Cultural Studies of Science Education (2023) 18:1255–1283
https://doi.org/10.1007/s11422-023-10201-3

ORIGINAL PAPER

Performing legitimate choice narratives in physics: possibilities for under-represented physics students

Anders Johansson[1] · Anne-Sofie Nyström[2] · Allison J. Gonsalves[3] · Anna T. Danielsson[4]

Received: 13 March 2023 / Accepted: 23 September 2023 / Published online: 30 October 2023
© The Author(s) 2023

Abstract

Higher education physics has long been a field with a disproportionately skewed representation in terms of gender, class, and ethnicity. Responding to this challenge, this study explores the trajectories of "unexpected" (i.e., demographically under-represented) students into higher education physics. Based on timeline-guided life-history interviews with 21 students enrolled in university physics programs across Sweden, the students' accounts of their trajectories into physics are analyzed as *choice narratives*. The analysis explores what ingredients are used to tell a legitimate story of physics participation, in relation to dominant discourses in physics culture, and wider social and political discourses. Results indicate that students narrate their choice as based on motivations of physics being a prestigious and challenging subject, of a deep interest in and a natural ability for physics, as well as a wish to use physics for contributing to the world. While most of these affiliations to physics has been documented in earlier research, the study shows how they are negotiated in relation to social locations such as gender, class and migration history, and used to perform an authentic and legitimate choice narrative in the interview situation. Furthermore, the study reports and discusses the possibility of conceiving the role of physics in students' lives as something beyond a "pure", intellectually challenging, and "prestigious" subject. In contrast, and with implications for widening participation, the stories of "unexpected" physics students indicate that physics can be reconceived as socially and altruistically oriented.

Keywords Physics · Widened recruitment · Study choice · University education · Nordic countries

Lead editor: A. Oliveira

✉ Anders Johansson
anders.l.johansson@chalmers.se

[1] Chalmers University of Technology, Hörsalsvägen 2, SE-412 96 Gothenburg, Sweden

[2] Uppsala University, Uppsala, Sweden

[3] McGill University, Montreal, Canada

[4] Stockholm University, Stockholm, Sweden

> Yes, I do believe that physics is quite male-dominated because of its culture. And because of the baggage that people come in with, I think. I believe many come in with a, what do you call it, Atlas complex. That the great smart man comes with his gigantic brain and just solves all problems. Smashes the theories. Just sweats testosterone all over the Nobel Prize. There are probably many who come with that view, in one way or another.
>
> (Thomas)

This quote from our interviewee Thomas frames several of the issues raised in this paper. It points to physics as a masculine field with a specific (gendered) culture and specific expectations on the normative physicist (Traweek 1988). In light of this, we want to study what nevertheless makes choosing physics possible for students from groups that are under-represented in physics, including women, and students with non-academic or migrant family backgrounds. By analyzing the accounts of our interviewees, students in the beginning of their university physics studies who responded to a call for stories of "unexpected" transitions to higher education physics, we highlight how physics can be approached and conceived differently. Can physics be a field not just for and about "the great smart man" achieving honor and recognition by solving "all the problems", but also a place where diverse people can contribute in many ways and to many causes? Much earlier research has focused on factors, activities or relationships that may support non-traditional students in science. However, we aim to take cultural norms in society as well as physics into account for analyzing the possibilities for under-represented students. Therefore, we start from the motivations for choosing physics in our interviewees' accounts to analyze their stories as bids to perform legitimate *choice narratives*, that is, stories that attempt to make sense of a certain choice, for oneself and others (Holmegaard 2015). In this framework, Thomas can be seen as presenting a counter narrative that challenges the masculine expectation that a physicist is supposed to be driven by a passion for understanding the world and simultaneously gaining prestige (or even Nobel Prizes) and instead conceptualizes physics as a tool for contributing to the world at large as well as one's local community. An uncommon narrative that nevertheless makes sense for him and some of his peers.

In general, the inclusion of "non-traditional" students in higher education has been a problem occupying policy-makers as well as researchers for years, with limited success (Shah, Bennett and Southgate 2016). Providing more equal opportunities is a matter of social justice, but it has also been argued that more diverse universities make for better research (Yang, Tian, Woodruff, Jones and Uzzi 2022), and widened participation in higher education is also a way of increasing the educated workforce, often seen as an important political goal. The case that is studied here, the "unexpected" paths into undergraduate physics, is special in several respects: First, physics is one of the fields of science and technology where the development toward gender parity has been slowest in most countries of the global north (American Physical Society 2018; Skibba 2019; Universitets- och högskolerådet 2022) with some variations between cultural contexts, including different European countries (Hasse and Sinding 2012) and Muslim majority or Western countries (Moshfeghyeganeh and Hazari 2021). In addition, students from minoritized ethnic/racial groups are also severely under-represented, for example women of color in the USA (Coble, Cunningham, Freeland, Hodapp, Hodari, Ivie, Martínez-Miranda, Ong, Petty, Seestrom, Seidel, Simmons, Thoennessen, Urry, and White 2013). This has been connected to the reproduction of an elitist, masculine culture of physics, in school (Archer, Moote and MacLeod 2020) as well as at universities (Gonsalves, Danielsson and Pettersson 2016). Second,

physics has a special kind of appeal, which may play a part in its still unequal composition. It is seen as one of the "hardest" sciences, both by virtue of being difficult to learn and by supposedly providing "hard facts" about the world (Schiebinger 1999). For this reason, physics is often considered a choice only for those specially interested and specially invested with the capabilities to take on the difficulties of understanding the "fundamental" relations of the world (Wertheim 1995). Although this may position physicists as "nerds" in some cases (Johansson 2020), studying physics is generally seen as prestigious. In the Swedish context, where engineering education is highly esteemed, this is especially true for the Engineering Physics program (Nyström, Jackson and Salminen Karlsson 2019). In light of these discourses about physics, we aim to explore how physics can be understood as a legitimate choice in the stories of under-represented students. More detailed research questions follow after the empirical and theoretical backgrounds to our analysis.

Previous research

To situate our study, we draw first on research documenting and seeking explanations for students' choices of STEM education, with a particular focus on physics, where certain motivation profiles have been documented. However, we argue that research of study choice needs to take both microsocial, macrosocial, and political aspects into consideration. Therefore, we also draw from sociological research about the relationship between class, gender, and race on study choice, as well as research situating students' choices in political educational agendas.

Study choice in STEM

Young peoples' choice of education has long been a concern. Since the decades after WWII, policy-makers as well as researchers have been preoccupied with the participation in higher education, and in particular higher education in Science, Technology, Engineering and Mathematics (STEM), raising concerns about democracy, equity and the state of the national workforce in international competition (European Commission 2004). In the global north, a purported declining interest for education in science and technology, both over generations (Schreiner 2006) and over most students' school careers (Anderhag, Wickman, Bergqvist, Jakobson, Hamza and Säljö 2016), has sparked a wide array of research approaches, enquiring into students' attitudes (Osborne, Simon and Collins 2003), aspirations (Archer, DeWitt, Osborne, Dillon, Wong and Willis 2013), identities (Tytler 2014), etc., in relation to science and technology. This research highlights the importance of the interplay between society and individual in structuring the pathways in and out of education. A central question concerns the under-representation of women and marginalized groups in science and technology subjects, and how widened recruitment and participation could be accomplished. Explanations for the gender differences in students' participation in STEM as a whole and within STEM have been sought for example by theories of self-concept (Sikora and Pokropek 2012), identities in late modernity (Bøe, Henriksen, Lyons and Schreiner 2011; Schreiner 2006), critical analyses of gender-based harassment (Barthelemy, McCormick and Henderson 2016), as well as bias in how science is conceived (Harding 1986). In a review of research on women's and men's differing choices in STEM education, Demet Yazilitas and colleagues (2013) outline three major approaches for explaining differences: A "micro" focus on social cognitive theory and notions such

as self-efficacy, a "macro" focus on culture and socialization, and finally, an institutional (meso) focus on the characteristics of educational systems. The authors argue that there is a need to bridge the differences between these approaches and call for more research that looks into the process of study choice.

Students' choice of physics

Physics has been singled out in relation to other sciences, both as a field where inequality in the representation of women and marginalized groups has persisted more strongly than other fields, but also as a subject sought by students with a particular profile, supposedly more interested in the subject as such compared to students in other fields (Sax, Lehman, Barthelemy and Lim 2016). While motivations for studying physics in upper secondary school may vary and be related to general motivations for studying science, like "extrinsic material gain" (Mujtaba and Reiss 2014), the choice of university physics has been strongly linked to intrinsic interest, across many contexts such as multiple European countries (Levrini, Ambrosis, Hemmer, Laherto, Malgieri, Pantano and Tasquier 2017), Norway (Bøe and Henriksen 2013), and the USA (Hazari, Sonnert, Sadler and Shanahan 2010). Many studies have compared the perceptions and profiles of women and men in physics. While differences in interest are found among students in secondary education (Häussler, Hoffman, Langeheine, Rost and Sievers 1998), or university students whose main field is not physics, (Adams, Perkins, Podolefsky, Dubson, Finkelstein and Wieman 2006), the most prominent differences are in the more positive experiences of physics in secondary school reported by boys (Hazari, Sonnert, Sadler and Shanahan 2010; Mujtaba and Reiss 2014). However, women and men in university physics programs overall seem to have quite similar motivations (Bøe and Henriksen 2013). Using an extensive survey data set for studying the profiles of women choosing university physics in the USA, Linda J. Sax and colleagues (2016) found that they tend to be overall more focused on physics as a subject and doing research, while having less of a "social activist orientation", compared to women in other fields. Given the identified centrality of an interest in the subject for actively choosing physics, it was added to the model of physics identity developed by Hazari, Sonnert, Sadler and Shanahan (2010) based on the work of Heidi Carlone and Angela Johnson (2007). Despite this, Maria Vetleseter Bøe and Ellen Henriksen (2013) note that the Norwegian university physics students in their survey were able to combine an interest in physics with an aspiration toward an idealistically oriented career, perhaps representing an emerging trend of "the idealistic physicist".

A stated interest or passion for a subject such as physics needs to be interpreted in relation to social expectations. It is part of telling a coherent story and performing a recognizable identity (Madsen and Holmegaard 2022). A story about one's long interest or deep fascination for physics, especially if it goes back to one's childhood, is a way of performing an authentic physics identity (Hasse 2008). However, given that physics is generally perceived as hard, nerdy, masculine and for the inherently smart (Francis, Archer, Moote, DeWitt, MacLeod and Yeomans 2017) the stories available to tell about your own choice of physics become limited. In a study examining mechanisms that dissuade women from choosing higher education physics, Archer, Moote and MacLeod (2020) note that the women in their sample are pushed out of a higher education physics career through perceiving themselves as not smart enough. Men opting out of physics often describe themselves as more interested in other fields, avoiding to present themselves as "failing" in physics. In this way, the important feeling of whether a field such as physics is "for me", is strongly structured by cultural discourses about the subject.

