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. Similarily, philosopher Sandra Harding has claimed that 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

A. J. Gonsalves (✉)
Department of Integrated Studies in Education, McGill University, Montreal, Canada
e-mail: allison.gonsalves@mcgill.ca

A. T. Danielsson
Department of Education, Uppsala University, Uppsala, Sweden
e-mail: anna.danielsson@edu.uu.se

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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 at 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 dis/ability 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".

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