry and/or Debarred from A Level Physics

There were three girls (Danielle, Thalia and Victoria) who at age 15/16 had wanted to study A level physics but who ended up not achieving this goal. All three girls were interested in the subject:

I love Physics [...] I like it because Physics is kind of like Maths and English and it's one ... like it's ... if you were sitting in ... let's say [...] if you were sitting a Physics exam you can read the question and work ... do the equations and work it out, even if you knew nothing about what it was all about [...] That's what I like about Physics. It's kind of like common sense. (Danielle, Y11)

I was doing Psychology, but then I decided ... I was talking to my Physics teacher about Physics, because I really like Physics and he said he did think I'd do fine, because I didn't think I'd do well in Physics, but he kind of was like no, you'll do all right. You'll be fine, so then I changed Psychology to Physics. (Thalia, Y11)

I do enjoy Physics [...] I just like knowing how things work, what's going on out there in space and everything. Just I like knowing what's – why things do what they do. (Victoria, Y11)

In other words, none of these girls seemed to suffer from a lack of interest, aspiration or inspiration – as is so often assumed by initiatives aimed at encouraging girls into physics. Rather, in each case, as we now discuss, we interpreted their inability to continue as due to stringent gatekeeping – and practices of debarring – enacted by the education system.

Prior to taking her GCSE examinations (the national examinations taken at age 16 in England), Danielle had told her school that she wanted to study A level physics. In her Y11 interview she told us that the school had explained that acceptance onto the A level course would be dependent on achieving a B grade in science in her upcoming GCSE examinations:

I was going to take Physics but I've got to wait and get my results from my exams back because if I don't get a B, I can't do physics (Y11)

She chose psychology as a back-up subject, although maintained a preference for physics ("if I can get it"). In the end, after not attaining a B grade in Physics GCSE, Danielle studied Sociology A level (along with English, Media and Health & Social Care) because she did not attain the B grade in maths that was required for entry to Psychology A level. After her results, Danielle had asked her school again to be considered for A level Physics and although the teacher initially consented to possibly give her a 'trial', Danielle was informally persuaded that she would probably find the course too difficult and, in end, did not take up the trial offer.

I asked my teacher if I could do physics, even though I had a C and she said 'yeah' but then I got put off because apparently it's really hard (Y13)