Individual choices and societal discourses

The studies discussed above point to the necessity of centering power for understanding paths into the university. In educational sociology, it has been shown that the choice to study at university and what to study at university is strongly structured by social class. Following Pierre Bourdieu, researchers have analyzed how education often amounts to a reproduction of class privilege, showing how the expectations of parents for students to choose (or just accept parents' decisions) wisely in a class-structured education market becomes a significant factor in educational decision-making (Pugsley 1998). Choosing what to study becomes a "choice of lifestyle" (Ball, Davies, David and Reay 2002, p. 53) and has been found to involve concerns about choosing a good enough university (Reay, Davies, David and Ball 2001) as well as fitting in and becoming respectable. Fitting in also comes with the risk of "losing yourself" when a working class-identity needs to be matched to the middle-class values of the university (Reay 2001). Some of the limited research about men with a working-class background in physics has, however, shown that these students can draw on their experience as skilled tinkerers to find a valued position in experimental physics (Danielsson 2014). In the UK, where most of the previously mentioned studies are situated, and in the USA, elite status is often attached to institutions, leading Reay, Crozier and Clayton (2010) to analyze how the "institutional habitus" of a university matches students' class habitus. In the Nordic countries, where education is free, elite status is not as strongly structured by the difference between universities but can vary considerably within the larger universities depending on educational program (Nyström, Jackson and Salminen Karlsson 2019). For example, most university physics education in Sweden is relatively prestigious. This highlights the need to also theorize the interaction between institutions and students in terms such as "disciplinary culture" (Madsen and Holmegaard 2022). While there is an expectation that working-class students will have to "adapt" to fit in and become "respectable" (Burke 2007) at university, middle-class students have been found to be expected to engage in a prolonged "self-regulation" since their early school days in the process of class reproduction (Reay 2001), perhaps explicitly fostered by the "concerted cultivation" (Lareau 2011) pursued by their parents. Nevertheless, the massification of university education and the emphasis on widened recruitment have lead to a structure where "non-traditional" students are mostly recruited to "non-traditional" (that is, newer and with lower status) universities and programs, in countries such as the UK (Archer 2007), Australia (Cunninghame 2022), and Sweden (Beach and Puaca 2014). At the same time, in response to the intersection of class and racial marginalization, students from immigrant backgrounds often aim for as "good" education as possible to counteract their positioning in society (Reay, Davies, David and Ball 2001).

Another facet of the social structuring of study choice comes from the expectation in late modern societies of performing an authentic identity while at the same time adapting to neoliberal expectations of employability (James, Mallman and Midford 2021). An authentic study choice is free and based on a personal interest (Holmegaard 2015). Pursuing one's passion to study a supposedly more interest-driven field, like arts (James, Mallman and Midford 2021), computer science (Ottemo 2015), mathematics (Mendick, Moreau and Epstein 2009), or physics (Johansson 2020) thus means subjecting to the expectation of authenticity, while at the same time possibly challenging expectations of employability. While choosing a study path based on authentic interest or "self-realization" is a "pervasive cultural ideal," it is still a "privilege of the few" (James, Mallman and Midford 2021, p. 468) given increasingly precarious labor markets. It has been argued that the imposition

of this pervasive "passion principle" serves as a way to exploit workers in both blue-collar and white-collar jobs, and doesn't provide the expected well-being promised by a career based on one's interest (Cech 2021). Another demand for authenticity is put on those from under-resourced communities, like children of immigrants, for which a choice of a prestigious educational program may need to be constructed as authentic by recounting having "always loved" the subject and "not being pushed" by parents, as shown by Marianne Takvam Kindt (2018) in a study in Norway. Otherwise, the choice risks being seen as "traditionalist" (non-modern) or fuelled by a drive for social mobility, clashing with the expectations for free, personal and authentic choices. The expectation for certain types of authenticity also structures the stories that can be told about class mobility. In a study of working-class students at elite colleges in the USA, Hurst and Warnock (2015) point to how a certain, "miraculous", narrative of class-mobility is the only legitimate one in this context, legitimized by how these students are part of special opportunities programs. In this narrative, coming from a lower class background is not a disadvantage as long as you are overcoming these odds by hard work and determination. However, there is no room for complaining about one's marginalized position. This class-mobility narrative frames the educational system as fair and meritocratic, conserving the elite status of these universities. Education, in an analogy borrowed from Bourdieu, becomes a kind of salvation for those of the poor proved worthy, legitimizing current inequalities.

Study choice is influenced by multiple forces, an interaction between the "micro" of psychological experiences, and the "macro" of habitus, field or societal discourses. A further influence, particularly salient for students considering STEM, is the concerted efforts by governments and other organizations in the global north to recruit students to STEM education. In light of the never-ending reports on the decline of interest in science and technology, a multitude of policies to make science and technology a preferred choice have been put in place, since the 1950s, in countries such as the USA (Lucena 2005) and Sweden (Lövheim 2014). Based on a purported need for "scientific manpower" (Kaiser 2002) as well as equality concerns, these developments have led to girls' "non-traditional" choices of technology becoming symbols of gender equality and modernity in countries such as Sweden (Hedlin 2011). While upholding the basic idea of a "society of free choice", these efforts do represent a form of governing of students helpfully characterized as Foucauldian "governmentality", where societal expectations are expected to be internalized and enjoyed (Lövheim 2014). That (STEM) study choice is a "politicised concern" (Holmegaard 2015, p. 1458), and that some choices are more sanctioned than others is, however, sometimes also recognized by students. An example is given by an interviewee in Holmegaard, Ulriksen and Madsen (2014, p. 32), who recounts that he does not want to be influenced by a career counsellor because he cannot trust them to be neutral, and instead explains that he wants to make a free and individual choice.

The studies of students' interest for physics, and the cultural and structural barriers to widened participation reviewed above provide a background for understanding how students participate in physics. In our view, it is important to approach the question of underrepresented students' choices of physics in a way that is sensitive to the macro- and micro-influences on choices, and that takes the political ramifications of making such a choice into account. For whom, why and when is it legitimate to choose physics? How can such a choice be recognized? To approach the question in this way, we turn to discursive and narrative theory.

Performing legitimate choice narratives: theory

Building on previous research in the field, we understand study choice as a process that is affected by many influences, a process of "decision-making" that can hardly be seen as a "free" choice (Ball, Davies, David and Reay 2002). We want to analyze what makes a choice of physics possible and legitimate in the context of our interviewees' lives. To do this while attending to social and political influences, we draw on poststructuralist discourse theory as well as narrative psychology. Here, identities are seen as performative, constructed through repeated actions and retellings of stories that make sense in the predominant discourse structuring how the world is interpreted (Butler 1990). Recounting of personal experiences is part of the process of identity construction, narrations of the self in different situations. It is common to limit the concept of narrative to mean a unit of text with a certain temporal structure, "a particular kind of discourse—the story" (Watson 2006, p. 511). While this notion of narrative is convenient for analysis, we prefer to define narratives in terms of *function* rather than *form*. Central to this definition is the organizing role that narratives play: a narrative is an organizing collection of statements that make sense of events, including social actors and locations. While our research is based in life-history interviews, the conceptualization of narratives here is not as someone's life story, but rather as a specific performance of identity, an account that makes sense of who you are by means of past, present, and future events, contingent on the interview context and situation at the time of the interview (Holstein and Gubrium 2000).

In the framework, we adapt for our analysis, someone's description of a choice is part of a *choice narrative*, an account that makes the choice intelligible in relation to a person's performed identity and their background, present and future (Holmegaard 2015). We draw from the elaboration of the concept of choice narratives by Henriette Holmegaard and colleagues, who analyze what is needed for performing choice narratives that can be interpreted as legitimate, primarily in relation to choices of higher education STEM. A few central aspects of choice narratives that we use for the present analysis are: coherence, personalization and recognition. A general expectation of coherence for narratives means that stories about study choices are often revised to fit the current "centre of the story". This means that when following up on students in longitudinal studies, what they maintain to "always" have liked, which "indicates a choice well-reasoned, motivated, and stable" (Holmegaard, Ulriksen and Madsen 2015, p. 37) may actually change from interview to interview. Our data are not longitudinal, but we nevertheless aim to analyze the elements constructing coherence in student narratives. Given the expectation for authenticity in late modern societies, a central aspect of choice narratives is that they are "personalized". This means that they should be "constructed without interference from others" and that they have to "appear as not too predictable, as natural and suitable to the person choosing, realistic and adjusted to personal capabilities and not too narrow to leave some room for interpretation" (Holmegaard 2015, p. 1475). Last, choice narratives need to make sense in a student's social context, they need to be intelligible, but also "recognized" by friends, family and others (Holmegaard 2015). We aim at analyzing the recognition of narratives, that is: how our interviewees could explain that their choices made sense to others, how they are presented to the interviewer, and how they relate to broader discourses of what a reasonable choice can be. This is in contrast to an analysis of the recognition of people or identities, as is commonly done in science identities research (Carlone and Johnson 2007) and other work on student identities (Burke 2007).

In conceptualizing the role of study choices for different students, we additionally draw on the notions of "normal biographies" and "choice biographies" (Du Bois-Reymond 1998), which aims to capture the traditional normalcy of following the expectation of your family and class toward a (highly gendered) occupation and family life, versus the more open, exposed and differently gendered situation for young people in late modern societies (Beck 1992). Along with these developments, legitimate choice narratives in late modern societies include showing the ability for governing oneself, "that is, to act as and be perceived as independent, authentic subjects who take on the responsibility to manage their own lives" (Holmegaard, Madsen and Ulriksen 2014, p. 210, drawing on Foucault 1997). Apart from society-wide conditions, another arena for legitimizing choice narratives are the specific narrative repertoires enabled by the disciplinary culture that students move into (Madsen and Holmegaard 2022). We argue that even though the students who are part of our study are newcomers to university physics, some "scripts" are more recognizable in their various stories of moving into physics, related to the general discourses about physics and physicists outlined above. Finally, we are interested in how the accessibility of certain scripts is structured by gendered, classed, and racialized discourses, coupling certain social locations to certain choice narratives (such as the miraculously successful working-class student, Hurst and Warnock 2015). Thus, as will be shown in the analysis, while our interviewees belong to groups that are under-represented in physics, their differing social locations may enable different ways of presenting legitimate choice narratives. In line with our theoretical framework, we analyze social locations (such as working-class girlhood in Sweden) as narratively constructed in interaction, rather than as reports on material conditions and educational trajectories (Anthias 2005). Paying attention to the intersecting relations between class, gender, and race/ethnicity/migration background, we adopt an intersectionally aware (Crenshaw 1989) analysis of students' social locations. This means that we investigate how educational choices and social locations are co-constituted in the students' narrations about themselves and their life history.

Aims and research questions

Our overall aim is to analyze how legitimate (personalized, coherent and recognizable) physics choice narratives are constructed, in relation to different social locations (based on gender, ethnicity/"race", class, etc.). We do this by exploring what motivations are mobilized in under-represented students' explanations of their choice of studying university physics, and how these motivations can or cannot be included in a legitimate choice narrative. Our research questions are:

1. What motivations for studying physics are mobilized for performing legitimate choice narratives?
2. How are legitimate physics choice narratives co-constituted with social locations?

Materials and methods

Research context

This study is situated in the context of Swedish university education. Overall, Sweden's educational system as in other Scandinavian countries, is characterized by the development of the social democratic welfare state, which involves education without tuition fees (currently only for EU/EAA citizens) and relatively generous student allowances and loans. Despite the limited economic obstacles, class differences in participation in secondary and tertiary education still persist, pointing to how "HE choices in a Scandinavian context are regulated by social structures that are internalized and performed by the individual" (Holmegaard 2015, p. 1474). Furthermore, inequality and class-based segregation between schools have been growing in recent years, attributed to processes of marketization with the introduction of government-funded but privately owned schools, and the free choice of school (Dahlstedt and Fejes 2019).

While Sweden is considered one of the most gender equal countries in the world (ranked 5th in the Global Gender Gap Report of the World Economic Forum 2021), large gender gaps persist in educational participation (Jämställdhetsmyndigheten 2022) and in the labor market (Ellingsæter 2013). This is particularly clear in some fields of natural science (like higher education physics) and engineering. University education in Sweden mostly follows the European tradition where students attend specialized programs of study from the start of their time at university. For the purposes of this study, we consider two types of programs, offered at several universities, as those educating physicists, the Bachelor of Physics program and the Engineering Physics program. In contrast to many other contexts, engineering in Sweden has a relatively high status, and Engineering Physics programs are highly regarded, relatively hard to get into, prepare students for possible careers both in business and academic research, and is generally more well-known than Bachelor of Physics programs (Nyström, Jackson and Salminen Karlsson 2019). As of 2022, physics programs awarding either a Bachelor/Master in Science or Master in Engineering degree are offered at 11 Swedish universities, primarily larger research-intensive institutions. Among newcomers to these physics programs in Sweden, the percentage of women have varied between 20 and 25% over recent years (Universitets- och högskolerådet 2022). Less detailed data are available for gaps based on class and migration background. In general programs of natural science and master of engineering, these gaps are, however, indicated by statistics showing the large over-representation of students with highly educated parents and smaller over-representation of students with Swedish background. 63% of engineering students and 50% of natural science students have parents with more than 3 years of university education, whereas the percentage in the general population of age 19–21 is 30% (SCB 2020). Similarly, one or both parents are born in Sweden for 81% of engineering students and 70% of natural science students, whereas the percentage in the general population of age 19–21 is 69% (SCB 2022).

Data collection

This paper is part of a larger study exploring the trajectories of students into higher education physics. The study is focused on students who are under-represented in physics

Table 1 List of participating interviewees and some characteristics of their background and their story

Interviewee	program	Gender	Parents' class	Parents' birth country	Prestige & ambition	Interest & ability	Wanting to contribute
Hamid	BSc	♂	W-STEM	Global south	○		○*
Rakel	BSc	♀	M-STEM	Sweden (lived abroad as a child)		○	
Frida	Eng	♀	M-STEM	Sweden	○*	○	
Bruno	BSc	♂	M-STEM	Sweden, Europe (moved to Sweden in teens)		○	
Lisa	Eng	♀	M	Sweden		○	
Ella	BSc	♀	W	Global south (moved to Sweden in early teens)	○	○	●*
Mattias	BSc	♂	M-STEM	Sweden	○	○	
Lukas	BSc	♂	M	Sweden, Global south		○	
Denis	Eng	♂	M	Global south (moved to Sweden before starting school)	○*	○	○
Omar	BSc	♂	W	MENA[1]	∽*	●*	
Abdel	Bsc	♂	W	Sweden, MENA	○	●	
Thomas	BSc	♂	W	Sweden	∽*	*	●*
Emma	Eng	♀	M-STEM	Sweden	*	○	
Moa	Eng	♀	M	Sweden		○	○*
Linn	BSc	♀	M-STEM	Sweden, Scandinavia		●	
Amir	Eng	♂	M	MENA		●	○*
Erika	BSc	♀	W	Europe		●	
Julia	BSc	♀	M-STEM	Sweden		●*	*
Jennifer	BSc	♀	M-STEM	Sweden, Global north (part of school in fathers' country)		●*	*
Karin	BSc	♀	W	Sweden		●	●*
Oskar	BSc	♀	STEM	Sweden		●	○

We have categorized the interviewees' class background by a rough categorization of the occupations and education of their parents into middle-class (M) and working-class (W), noting if there is a STEM component to the occupation. One or two parents who are engineers (quite common) gets designated M-STEM, whereas a technically interested parent without formal education (like Abid's father) can be designated W-STEM. Regarding national background, we indicate parents' birth-country and note that almost all interviewees grew up in Sweden. Exceptions about the interviewees' own migration history are noted in parentheses. The columns "Prestige & ambition", "Interest & ability", and "Wanting to contribute" are used to indicate how dominating that particular motivation for studying physics was in the stories. A ○ indicates that a motivation was present and used in the choice narratives. A ● signifies a dominating or strong narrative about that motivation. A ∽ indicates an ambivalent or opposing discussion of the motivation. A * Indicates that the story of this interviewee is elaborated on in the corresponding section below

[1]Middle-east and North Africa

in Sweden today (that is, women, mature students, students from non-academic or with migration backgrounds), and based on individual interviews with students.

Interviewees were recruited through visits by the research team to inform about the project in lectures for first or second year students, as well as posters put up in physics departments. The information included the project's focus on "unexpected physics students", but it was also stressed that we were interested in recruiting students from all sorts of backgrounds. Interviews were conducted by Anna Danielsson and Anne-Sofie Nyström, in person or over video call during pandemic restrictions. In total, 21 students were interviewed, 10 women and 11 men, enrolled either in Engineering Physics or Bachelor of Physics programs at three different Swedish universities. An overview of the interviewed students can be found in Table 1.

The interviews took a broad, life-history approach to exploring the interviewees' science trajectories and their identification in terms of a range of social categories, e.g., gender, age, social class, ethnicity, and dis/ability. Such an approach is concerned with understanding a person's account of their life, in particular how this life story is related to wider socio-political contexts (Goodson and Sikes 2001). The interviews also focused on students' identification with and aspiration toward science in general and physics in particular and aimed to elicit their experiences of informal and formal science education practices. To structure the interviews, a timeline method was used (Adriansen 2012) where participants were asked to construct a timeline with paper, sticky notes, and markers (or digital equivalents) to indicate important events related to physics. Introducing this method, the interviewer indicated that the timeline is a tool for helping to center important events and circumstances in the interviewee's story. The timeline was constructed in collaboration between interviewer and interviewee and is a visual artifact that simultaneously emphasizes a chronological and causal connection between events, highlights gaps and ambiguities and allows for a reflexive and complex retelling of one's history. In our interviewing, we were open to detours and contradictions, in recognition that life is not necessarily simple and linear, but with the timeline as an anchor in aiding reflection and reconstruction of important events and processes (Gray and Dagg 2019). Participants were asked about experiences with their families, in and outside school, and to describe moments where they felt physics was more or less "for me", which is indicated by previous research to be central elements in choosing (or considering not to choose) physics (Archer et al. 2020). The interviews were conducted in Swedish, lasted between 60 and 120 min and have been transcribed by professional transcribers.

In the analysis, we have used the Swedish transcripts; excerpts included in the manuscript have been translated to English. The translations have been made to capture the meaning of utterances, rather than being strictly literal, and some gentle editing, for example removal of false starts (ums and uhs), has been done to enhance readability. The project adheres to the ethical guidelines of the Swedish Research Council and has undergone ethical vetting (due to handling of sensitive personal data) and been approved by the Swedish Ethical Review Authority. The participating students have been informed about the purpose of the project and have given written consent to participate. All participants have been assigned pseudonyms. Furthermore, as the community of physics students in Sweden is relatively small, special care has been taken to keep descriptions of universities as well as some students' or parents' countries of origin vague in order to preserve confidentiality. This does, however, create some limitations for discussing racialization in detail and risks homogenizing the experience of migration. To make our case without exposing our interviewees, we use broad categories such as Europe, Global South, and MENA (Middle-East

and North Africa) to capture enough of the nuance in our interviewees' backgrounds and what type of prejudices or discrimination they may be exposed to in Sweden.

Analysis

The analysis aimed to connect the micro-level of interviewees' study choice with the macro-level of societal discourses. We are interested in what makes it possible to *understand* a choice of physics as legible as well as legitimate, which means that we are not looking for factors or events that can be said to be causal influences of our participants' choices, even if that was a common frame for the discussions in the interviews. Instead, we are looking for how physics choice narratives are made recognizable, personalized and coherent, interpreting the interviewees accounts as performing a discursive function (Holmegaard 2015). To do this, we started by a general inductive coding of all instances of descriptions of choices of study and motivations for these choices. This was done on the full transcripts of the interviews, by Anders Johansson, and resulted in some broader and some more specific codes such as "prestige", "interest → childhood → astronomy", "choices → expectations → from parents", and "choices → motivation → contribute or change society". By collecting and comparing these codes, a few broader themes discernible across the interviews and corresponding to earlier research were identified. These themes were discussed and validated with the full group of authors, who had either conducted some of the interviews or fully familiarized themselves with the interview transcripts. Overall, this confirmed that we had a few common groups of "motivations" mobilized for explaining a physics choice (prestige and ambition, interest and ability, and wanting to contribute; presented below in the first subsection of the findings). Anders Johansson and Anne-Sofie Nyström mapped whether, and how strongly each interviewee mobilized these motivations (represented in Table 1), providing an answer to our first research question. Interpreting the students' descriptions of choosing physics, their motivations and negotiations, as *choice narratives* (accounts making sense of events, Watson 2006), we searched for patterns in how choices were explained as personal, how recognition was sought from the interviewer, or discussed as given or not from others, and how choice narratives were constructed as coherent. To answer our second research question, we mapped these patterns to the students' positionality in terms of demographics, but also paid attention to how certain choice narratives could be used to tell a story "locating" a person in social space, i.e., *performing* a social location. Drawing on these patterns, extensive analysis drafts were written, containing extracts and interpretations of the data, analyzed in relation to previous literature. These were discussed and revised by the author group, resulting in the final analysis as presented here.

Researcher positionality

In line with a feminist research tradition, we aim to avoid presuming a "view from nowhere" (Haraway 1988) and instead take the role of our position as researchers into account. First, while several of us are academics with non-academic background, the two interviewers who each conducted half of the interviews are both white women from a Swedish background, and from a generation older than most of our interviewees. They are both educational researchers but with a social sciences background and a physics background. This plays a role in how the interviews play out, for example in influencing what appears to be needing explanations in the interviews and what can be left as shared

assumptions. More details and reflections about cultural expectations are given by interviewees with an immigration background. More physics references are discussed with the interviewer with a physics background. Furthermore, we have positioned ourselves and the project as focused on equity, which means that we are at times seen as allies in some of the students' struggles with adversity. Similarly, the framing of our project as focused on "unexpected" students' paths into physics may be positioning the goal of equity work as getting a breadth of people to study physics at university, an assumption that may direct the interviewees' accounts of their experiences to those that fit such a framing, excluding other relationships with physics. However, we believe our open life-history approach to the interviews have still allowed for variations in explanations and experiences to be told. Being a mixed-nationality, though mainly Swedish, research team has provided some benefits in nuancing our analysis and interpretations, where assumptions about the Swedish system and culture have needed to be explained.

Findings and discussion

Our findings are presented in two stages. First, in the first section below, we outline the grounds used by our interviewees for motivating their choice of a physics education, summarized as three groups of related "motivations" for studying physics: A drive for prestige and challenges, a natural inclination and interest, and a will to contribute to one's community or society. This addresses research question 1. Table 1 contains an overview of the interviewees and what motivations are mobilized for explaining their choices, along with indications of how important each motivation was in the explanations and which accounts are referred to in the following text. Second, in the subsequent three sections, we present our analysis of how these motivations are used to perform a legitimate choice narrative and how this narration is dependent on and constructs certain social locations. These findings are presented in an integrated and dialogue with previous literature, and address research question 2.

What motivations are mobilized?

Prestige and ambition

Several of our interviewees related to how physics is seen as a prestigious subject, and a study choice that communicates ambition and a high intellectual ability. This aspect of physics was mobilized as motivating in a few different ways by several, but not all, of the interviewees. For some, choosing physics corresponded with an expectation to study a prestigious subject and get a "good" job, expressed by parents, others or oneself. There were only a few who explicitly expressed that prestige was an important motivation for their choice (Frida, Denis). Still, more of the interviewees mobilize a notion that underpins the idea of physics as prestigious, namely that the discipline is challenging and that they are well-suited for this discipline in that they are ambitious and driven by a desire for challenges (Frida, Ella, Mattias, Moa, Linn, Julia), a narrative that could easily be recognized by their peers. Several of the interviewees have also sought out challenges in their secondary school years by participating in science competitions and internships, which has encouraged their participation in physics (Gonsalves, Johansson, Nyström and Danielsson 2022). Some of our interviewees (Bruno, Ella, Omar, Moa, Linn) are inspired by

well-known physicists, aspiring in some ways to be like them. However, while being a physicist is seen as inspiring, some also discuss how the elitism, arrogance and competition in physics culture is off-putting to them (Lukas, Omar, Thomas, Amir, Julia), the flip-side of the coin of a prestigious education.

Interest and ability

While physics as challenging and thereby prestigious was mobilized more or less explicitly by a few of the interviewees, a clear majority mobilized "interest" as the basis for their choice of education. This is of course not an unexpected basis for any choice of vocation or education (a central part of any choice narrative, Holmegaard 2015), which makes these narratives highly recognizable. However, in the case of physics this choice also follows a familiar script of the curious child wanting to understand how things work, and proceeding through school or out-of-school science toward a career in physics, the story of the "child physicist" (Hasse 2008), a biographically coherent narrative. Many of our interviewees mobilized some aspects of the child physicist narrative, describing themselves as curious, with an interest in nature or in understanding how things work, going back to their childhood. For some, this script is a reoccurring narrative in the interviews, where an almost life-long passion for physics or astronomy (Linn, Amir, Erika, Julia, Karin, Oskar) or more generally for understanding nature (Bruno, Omar, Emma, Moa) became a central ingredient of the story. For others, an interest in physics developed in later school years or even after formal schooling (Rakel, Ella, Lukas, Denis, Abdel, Jennifer). Some also described physics as one of several equally interesting possible choices (Frida, Lisa, Ella, Mattias). Notably, three interviewees did not discuss an interest in physics in particular as an important motivation for their choice (Hamid, Denis, Thomas). It can also be noted that compared to the Bachelor students, none of the students on the Engineering Physics program except Amir drew strongly (indicated with filled circles in Table 1) on an interest-based motivation in their narratives. This is consistent with earlier findings that many students on this type of program choose it because it is well-reputed and provides many future opportunities, rather than due to a strong interest in physics (Andersson and Linder 2010).

Related to a general interest for science, our interviewees often said that science-related subjects have been where they performed best in school, describing themselves as maths people rather than text people. Moa's experience of "enjoying structure and logic" and "solving exercises and understanding […] how different concepts work out" mirrors the picture many others have of maths and physics, of having and enjoying a "scientific way of thinking" (Holmegaard, Madsen and Ulriksen 2014). This fit between one's ability and the characteristics of science in general and physics in particular makes the choice coherent and personalized. In addition, many of the interviewees related the recognizable story of possibly being seen as a geek in school, when having a science mindset and performing well. A shared interest for science was, however, also a basis for community and friendship for some interviewees who could find peers in school (if they went to a more study-oriented, elite, school) or outside.

Making a contribution

We found a limited, but noteworthy, mobilization of idealistic notions of wanting to "help others" or "make a contribution" in the choice narratives of our interviewees. Somewhat surprisingly, some of our interviewees describe that as "unexpected" physics students, their

choice of physics is a kind of contribution in itself, in that they can act as role models or disturb the status quo (Hamid, Moa, Jennifer, Julia). Several interviewees (Hamid, Ella, Denis, Thomas, Amir, Karin, Oskar) describe their choice of a good university education as a way of giving back to their family, a notion of helping others that can be based both in the expectations of the family or a more individual desire to give back. Others draw on wider notions of contributing to society in general—like Ella, who wants to help others with backgrounds similar to her to get access to science, or Thomas, who sees the collective effort of bringing science further as a highly social and political goal. In the final section below, we will explore in detail how such motivations are possible to mobilize in more or less legitimate choice narratives.

Aspiring toward a prestigious education

How and for whom is it possible to mobilize a desire for prestige as part of a legitimate physics choice narrative?

For Denis, prestige took a central role in explaining his choices. His family expected him to prepare for an upper middle-class profession, which boiled down to three possible career choices:

> I think it [the enrolment in Engineering Physics] probably has a lot to do with the fact that my father was an engineer and that there was a lot of pressure in our home that we should study at the university, and that of all these educations that I, so to speak, got to choose among at home […] Either you become a doctor or an engineer or a lawyer. That's how it was. Because my dad always said: "I did not move to Sweden so that you could become an assistant nurse or a cleaner or something". It was either of those three fields for me. Well, then I had to choose what I liked most among the three, and it was maths and physics. That's where the engineering education came from.
>
> (Denis)

Denis's narrative suggests that familial expectations to study a prestigious path were forceful. Among his limited choices, he finds physics interesting enough, but does not explain his choice of engineering physics as driven by a particularly strong interest in the subject as such. Compared to interviews with other participants, Denis's admission of his own limited agency in making a study choice stands out. Although we cannot be sure how recognizable this choice narrative is among family and friends, it clashes with the discourse of free choice that dominates societies in the Global North such as Sweden. Denis's distinctly immigrant-coded narrative of mobility toward good careers means he makes the "right choice" with the "wrong motive" in relation to societal discourses (Kindt 2018). While the actuality of family pressure was mentioned in other interviews, no other interviewee spoke about *their own* choice of higher education as highly influenced by their family.

For many of our interviewees with a Swedish middle-class background, going on to study a good subject at university was more of an obvious and internalized expectation, part of a "normal biography" (Du Bois-Reymond 1998) for this generation with academically trained parents or even grandparents. Studying at university is normal, "it's just what you do" when you have two university educated parents, as Linn explained. Choosing to study at the university at all is an obviously recognizable choice here. In addition, studying physics in particular can include wilder dreams of also doing great things, like when Omar described his ambition to become a theoretical physicist as "doing Einstein's homework",

which he immediately confesses is "dream thinking" as there is still a long way to go to reach such a position. Hamid was also inspired by "cool" people in science but referred more clearly to the desirable positions of people such as one of his cousins, who is a researcher, people who can form more realistic role models. The elite status of physics was, however, denounced by some interviewees, notably those from a working-class background and with negative experiences of elitism in school (Omar, Thomas, Amir), who described that they did not want to take part in an environment of competition. Omar had met a kind of arrogance among physics students, and said that the competitive nature of physics and research, compared to the idealistic picture he had of it before, has made him consider the wisdom of his choice at times (see also Larsson and Danielsson 2023). Thomas, who we quoted in the introduction joking about the idea of the arrogant great physicist man who gets a Nobel Prize, also expressed a kind of admiration for some of his fellow physics students who displayed such deep dedication and dreams for physics that they have the "absurd thought of getting a Nobel Prize in something". Pretentious physics students can thus be seen as arrogant when "going Einstein" (Johansson 2020) but also admirable in their ambition. Overall, relating explicitly to notions of prestige seems more common for those who cannot easily follow a "normal biography" (Ball, Davies, David and Reay 2002), but are forced to choose and negotiate their choices. However, these students, who have not been raised with the values of academia since they were children, also seem prone to hold a critical stance toward an elitist and competitive academic culture, as we saw among our interviewees (see also Reay 2001).

Being perceived as choosing an education because of prestige inhabited a tenuous position in most accounts. Frida discussed this as a tension between external and internal expectations of prestige. She was frank about growing up in a middle-class environment and going to an elite school where the teachers expected all the students to go on to prestigious schools, "kind of because you deserve to be there". Frida described how her mother had clear and high expectations for her children, partly ascribed to her grandparents' migration history and academic aspirations. Frida's mother arranged "maths Sundays" for Frida and her siblings, which can be seen as an example of the "concerted cultivation" (Lareau 2011) that middle-class parents engage in to better their children's chances. When considering her choice of university program, Frida attended an event for women in technology and realized that being an engineer could be an appropriate job:

> I kind of chose between becoming a doctor or this, because the prestige guru is in me [laugh] […] But as a doctor, it seems like the job will require a lot. It will be great fun, you will have a job for life, but as an engineer you will have a job that does not require as much and you will have more time for hobbies and family.
>
> (Frida)

She further commented that when considering which engineering program to choose, she ended up with Engineering Physics, "because it is the broadest, and you get the most choices. And prestige. Now I'm completely honest [laughing], there's prestige, absolutely, in it." Frida, in contrast to many of our other interviewees with middle-class background, thus was very honest about the prestige expected of her by both others and herself, and explained that this is a part of her motivation for choosing physics. Like many of the others, she considers Engineering Physics a "broad" education and in that way a good choice making many future professional routes possible. It is an elite, prestigious program (Nyström, Jackson and Salminen Karlsson 2019), the choice of which becomes a non-choice (Danielsson, Gonsalves, Silfver and Berge 2019) in that it provides so many possible futures. Nevertheless, Frida's account of the internalized prestige guru was told with some caution,

related to the possible impression of having been given undue privileges ("deserving to be there"), but also perhaps to the tenuous position that "elite" aspirations holds in Scandinavian societies. While on the one hand aiming for good careers and making independent study choices are valued in Scandinavian society, on the other hand distinguishing yourself as better than others can be looked down upon, according to the so-called Law of Jante (Thomsen, Sidanius and Fiske 2007).

Apart from possibly being seen as pretentious, a choice based on prestige can reflect an insufficiently personalized choice narrative. Emma, who grew up in a rural community, with parents and older siblings in STEM occupations, describes how she, despite her family background and especially compared to some of her fellow students in Engineering Physics, did not have a very clear picture of which universities and programs were considered better or worse. She described her choice of Engineering Physics as "just based on the name", because she liked mathematics and physics. When people later on informed her that it was viewed as "one of the hardest courses of study", she maintained that she had not considered that, and joked that it would have been smart to be aware of that when applying. Her somewhat arbitrary choice of a rather prestigious program is not something that gives credit in the environment "back home", however:

> If I would come home and say, "well, I've studied this" then really, it would be: "I don't understand what you're talking about". Just like, you're just a nerd, and no one cares.
>
> (Emma)

A prestige-driven choice, or knowing which choices are prestigious, is apparently not legitimate among all of Emma's peers. However, her positioning of herself as coming from this rural context with limited social and cultural capital (knowing what to study) also enables her to narrate her choice as authentic, personalized, and interest-driven (albeit not so "well-researched", Holmegaard 2015). In this way, she presents a choice narrative that is more legitimate in the context of physics and liberal societal discourses, than it would be if she claimed to be influenced by notions of prestige or ideas of good education present in her family.

A motivation related to prestige, that is mobilized by some of our interviewees, is to seek challenges. This can easily be part of a personalized choice narrative, where "a need for being challenged" can be seen as a personal characteristic. This is apparent in the story of Ella, who is an immigrant from the Global South who arrived in Sweden with her family while she was in her teens. Ella tells a story featuring narratives of determination for following one's dreams, moving beyond restrictive societal expectations, and finding appropriately worthy challenges. She described how she was dissatisfied in primary school:

> It wasn't like I found natural sciences easy really, but I wanted some kind of challenge. And it felt like that was where I could get a challenge that is, yeah a challenge worth devoting oneself to.
>
> (Ella)

We interpret Ella as performing a legitimate (personalized) choice narrative when describing how she, without particular influence from her working-class family, chose to engage in physics for her own sake, for the challenge, but also to give back to her family and community. In this way, her prestigious studies become a "right choice" with the "right motives" (Kindt 2018), perhaps representing a "proper mobility narrative" (Hurst and Warnock 2015). This suggests that in comparison with how the idea of choosing based on prestige is

negotiated extensively, choosing based on wanting to be challenged inhibits a less tenuous position in physics choice narratives.

With interest and a natural inclination for physics

Performing a physics choice narrative with interest as an ingredient may seem obvious and natural, but how does this narrative manifest itself in interviewee's talk? And how is this interest motivation mobilized in order to present a sufficiently personalized, authentic choice narrative that can be perceived as legitimate?

When interest, ability, and recognition given by family and school aligns, narrating a science or physics choice becomes natural. This is evidenced by several of our interviewees who followed the "script" in developing a physics interest and were supported in this by both school and family. We see that although women are often discouraged from pursuing physics by many mechanisms (Archer, Moote and MacLeod 2020), several of the women in our study could describe their choice of physics as rather undramatic given the ingredients of interest, ability and recognition (Rakel, Frida, Lisa, Emma, Moa, Linn, Julia, Jennifer). These women mostly fulfill the characteristics of what has been named the "exceptional" physics girl, in that they perform well in physics, receive support for it, and have even participated in competitions and other extra-curricular activities (Archer, Moote, Francis, DeWitt and Yeomans 2017). Although they are well aware of the fact that the field they are in is very male-dominated, many of them describe that they are comfortable among men, while at the same time not necessarily disassociating themselves from femininity. One interpretation of this is that physics can be a quite "expected" choice, for (certain) women in Sweden. This does not mean that it is always straightforward. Julia is one of the "expected" physics girls, who participated in many informal physics learning activities during high school, which were regarded as stepping-stones toward continuing with physics (Gonsalves, Johansson, Nyström and Danielsson 2022). On a science camp abroad, one of the other participants asked Julia "is it common in Sweden that girls study maths and physics" to which she answered: "I think so". Julia recounts how this shocked her, and that she had not even considered this as a problem, but then realized she was the only woman doing maths and physics at the camp. Julia discusses at length how she has felt quite isolated in physics at the university and has actively been organizing and working against the norms of smartness and elitism in physics, norms that she explains are harsher on women.

Jennifer is one of the women for whom the choice of physics may seem quite obvious, but her story also involves a lot of work in performing a personalized choice narrative. Overall, Jennifer recounted how she received much support by her parents, even though she described that the expectations of her father, who is an engineer working with space technology, were sometimes too high. Jennifer said she has a brain for natural science, and she liked mathematics as a small child but did not always perform so well in school settings. She has not felt very aligned with the norms and expectations of school and the majority of young people. During upper secondary school, Jennifer developed a fascination for space and entertained this in a youth organization where she met many like-minded people. On the one hand, Jennifer described how natural science was always an obvious and encouraged choice by her father. On the other hand, while acknowledging this situation, in the interview she still worked to describe her choice as independent and personal.

> People always say that you will become like one of your parents, but I don't want… I mean, like this: "but my dad is a space engineer". Then it's like: "yes, but then it's obvious that you are into space". But I'm like: "I actually discovered this all by myself" [laughing].
>
> (Jennifer)

Studying a Physics Bachelor program at the time of the interview, Jennifer was not sure if astronomy would be her profile in the future, but jokingly referred to it as a gateway for young people to get interested in physics. Pointing out that she found her interest in space "all by myself", is one way in which Jennifer narrates her choice as personal and individual, defending against a supposed accusation of just following the expectations and traditions of her family.

While motives of interest or passion are expected to be mobilized in a personalized choice narrative, they often have to be balanced against other concerns. As we saw in the previous section, this can be about getting a good or prestigious job. Jennifer, whose interests made her follow in her father's footsteps, compared her choice to her brother's and recognized that he had a much harder time reconciling his interest-driven studies in humanities with the expectations for getting a "respectable" job. Jennifer gathered that physics is still a sufficiently respectable choice (although less so compared to engineering) and easier to justify than humanities. In a similar vein, Omar, who describes how he developed a strong passion for physics in his teens and wants to go on to study the big questions in theoretical physics, said that his parents were supportive in general, but "didn't think he should do it" when he said he applied for a physics bachelor program. They were worried and asked "what jobs are there" and "are you going to sit writing equations all your life". They would much rather see him study an engineering degree. Omar explained how getting a safe education and a good job is a priority for his parents, with their working-class and migrant background. However, he described his parents as more open than the older generation and emphasizes the importance of making his own choices. Both Omar and Jennifer thus work to explain their choices as based in an individual interest, but while Omar negotiates family expectations to carve a space for doing what he loves, Jennifer follows in her father's footsteps but works to explain this in line with the expected middle-class privilege of following one's dreams (within reasonable limits). From these different positions, both work to perform a personalized choice narrative, where their own interest and own accomplishments are centered.

Claiming a natural ability and interest for physics seems easier from a privileged class-position where the cultural and social capital needed for this is available. Still, for some of our interviewees with a working-class background, physics has been a long deferred dream, made possible later in life through further education (Karin, Oskar). In their stories, a passion for physics is mobilized to explain an unconventional choice that is made despite many other concerns. For others, physics is just one part of getting a better, intellectual life. For Thomas, natural sciences became possible to engage in after several years of manual labor. He has considered becoming a doctor or nurse, but now studies medical physics. Hamid was similarly interested in natural sciences and engineering in general. For these two interviewees, an interest in physics is not mobilized as a primary motivation for studying it at all. Other reasons for choosing physics were then needed to narrate the choice in a legitimate way, like wanting to get a better life or making a contribution to others' lives.

The narration of a choice of physics as driven by interest mirrors several themes highlighted in earlier research. First, the imperative of authenticity in late-modern societies makes it important to explain one's choices as stemming from who one is, for example a science person or maths person with a burning interest to understand the universe. By describing an early interest and ability, a natural and coherent choice narrative

is constructed. As noted by (Holmegaard, Ulriksen and Madsen 2014), when creating a coherent narrative, the past is cast in a way that matches one's current situation. This is done by our interviewees who, now that they have succeeded to study university physics, can legitimately interpret their earlier troubles in school as a problem of not matching the expectations even if they were "mathematically minded" (Jennifer) or always "very smart" (Oskar). Had they not "succeeded" in getting to university studies, this interpretation would perhaps be different. Despite all this, an authentic choice based on innate interest has to be negotiated with ideals of getting a good career (Holmegaard, Ulriksen and Madsen 2014). In light of the descriptions of our interviewees, choosing a Physics Bachelor program represents a middle-ground between the "'authentic' career pathway" of studying arts (James, Mallman and Midford 2021) and the pragmatic one of studying engineering. The Engineering Physics program is chosen by many, for example Moa, who despite what she describes as an interest in quite theoretical aspects of physics chose this more applied program. This may seem like a perfect compromise, especially in Sweden where Engineering Physics is a prestigious education (and more recognized than a Bachelor in physics), giving access to both high-paid industry jobs and academic research. Second, making an individual and authentic choice becomes even more important for students with immigrant background who may be expected to not be "independent enough" from their parents' culture of familial obligations. Like Kindt (2018), we can see the narratives of "always having loved it" and "never being pushed" being used in Omar's story. Among our interviewees, the story of always having been interested in science/physics is, however, more common among the students with a Swedish middle-class background, perhaps reflecting the support for science aspirations in families with more social and cultural (science) capital.

Studying physics to contribute to one's community

While idealistic reasons for studying physics are relatively uncommon in our material, how and for whom does it become possible to draw on this in a legitimate choice narrative?

A few of the women with a middle-class background in our data describe how they are making a contribution just by making the personal choice of studying what they study. Moa captures this well, when discussing the possible trouble of being a woman in a field dominated by men and explains that the fact that men are over-represented in her Engineering Physics program "probably made me more inclined to apply, because I think no one should be allowed to tell me what I can and cannot do". In a similar vein, Jennifer says:

> If someone asks "what are you doing for feminism?" "I'm a physicist." Like, I think it's quite fun. I'm here and I disturb things a bit. That's great. I'm very satisfied with it [laughs]
>
> (Jennifer)

Moa and Jennifer, but also Julia reason about their "unexpected" choice as important because they may serve as role models. Although they have experienced some of the stress of being minoritized in the field of physics, they also discuss the many benefits in terms of explicit encouragement, scholarships, etc., that this has given them in the current Swedish equality discourse, where girls choosing science and technology are seen as an important goal for equality as well as economics (Lövheim 2014, see also Archer, Moote, Francis, DeWitt and Yeomans 2017 about the strategic view of being distinct as a woman in physics). In this context, narrating a norm-breaking choice is recognizable and celebrated in political discourse.

Physics can be seen as a good study choice that can contribute to the welfare of one's family, but is not necessarily so, as evidenced by the concern Omar's parents had about whether a bachelor in physics was a safe or good enough education. For others, the choice of physics was clearly seen as a way of giving back to their families. If your parents have immigrated to Sweden to get a better life, your choice of a good education is a means to continue that upwards social mobility. This pattern was clear in the stories of Hamid and Ella, who both described how their mothers had directed them toward higher education to achieve a better life than they themselves had. Denis situates this goal of getting a good life and a well-paying job in a concrete desire for providing for his mother as she ages. Reflecting that this is perhaps mostly a question about class, we can observe that helping his family materially also goes into Thomas's (who has a Swedish background) considerations of choosing a health-oriented occupation (medical physics) in order to understand and being able to help his closest family with current and future health problems. A choice that becomes recognizable and legitimate for Thomas's family because of this.

However, the merits of a good profession for helping one's family also goes beyond material wealth. Thomas grew up in a working-class family with a cultural interest but said that he "spent most of my waking time in front of the TV when I was little, and no one really told me not to". In secondary school, he had friends from middle-class backgrounds, and described how spending time in their families made him see how a different way of approaching life could be a motivation "to somehow get something bigger than what you had when you were little." These parents, "knew things" and talked about their jobs with happiness and pride at the dinner table, instead of watching TV while eating. Becoming educated and learning physics thus becomes a way of providing a better life for his current family (who consults him in health and other matters) and a possible future family with children of his own. Karin, who has worked in unskilled labor for many years described how choosing to study physics means to aim for "a life where you don't have to take antidepressants for the rest of your life to be able to live, and my daughter can have a good mother, a whole mother". Karin makes this choice despite it meaning many other sacrifices for her in terms of job security and other concerns. Thus, a choice of physics becomes a choice of a better life in multiple ways, most often told in relation to class mobility. On the one hand, physics is a respectable university education which may lead to a fulfilling career, allowing you to provide for your family. On the other hand, it does not represent the safest or most expected choice for someone in Karin's position who might be expected to follow class and gender norms and study a shorter education leading to a well-defined career in a "female" field, such as nursing. This personal and unexpected choice does, however, become legible in Karin's narrative where physics figures prominently as a passionate interest, which has long been denied her. Engaging in the intellectual pursuit of physics is thus expected to allow Karin to thrive and provide a better live for herself and her family (even if a more pessimistic interpretation indicates that following your passion may not lead to well-being in the form of a sustainable working-life, Cech 2021). While for Karin living a good life is strongly connected to the intellectual particulars of physics, the general idea of achieving a middle-class life is more prominent for others.

More idealistic ideas about the contribution one can make by studying physics is given by Thomas, Oskar and Lukas, who compare it to working with things that contribute less to society. Thomas framed this quite ideologically:

> [Science] is not about oneself, but about broadening an understanding for all, and bringing a common collective to greater happiness
>
> (Thomas)

While these dreams situate the contribution of physics more in the abstract, it may also be seen as something that can help people concretely. Amir reasoned about how choosing science and technology (in the Engineering Physics program) in contrast to law or politics will probably be something that may enable him to make a difference in the world, for example by building infrastructure in developing countries. For Ella, the possibility of using physics to give back to people is central. She narrates her choice of physics as based in a genuine interest, combining this with wanting to be challenged and making the best of the opportunities she has been given coming to Sweden. She outlines her dreams:

> I want to do research, but then I also want to […] I want to build an institute in [region of origin], I want to give others the chance I have had myself, at the same time as I do my own stuff too. It would be cool to make [region] a … [regional] Hub of Technology or something. […] it feels like people … either they promote physics learning as a science communicator in some way, or they do science themselves. And I don't want to do one or the other, I want to do both.
>
> (Ella)

Apart from the distant dreams of a physics institute, she has already been in contact with the embassy of her parents' home country about starting a physics summer school similar to the ones she has attended herself.

These choice narratives, where physics becomes a vehicle for contributing to one's family, community or society in general, are in minority in our data, in agreement with earlier research. In addition, we mainly see students from under-represented class and national backgrounds articulating these motivations, mirroring some earlier research (Saddler and Sundin 2020). In Swedish society, as well as in the interview situation, a personalized narrative basing ones' choice in a personal interest for the field is expected. Still, in the extensive descriptions of their experiences, trajectories and motivations in our interviews, the students do articulate idealistic alternatives. These motivations become legitimate in the interviews and can be expected to represent narratives that are to some extent validated externally, a story that have got recognized by others. This might suggest that idealistic motivations are an "emerging trend" (Bøe and Henriksen 2013) for choosing physics. However, it is still unclear to what extent such choice narratives are seen as legitimate in physics, or if students need to seek recognition in other contexts.

Conclusions

Considering the perpetual concern for widened participation in physics, we have explored under-represented students' pathways into physics by analyzing their choice narratives. Physics education research focusing on widened participation commonly compares experiences of "traditional" and "non-traditional" students, often men and women, an analytical approach that is at risk of homogenizing these groups. However, our exclusive focus on the stories of students positioned as under-represented in physics (similar to the focus on women in the study by Sax, Lehman, Barthelemy and Lim 2016), as well as the intersection between structures shaping their social locations, has allowed us to provide a diverse picture of how physics can be narrated as a possible choice. To analyze this diversity while taking the social and political construction of experiences into account, we have conceptualized students' accounts of their decision-making process as "choice narratives", an approach previously developed for STEM student choice, but not previously used for

studying physics and under-represented students in particular (Holmegaard 2015; Madsen and Holmegaard 2022). Analyzing the choice narratives of our interviewees, we have documented how the diversity of negotiations of choices are co-constituted with social locations.

Attending to the pursuit of a widened recruitment to physics studies, we have documented multiple ways of getting into physics, even for students traditionally seen as having few choices and opportunities. Some of these possibilities may be enabled specifically by the Swedish study context. At the same time, these possibilities are circumscribed by societal discourses, disciplinary culture and social norms, which necessitates an analysis of what choices can be seen as legitimate for whom. In our data, it was clear that engineering provides one path into physics, both for women and students with migration backgrounds. While this may be seen as confirming ideas that women are not as interested in physics for physics sake, as other research has shown, many women are strongly invested in physics (Sax, Lehman, Barthelemy and Lim 2016), and this holds true for some of our participants as well. Still, the engineering pathway, mostly enabled by the strong social capital of most women choosing engineering in Sweden (Engström 2018), enables physics to be an "expected" choice for some of the participants in our study.

Performing a legitimate choice narrative involves an interplay between agency and social structures. In our case, these structures are the culture of physics and the institutional and political discourses about school, higher education and social justice in Sweden. Drawing from our analysis of how student interviewees are performing legitimate choice narratives in terms of personalization, coherence and recognizability, we want to highlight some pertinent aspects of this process: How some choices become politically and socially sanctioned, what a personalized choice in physics culture involves, and how this connects to the demand for authenticity in late modern societies. While on the one hand physics is an unconventional, and thus "personalized", choice for women, on the other hand, studying physics, and in particular the Engineering Physics program in Sweden, can for many of the young women in our study be seen as sanctioned both by their family and friends and the general political discourse. Making this choice makes them symbols for modernity and gender equality, long-time hegemonic discourses in Sweden (Hedlin 2011). By challenging social convention in line with political priorities, the "physics girl" becomes visible and can also gain some concrete privileges in the form of for example scholarships, as well as the immaterial privilege of being seen as making a right choice for the right reasons. On making a personal choice, the interviewees in our study, which of course is a self-selected sample, with few exceptions describe how they have managed to follow their own interest in choosing what to study. This possibility can perhaps in part be attributed to the affordable and flexible Swedish system of education (part of the social democratic vision of a "society of free choice" Lövheim 2014). However, given the social sanctioning of basing one's choice in personal interest, as well as the pervasive script of the absorbed and fascinated child-physicist, we can also assume that the strong mobilization of interest in our interviews is a way to perform a legitimate and coherent choice narrative in physics, in that way positioning oneself as an authentic physics person. Nevertheless, narrating a choice as authentic is not equally possible for everyone, and the imposition to do so may also limit critical possibilities. As discussed before, students with migrant backgrounds tend to have to do more work for claiming to have made an authentic choice (see Kindt 2018). At the same time, the limited friction some of our more privileged interviewees have experienced in making "the right choice", points to the early "self-regulation" of interest and ambitions expected of middle-class students (Reay 2001). As self-governing individuals in late

modern societies, everyone needs to construct their narrative as authentic by obscuring the restricting influences on their choices, it is just easier to pull this off for some.

While we have seen how explaining one's path and choices involves being subjected to restrictive structures, we have also seen openings for resistance and reconfiguring of normative discourses, "performative subversions" (Butler 1990). We interpret some stories of our interviewees as subverting certain norms about physics in this way. Choosing physics for the sake of others clashes with the more common motivation of choosing it based on an intrinsic interest, which is legitimated by the norm of "physics for the sake of physics" (Bøe and Henriksen 2013, p. 553). It has been highlighted that this usually implies that students "who have additional motivations, like socio-economic concerns, will need to have a passion for physics above and beyond the norm in order to disregard such concerns and opt into physics" (Hazari, Sonnert, Sadler and Shanahan 2010, p. 994). In our case, this does not seem to be strictly necessary, the "emerging trend" of the "idealistic physicist" may indicate a change in physics culture (Bøe and Henriksen 2013). By narrating a choice of physics as based on altruistic motivations, some of our interviewees disrupt the understanding of physics as a "pure" subject, only concerning knowledge disconnected from human concerns. It resonates with critical theoretical analyses of how physics has never been pure (Harding 1991), and points out one possible direction away from the problematic, for example military, associations of many of its "impure" applications (Kaiser 2002), toward a reconnection with the concerns of all people. Imagining a diverse profession of physicists needs to go hand in hand with imagining a diverse and just understanding of *what* and *who* physics is for (Johansson and Larsson 2023), something that some of the participants in our study are already doing.

Returning to how Thomas mockingly calls the normative tenets of physics into question in the introduction, we suggest that this can be read as an example of how a working-class student can carve out a critical location for himself within physics. His positionality as a white, Swedish man in physics is of interest here, as it may not be seen as an immediate display of equality in the same way as for the more visible women in physics. At the same time, Thomas relates to physics through a critical intersectional analysis and distances himself from some of the scientific ideals and gendered culture of the subject; he wants to use physics for a good purpose. Furthermore, he names the hubris of the Nobel Prize-yearning physicist, as related not to the neutral, professional, middle-class masculinity of physics (Danielsson 2014), but as part of a sweaty testosterone-drenched drive for domination associated with more "barbaric" forms of male behavior. Thomas does not want to be part of this, to be that type of physicist, or that type of middle-class man. This hints at a possibility for crafting stories of physics participation that subverts both traditional norms of physics and expectations of the blessings of social mobility. Many structures limit the formation of physics people and physics knowledge, but there are also openings for imagining physics differently.

Acknowledgements This study was supported by the Swedish Research Council (Vetenskapsrådet), VR-UVK (Grant Number 2018-04985). We wish to thank Johanna Larsson for in-depth reading of paper drafts.

Author contributions AJ did the main part of analysis and writing, one part of it in collaboration with A-SN, ATD and A-SN did data collection. Analysis notes and paper drafts were discussed among all authors.

Funding Open access funding provided by Chalmers University of Technology.

Declarations

Competing interests The authors declare no competing interests.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

References

Adams, W. K., Perkins, K. K., Podolefsky, N. S., Dubson, M., Finkelstein, N. D., & Wieman, C. E. (2006). New instrument for measuring student beliefs about physics and learning physics: The colorado learning attitudes about science survey. *Physical Review Special Topics: Physics Education Research, 2*(1), 010101.

Adriansen, H. K. (2012). Timeline interviews: A tool for conducting life history research. *Qualitative Studies, 3*(1), 40–55. https://doi.org/10.7146/qs.v3i1.6272

American Physical Society. (2018). *Percentage of women in physics*. American Physical Society. https://www.aps.org/programs/education/statistics/womenphysics.cfm

Anderhag, P., Wickman, P.-O., Bergqvist, K., Jakobson, B., Hamza, K. M., & Säljö, R. (2016). Why do secondary school students lose their interest in science? Or does it never emerge? A possible and overlooked explanation. *Science Education, 100*(5), 791–813.

Andersson, S., & Linder, C. (2010). Relations between motives, academic achievement and retention in the first year of a master programme in engineering physics. In G. Çakmakci & M. F. Taşar (Eds.), *Contemporary science education research: Learning and assessment* (pp. 123–128). Pegem Akademi.

Anthias, F. (2005). Social Stratification and Social Inequality: Models of Intersectionality and Identity. In F. Devine, M. Savage, J. Scott, & R. Crompton (Eds.), *Rethinking class: Culture, identities and lifestyles* (pp. 24–45). Palgrave Macmillan.

Archer, L. (2007). Diversity, equality and higher education: A critical reflection on the ab/uses of equity discourse within widening participation. *Teaching in Higher Education, 12*(5–6), 635–653.

Archer, L., Moote, J., Francis, B., DeWitt, J., & Yeomans, L. (2017). The "exceptional" physics girl: A sociological analysis of multimethod data from young women aged 10–16 to explore gendered patterns of post-16 participation. *American Educational Research Journal, 54*(1), 88–126.

Archer, L., Moote, J., & MacLeod, E. (2020). Learning that physics is 'not for me': Pedagogic work and the cultivation of habitus among advanced level physics students. *Journal of the Learning Sciences, 29*(3), 347–384.

Archer, L., DeWitt, J., Osborne, J. F., Dillon, J. S., Wong, B., & Willis, B. (2013). *ASPIRES Report: Young people's science and career aspirations, age 10–14*. King's College. https://kclpure.kcl.ac.uk/portal/en/publications/aspires-report(a0237ac7-cb43-473e-879a-1ea0addff0e3).html

Ball, S., Davies, J., David, M., & Reay, D. (2002). 'Classification' and 'judgement': Social class and the 'cognitive structures' of choice of higher education. *British Journal of Sociology of Education, 23*(1), 51–72.

Barthelemy, R. S., McCormick, M., & Henderson, C. (2016). Gender discrimination in physics and astronomy: Graduate student experiences of sexism and gender microaggressions. *Physical Review Physics Education Research, 12*(2), 020119.

Beach, D., & Puaca, G. (2014). Changing higher education by converging policy-packages: Education choices and student identities. *European Journal of Higher Education, 4*(1), 67–79.

Beck, U. (1992). *Risk society: Towards a new modernity*. Sage.

Bøe, M. V., & Henriksen, E. K. (2013). Love it or leave it: Norwegian students' motivations and expectations for postcompulsory physics. *Science Education, 97*(4), 550–573.

Bøe, M. V., Henriksen, E. K., Lyons, T., & Schreiner, C. (2011). Participation in science and technology: Young people's achievement-related choices in late-modern societies. *Studies in Science Education, 47*(1), 37–72.

Burke, P. J. (2007). Men accessing education: Masculinities, identifications and widening participation. *British Journal of Sociology of Education, 28*(4), 411–424. https://doi.org/10.1080/01425690701369335

Butler, J. (1990). *Gender trouble: Feminism and the subversion of identity*. Routledge.

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.

Cech, E. (2021). *The trouble with passion: How searching for fulfillment at work fosters inequality*. University of California Press.

Coble, K., Cunningham, B., Freeland, E., Hodapp, T., Hodari, A. K., Ivie, R., Martínez-Miranda, L. J., Ong, M., Petty, S., Seestrom, S., Seidel, S., Simmons, E., Thoennessen, M., Urry, M., & White, H. (2013). Many steps ahead, a few steps back: US women in physics. *AIP Conference Proceedings, 1517*, 162–163.

Crenshaw, K. (1989). Demarginalizing the intersection of race and sex: A black feminist critique of antidiscrimination doctrine, feminist theory and antiracist politics. *University of Chicago Legal Forum, 1989*(1), 139–167. https://chicagounbound.uchicago.edu/uclf/vol1989/iss1/8

Cunninghame, I. (2022). Influence of policy discourse on student choice in Australian higher education. *International Journal of Inclusive Education, 26*(13), 1227–1242. https://doi.org/10.1080/13603116.2020.1791980

Dahlstedt, M., & Fejes, A. (2019). *Neoliberalism and market forces in education: Lessons from Sweden*. Routledge.

Danielsson, A. (2014). In the physics class: university physics students' enactment of class and gender in the context of laboratory work. *Cultural Studies of Science Education, 9*(2), 477–494.

Danielsson, A., Gonsalves, A. J., Silfver, E., & Berge, M. (2019). The pride and joy of engineering? The identity work of male working-class engineering students. *Engineering Studies, 11*(3), 172–195.

Du Bois-Reymond, M. (1998). 'I don't want to commit myself yet': Young people's life concepts. *Journal of Youth Studies, 1*(1), 63–79. https://doi.org/10.1080/13676261.1998.10592995

Ellingsæter, A. L. (2013). Scandinavian welfare states and gender (de) segregation: Recent trends and processes. *Economic and Industrial Democracy, 34*(3), 501–518. https://doi.org/10.1177/0143831X13491616

Engström, S. (2018). Differences and similarities between female students and male students that succeed within higher technical education: Profiles emerge through the use of cluster analysis. *International Journal of Technology and Design Education, 28*(1), 239–261.

European Commission. (2004). *Europe needs more scientists: Report by the high level group on increasing human resources for science and technology in Europe*. Office for Official Publications of the European Communities.

Foucault, M. (1997). *Ethics: subjectivity and truth* (P. Rabinow, Ed.). The New Press.

Francis, B., Archer, L., Moote, J., DeWitt, J., MacLeod, E., & Yeomans, L. (2017). The construction of physics as a quintessentially masculine subject: Young people's perceptions of gender issues in access to physics. *Sex Roles, 76*(3–4), 156–174.

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.

Gonsalves, A. J., Johansson, A., Nyström, A.-S., & Danielsson, A. T. (2022). Other spaces for young women's identity work in physics: Resources accessed through university-adjacent informal physics learning contexts in Sweden. *Physical Review Physics Education Research, 18*(2), 020118. https://doi.org/10.1103/PhysRevPhysEducRes.18.020118

Goodson, I., & Sikes, P. J. (2001). *Life history research in educational settings: Learning from lives*. Open University Press.

Gray, J., & Dagg, J. (2019). Using reflexive lifelines in biographical interviews to aid the collection, visualisation and analysis of resilience. *Contemporary Social Science, 14*(3–4), 407–422. https://doi.org/10.1080/21582041.2018.1459818

Haraway, D. (1988). Situated knowledges: The science question in feminism and the privilege of partial perspective. *Feminist Studies, 14*(3), 575–599.

Harding, S. (1986). *The science question in feminism*. Cornell University Press.

Harding, S. (1991). *Whose science? Whose knowledge?* Open University Press.

Hasse, C. (2008). Learning and transition in a culture of playful physicists. *European Journal of Psychology of Education, 23*(2), 149–164.

Hasse, C., & Sinding, A. B. (2012). The cultural context of science education. In D. Jorde & J. Dillon (Eds.), *Science education research and practice in Europe* (pp. 237–252). SensePublishers.

Häussler, P., Hoffman, L., Langeheine, R., Rost, J., & Sievers, K. (1998). A typology of students' interest in physics and the distribution of gender and age within each type. *International Journal of Science Education, 20*(2), 223–238.

Hazari, Z., Sonnert, G., Sadler, P. M., & Shanahan, M.-C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. *Journal of Research in Science Teaching, 47*(8), 978–1003.

Hedlin, M. (2011). How the girl choosing technology became the symbol of the non-traditional pupil's choice in Sweden. *Gender and Education, 23*(4), 447–459. https://doi.org/10.1080/09540253.2010.490206

Holmegaard, H. T. (2015). Performing a choice-narrative: A qualitative study of the patterns in STEM students' higher education choices. *International Journal of Science Education, 37*(9), 1454–1477.

Holmegaard, H. T., Madsen, L. M., & Ulriksen, L. (2014). To choose or not to choose science: Constructions of desirable identities among young people considering a stem higher education programme. *International Journal of Science Education, 36*(2), 186–215.

Holmegaard, H. T., Ulriksen, L. M., & Madsen, L. M. (2014). The process of choosing what to study: A longitudinal study of upper secondary students' identity work when choosing higher education. *Scandinavian Journal of Educational Research, 58*(1), 21–40.

Holmegaard, H. T., Ulriksen, L., & Madsen, L. M. (2015). A narrative approach to understand students' identities and choices. In E. K. Henriksen, J. Dillon, & J. Ryder (Eds.), *Understanding student participation and choice in science and technology education* (pp. 31–42). Springer.

Holstein, J. A., & Gubrium, J. F. (2000). *The self we live by: Narrative identity in a postmodern world* (p. xi, 268). Oxford University Press.

Hurst, A. L., & Warnock, D. M. (2015). *Les miraculés*: "The magical image of the permanent miracle"—Constructed narratives of self and mobility from working-class students at an elite college. In E. M. Lee and C. LaDousa (Eds.), *College Students' Experiences of Power and Marginality: Sharing Spaces and Negotiating Differences*. Routledge.

James, S., Mallman, M., & Midford, S. (2021). University students, career uncertainty, and the culture of authenticity. *Journal of Youth Studies, 24*(4), 466–480.

Jämställdhetsmyndigheten. (2022). *Val efter eget kön – En kunskapssammanställning om könsskillnader i utbildningsval* (2002:4).

Johansson, A. (2020). Negotiating intelligence, nerdiness, and status in physics master's studies. *Research in Science Education, 50*, 2419–2440.

Johansson, A., & Larsson, J. (2023). Identity perspectives in research on university physics education: What is the problem represented to be? In H. T. Holmegaard & L. Archer (Eds.), *Science Identities: Theory, method and research* (pp. 163–184). Springer. https://doi.org/10.1007/978-3-031-17642-5_8

Kaiser, D. (2002). Cold War requisitions, scientific manpower, and the production of American physicists after World War II. *Historical Studies in the Physical and Biological Sciences, 33*(1), 131–159.

Kindt, M. T. (2018). Right choice, wrong motives? Narratives about prestigious educational choices among children of immigrants in Norway. *Ethnic and Racial Studies, 41*(5), 958–976.

Lareau, A. (2011). *Unequal childhoods: Class, race, and family life* (2nd ed.). University of California Press.

Larsson, J., & Danielsson, A. (2023). *Woman physics teacher candidates utilizing their double outsider position as women and trainee teachers to productively learn physics Physical Review Physics Education Research, 19*(1), 010140. https://doi.org/10.1103/PhysRevPhysEducRes.19.010140

Levrini, O., Ambrosis, A. D., Hemmer, S., Laherto, A., Malgieri, M., Pantano, Ornella, & Tasquier, G. (2017). Understanding first-year students' curiosity and interest about physics—lessons learned from the HOPE project. *European Journal of Physics, 38*(2), 025701.

Lövheim, D. (2014). Scientists, engineers and the society of free choice: Enrollment as policy and practice in Swedish science and technology education 1960–1990. *Science & Education, 23*(9), 1763–1784.

Lucena, J. C. (2005). *Defending the nation: US policymaking to create scientists and engineers from Sputnik to the 'War against Terrorism.'* University of America Press.

Madsen, L. M., & Holmegaard, H. T. (2022). Science students' post-bachelor's choice narratives in different disciplinary settings. *European Educational Research Journal*. https://doi.org/10.1177/14749041221095151

Mendick, H., Moreau, M.-P., & Epstein, D. (2009). Special cases: Neoliberalism, choice and mathematics education. In L. Black, H. Mendick, & Y. Solomon (Eds.), *Mathematical relationships: Identities and participation* (pp. 71–82). Routledge.

Moshfeghyeganeh, S., & Hazari, Z. (2021). Effect of culture on women physicists' career choice: A comparison of Muslim majority countries and the West. *Physical Review Physics Education Research, 17*(1), 010114.

Mujtaba, T., & Reiss, M. J. (2014). A survey of psychological, motivational, family and perceptions of physics education factors that explain 15-year-old students' aspirations to study physics in post-compulsory English schools. *International Journal of Science and Mathematics Education, 12*(2), 371–393.
Nyström, A.-S., Jackson, C., & Salminen Karlsson, M. (2019). What counts as success? Constructions of achievement in prestigious higher education programmes. *Research Papers in Education, 34*(4), 465–482.
Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education, 25*(9), 1049–1079.
Ottemo, A. (2015). *Kön, kropp, begär och teknik: Passion och instrumentalitet på två tekniska högskoleprogram* [PhD thesis, Gothenburg University]. http://hdl.handle.net/2077/39621.
Pugsley, L. (1998). Throwing your brains at it: Higher education, markets and choice. *International Studies in Sociology of Education, 8*(1), 71–92.
Reay, D. (2001). Finding or losing yourself? Working-class relationships to education. *Journal of Education Policy, 16*(4), 333–346.
Reay, D., Davies, J., David, M., & Ball, S. J. (2001). Choices of degree or degrees of choice? Class, 'race' and the higher education choice process. *Sociology, 35*(4), 855–874. https://doi.org/10.1017/S0038038501008550
Reay, D., Crozier, G., & Clayton, J. (2010). 'Fitting in' or 'standing out': Working-class students in UK higher education. *British Educational Research Journal, 36*(1), 107–124. https://doi.org/10.1080/01411920902878925
Saddler, Y., & Sundin, E. C. (2020). Mature students' journey into higher education in the UK: an interpretative phenomenological analysis. *Higher Education Research & Development, 39*(2), 332–345. https://doi.org/10.1080/07294360.2019.1672624
Sax, L. J., Lehman, K. J., Barthelemy, R. S., & Lim, G. (2016). Women in physics: A comparison to science, technology, engineering, and math education over four decades. *Physical Review Physics Education Research, 12*(2), 020108.
SCB. (2020). *Högskolenybörjare 2019/20 och doktorandnybörjare 2018/19 efter föräldrarnas utbildningsnivå* (UF20 - Universitet och högskolor. Grundutbildning). https://www.scb.se/publikation/40968.
SCB. (2022). *Svensk och utländsk bakgrund för studenter och doktorander 2020/21* (UF19 - Högskolestuderande med utländsk bakgrund). https://www.scb.se/publikation/45735.
Schiebinger, L. (1999). *Has feminism changed science?* Harvard University Press.
Schreiner, C. (2006). *Exploring a ROSE-garden: Norwegian youth's orientations towards science—seen as signs of late modern identities* [PhD thesis, University of Oslo]. http://urn.nb.no/URN:NBN:no-12326.
Shah, M., Bennett, A. K., & Southgate, E. (2016). *Widening higher education participation: A global perspective*. Chandos Publishing.
Sikora, J., & Pokropek, A. (2012). Gender segregation of adolescent science career plans in 50 countries. *Science Education, 96*(2), 234–264.
Skibba, R. (2019). Women in physics. *Nature Reviews. Physics, 1*(5), 298–300.
Thomsen, L., Sidanius, J., & Fiske, A. P. (2007). Interpersonal leveling, independence, and self-enhancement: a comparison between Denmark and the US, and a relational practice framework for cultural psychology. *European Journal of Social Psychology, 37*(3), 445–469. https://doi.org/10.1002/ejsp.366
Traweek, S. (1988). *Beamtimes and lifetimes: The world of high energy physicists*. Harvard University Press.
Tytler, R. (2014). Attitudes, identity, and aspirations toward science. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education* (Vol. II, pp. 82–103). Routledge.
Universitets- och högskolerådet. (2022). *Antagningsstatistik*. https://www.uhr.se/studier-och-antagning/antagningsstatistik/.
Watson, C. (2006). Narratives of practice and the construction of identity in teaching. *Teachers and Teaching, 12*(5), 509–526.
Wertheim, M. (1995). *Pythagoras' trousers: God, physics, and the gender wars*. Times Books/Random House.
World Economic Forum. (2021). *Global gender gap report 2021*. https://www.weforum.org/reports/global-gender-gap-report-2021.
Yang, Y., Tian, T. Y., Woodruff, T. K., Jones, B. F., & Uzzi, B. (2022). Gender-diverse teams produce more novel and higher-impact scientific ideas. *Proceedings of the National Academy of Sciences, 119*(36), e2200841119. https://doi.org/10.1073/pnas.2200841119
Yazilitas, D., Svensson, J., de Vries, G., & Saharso, S. (2013). Gendered study choice: A literature review. A review of theory and research into the unequal representation of male and female students in mathematics, science, and technology. *Educational Research and Evaluation, 19*(6), 525–545.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Anders Johansson is a senior lecturer in Engineering Education Research at the Department for Communication and Learning in Science at Chalmers University of Technology. His research concerns diversity and inclusion in university science and engineering education, with a specific focus on physics and the interaction between policy and practice.

Anne-Sofie Nyström is PhD in Sociology, and a senior lecturer in Child & Youth Studies at the Department of Education at Uppsala University. Her research focuses on educational inequality and prestigious educations, with focus on (young) men, masculinities and identity processes in peer-groups.

Allison J. Gonsalves is an Associate Professor in the Department of Integrated Studies in Education at McGill University. Her research focuses on identity trajectories of post-secondary students who are historically under-represented in science, with a special interest on experiences of gender in physics. Gonsalves is the Director of the Science Education Laboratories at McGill, and the co-chair of the ESERA Science Identities Special Interest Group.

Anna T. Danielsson is Professor of Science Education at the Department of Teaching and Learning, Stockholm University. Her research interests are focused on issues of gender, power, and identity in the context of teaching and learning of science.